

WHAT SWIFTLETS DO IN THE CAVES AT CHILLAGOE AND SOME IDEAS ON HOW CAVERS CAN SHARE THOSE CAVES WITHOUT INTERFERENCE

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ABSTRACT

The breeding of the White-rumped Swiftlet *Aerodramus spodiopygius chillagoensis* was studied during both a good and a poor season at Chillagoe, Queensland, Australia. Most of the nests were in totally dark sections of caves where colonies contained from 1 to 264 nests. The clutch of one was incubated for an average of 26.6 days during the better season when 64% of eggs hatched successfully. If the clutch or young brood was lost, it was usually replaced within 14 days. Fledgling success for this season was 69% giving a breeding success of 44% or, 0.9 young fledged from the two broods of a breeding pair. In the poor season incubation took 28.7 days, hatching success was 60%, fledging success was 50% and the nestling period had increased from 46.1 days to 51.0 days. Most chick mortality resulted from chicks falling from their nests. While the fledging rate for the single-egg clutch of *chillagoensis* is well below that of the two-egg clutch of Fijian swiftlets the unique practice of laying a second single-egg clutch for the first chick to incubate, increases the breeding rate in good seasons to almost that of the Fijian subspecies. There is no sexual dimorphism and both sexes share in incubation and feeding nestlings. Chillagoe chicks were fed an average of 5.2 times a day. Even though *chillagoensis* increases immediate energy demands by synchronizing moult and breeding, the length of time to complete the moult of primaries is as short as any swift studied so far and is shorter than some that moult independent of breeding.

An effort is made to make cavers aware of which activities may prejudice the breeding efforts of swiftlets and which may be continued without putting the birds or their young at risk.

INTRODUCTION

The white rumped Swiftlet that inhabits the Chillagoe district of inland peninsular Queensland (*Aerodramus spodiopygius chillagoensis*), has only recently been separated from *A. s. terraereginae* which inhabits coastal Queensland (Pecotich 1982).

In this paper these two subspecies will be referred to as *chillagoensis* and *terraereginae*. Some comparisons are made with the subspecies (*A. s. assimilis*) that occurs in Fiji and it will be referred to as the Fijian subspecies. The subspecies *chillagoensis* breeds in the caves that have formed in the tower-like outcrops of limestone at Chillagoe and Mitchell-Palmer districts. The vine thickets of the limestone outcrops and the intervening savanna woodlands sustain the aerial insects that form the swift-

let's diet. Descriptions of this vegetation (Godwin 1983) show that while most species in the area are typical savanna, some species on the limestone outcrops are rainforest remnants. Some of the bird species are also more likely to be met with in rainforest and it is more characteristic to find the White-rumped Swiftlet over rain forest than such dry country.

Currently 25 of the 400 caves south of the Walsh River that have been recorded and tagged, contain Swiftlet colonies. Swiftlets use these caves for roosting each night of the year and for breeding each wet season (October - March). This paper summarizes the breeding biology, feeding behaviour, and flight of the Swiftlet that occupies the caves at Chillagoe. It also makes some suggestions as to how cavers can reduce or eliminate the possible decrease in breeding success caused by their presence in a cave used by White-rumped Swiftlets for roosting and breeding.

METHODS

Data were obtained in the main from colonies in Gordale Scar Pot (CH187) and Guano Pot (CH146). These were visited six days a week from 28th November 1985 to 27th January 1986 and from 2nd December 1986 to 23rd January 1987. Most other sites were visited only once.

Two all day chick watches were made in Gordale Scar Pot, to determine the number of times a day each chick was fed. The first one was made from 0600 to 1300 hours on 18th December 1985 and 1300 to 1800 hours on 19th December 1985 and the second was from 0615 to 1715 hours on 22nd December 1986.

The first season at Chillagoe was a normal wet season in which chicks grew more quickly and fledged in higher numbers than in the following season. The second breeding season was markedly dry and for the first time in my study of this species in Fiji and Queensland, I found nestlings that had starved to death. Because of this the 1985/86 season is referred to as the good season and the 1986/87 as the poor season.

Individual chicks were identified with daubs of fast-drying model paint placed on their head, shoulder or rump. Once the chicks were old enough they had an individually numbered band from the Australian Bird and Bat Banding Scheme, Canberra, Australia, placed on one leg. Wing growth, which Lack and Lack (1951) demonstrated to vary with the quantity of food provided

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was determined by measuring from carpal joint to the tip of the longest primary when the wing was held flat on a ruler. Weights were measured on 5, 10 and 50 g Pesola spring balances.

By experimental manipulation some parents were given a second chick to see if the parents could raise one more than they normally did. If parents had been able to raise an extra chick then the manipulative doubling up of broods would have been a quick way of increasing any endangered population. The measures that were taken daily on all chicks were averaged and when reported in the text are given with the standard error of the mean in the form (mean \pm S.E.).

The only other detailed breeding study published on this species is that on the Fijian subspecies *assimilis* (Tarburton 1986b). As comparisons with *assimilis* are frequent this reference is not given each time. In both studies, nest volume was determined as an approximation, called the volume index. This is derived by multiplying the average length, breadth and depth measurements together. In determining colony size where nests were empty or their contents could not be observed, only those nests having some fresh, glistening saliva were counted. Generally this method rejected only a few whole nests.

RESULTS AND DISCUSSION

Breeding Distribution

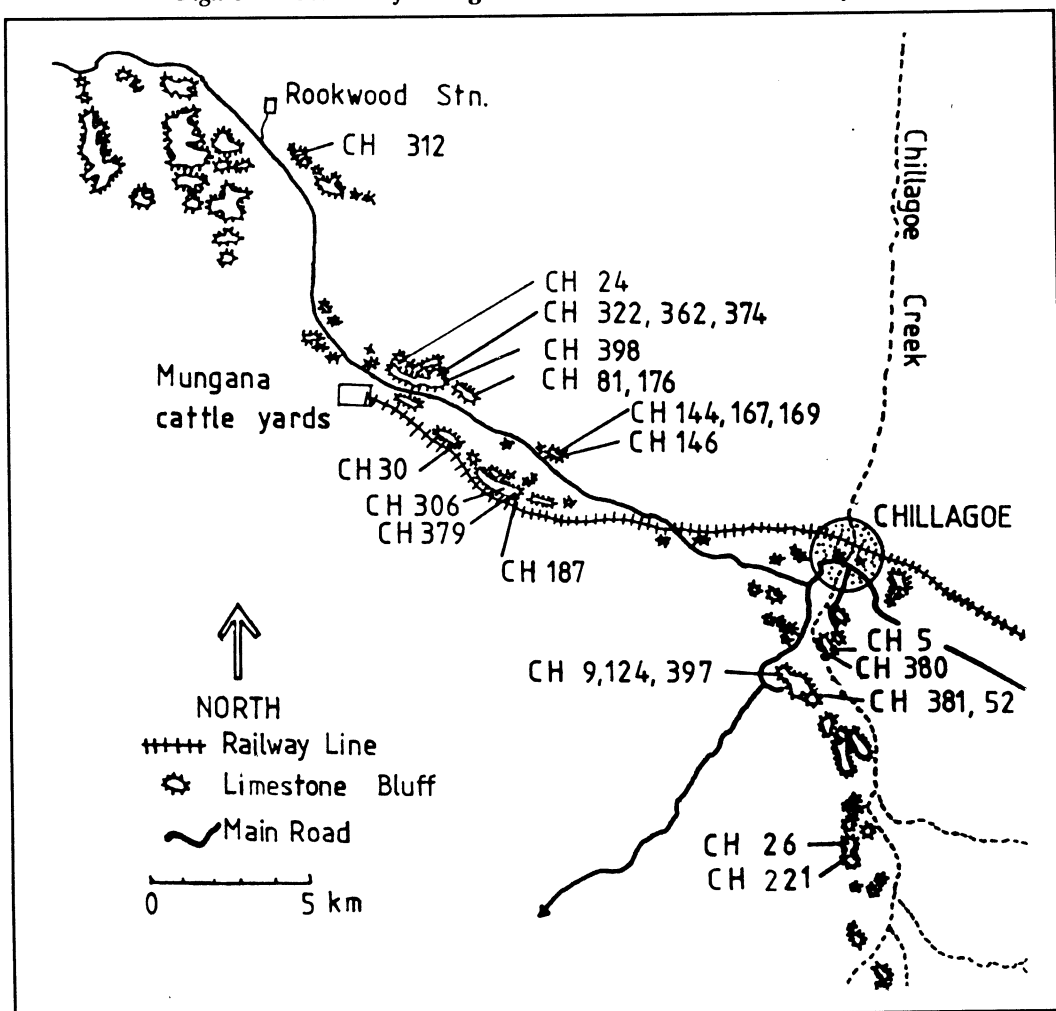
The White-rumped Swiftlet is restricted to areas having caves and sufficient aerial insects for food. The feeding range is restricted to the savanna surrounding the Chillagoe and Mitchell-Palmer limestone outcrops in which it breeds and it has not been recorded foraging more than 30 km from known breeding areas. The approximate location of the nesting sites visited in this study are shown in Figure 1.

The Nests

The nests of *chillagoensis* have similar construction to those in Fiji except that they are all composed of dried grass whereas those in Fiji are more often composed of filmy ferns and mosses or fibres from the crown of coconut trees. The most common grass species used are Kangaroo Grass *Themeda australis* and Black Spear Grass *Heteropogon contortus*.

The internal dimensions of 36 nests averaged 51.5 ± 0.9 mm across, 44.9 ± 0.8 mm front to back, and 12.5 ± 0.7 mm in depth. The average volume index of the Chillagoe nests (23 cm^3) is smaller than that of Fijian nests (52

Figure 1. Location of *chillagoensis* colonies visited in this study



cm³). This is to be expected as Fijian nests hold two young at a time, whereas Chillagoe nests hold only one young.

In both subspecies, parents may also sit on the nests at night. Up to five adults and fledged chicks (not disturbed by our presence) were seen on a single nest in Keef's Cavern. This means that the smaller size of the nests at Chillagoe does not reduce the number of fledged birds that they can support in a good season. However in the poor season some nests that were never seen to have more than three birds on them, had so little saliva in them that they fell apart.

The Nest and Colony Size

All colonies were in totally dark sites, though in a few, twilight could be seen from unoccupied parts of the nesting chamber. Colonies at Chillagoe are on smooth concave walls 2 - 20 m above the cave floor. However, small protrusions such as solution furrows or fault cracks in the limestone are often favoured within the colony. Thus rows of nests appear in the general random scatter, with those alongside closer than those above and below.

The average distance between nests at Chillagoe was greater than that between Fijian nests. This may result from *chillagoensis* having more caves in which to nest, though the situation is not clear for even in Fijian colonies where many nests were joined, there appeared to be large areas of suitable though unused cave wall and ceiling. The average distances between Chillagoe nests were 7.9 cm at Gordale Scar Pot (n = 20), 17.4 cm at Guano Pot (n = 36), 29 cm at Crack Pot (n = 41), 29.4 cm at Keef's Cavern (n = 11), an estimated 10 - 40 cm at Squeeze Pot (n = 50) and an estimated 3 - 4 cm at Mudlark Cave (n = 31). The greatest distance between nests were found in Flow Cavern, where nests were 10 cm to 5 m apart (n = 8). A new site with just one nest was established in Swiss Cottage Chamber of Royal Arch Cave (CH9) during October 1986. This site is about 90 m from the other site in this complex cave system.

The population size of *chillagoensis* colonies visited is given in Table 1. With the average colony size of *chillagoensis* being 77 nests, it is clear that this subspecies breeds in much smaller colonies than the Fijian subspecies which has an average colony size of 1,762 nests. However, it must also be noted that colonies of *chillagoensis* are much closer to one another than those in Fiji. This means that the population density per hectare for the two subspecies might not be as different as the difference in colony size might at first indicate.

While colonies of *terraereginae* are also small compared to those in Fiji they tend to be in twilight situations (Smythe, Pecotich and Roberts 1980, Crouther 1983) where predation may be greater.

The Breeding Season

Working from the oldest chick (which had a 51 mm wing) found in Gordale Scar Pot and at Guano Pot at Chillagoe on November 1985, it is estimated that the first egg for that season was laid about 6th October. The oldest chick found on December 1986 (wing span 57 mm) gives an estimated laying date of 4th October for the first egg that season. In both seasons the first few eggs were followed two weeks later by a heavy bout of laying. Initial egg laying in *chillagoensis* precedes the marked increase in rainfall that usually occurs during November or December. In 1985 there had been no rain recorded at the Post Office for 28 days prior to laying of the first egg for the season and there had only been small showers prior to the peak laying period. In 1986 there had been rain just 5 days prior to the laying of the first egg but only two good rain days before the middle of January, when most of the laying was over. So if rain stimulates laying in *chillagoensis* only small local showers, which may not fall on the Chillagoe township, are needed even though more persistent rain (Tarburton 1987a) is essential to raising chicks. This early laying in anticipation of the heavy rain suggests that the time provided by the average breeding season is limiting and that the birds may have other adaptations that reduce the time required to hatch their eggs and raise their chicks.

In that Alan Cummins and Les Pearson report having seen numerous eggs in Squeeze Pot in early May, it is possible that when heavy rains are later than usual the birds relay in a season that extends later than normal.

The Eggs

As in all swifts but one, the eggs are white and without gloss. The average dimensions of 118 *chillagoensis* eggs (from Gordale Scar Pot and Guano Pot) were 19.81 ± 0.06 by 13.04 ± 0.04 mm ($\bar{x} \pm \text{S.E.}$). The fresh egg of the Chillagoe Swiftlet weighs 1.83 ± 0.01 g. The average weight of eggs declined to 1.66 ± 0.03 g the day before hatching. The average fresh weight of the Chillagoe eggs represents 19.7% of the average adult weight. This is slightly more than the 18.7% for the Fijian eggs but is not extreme for swiftlets, which lay proportionally larger eggs than swifts (Tarburton 1986b).

Incubation

The incubation period was found to average 26.6 ± 0.23 days (n = 27) and to range between 25 and 29 days.

Egg Loss and Replacement

The average time for the replacement of all lost clutches and broods less than ten days old, was 10.4 ± 0.4 days (range 6 - 18 days, n = 41). When *chillagoensis* lost chicks older than 20 days the nest either already contained the second egg or the second egg appeared in less

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TABLE 1
THE SIZE OF BREEDING SWIFTLET COLONIES AT CHILLAGOE

CCC No.	Cave Name	Number of currently used nests.		
		Previous	85/86	86/87
CH005	Tower of London Cave:			
	Site A	-	0	1
	Site B	80*	0	0
	Site C	-	-	23
CH009	Royal Arch Cave			
	Swiftlet Cavern	122#	15	26
	Swiss Cottage	0	0	1
CH024	Keef's Cavern	P~	109	-
CH026	Clam Cavern	23#	11	11
CH030	Stop Press Cave	P~	-	4
CH046	Snakey Cavern	46*	-	0
CH052	Swiftlet Cave	P~	-	129
CH081	New Southlander Cave	P~	22	14
CH124	Flow Cavern	13#	-	8
CH133	But Good Cave	P~	-	0
CH138	Chinese Cavern	P~	-	0
CH144	Christmas Pot (a)	P~	29	-
	(b)	P~	44	-
CH146	Guano Pot	P~	81	88
CH167	Crack Pot	P~	194	188
CH169	Squeeze Pot	P~	135	-
CH176	Capricorn Cave	47#	0	-
CH187	Gordale Scar Pot	500?#	169	160
CH221	September Cave	P~	-	118
CH227	Pope John Paul I Cave	P~	-	0
CH306	Mudlark Cave	P~	31	28
CH312	Project 31 Cave	60+ ~	-	253
CH322	Swiftlet Scallops Cave	-	-	8
	Entrance CH374	P~	-	49
	Hercules Cave CH362	P~	-	23
CH379	Tarby's Swiftlet Pot	-	180	179
CH380	Golgotha Cave (a)	-	48	-
	(b)	-	69	-
CH381	Swiftrimelt Cave	-	25	29
CH382	Otobeaswiftlet Cave	-	P	P
CH397	Shirl's Triple Twirl Cave	-	-	21
CH398	Swiftlet Swallet Cave	-	-	264

Note:

CCC Chillagoe Caving Club Inc.

CH### ASF registered cave number issued by CCC.

* Indicates that marks left on walls by previous nests were counted, these may not have all been occupied in any year.

+ Indicates possibly more nests on shelf not fully visible.

? Indicates my doubt that this number of nests were recently found in this cave.

Refers to Smythe et al.

~ Data from Chillagoe Caving Club Inc. records.

P Indicates swiftlets reported present but no count.

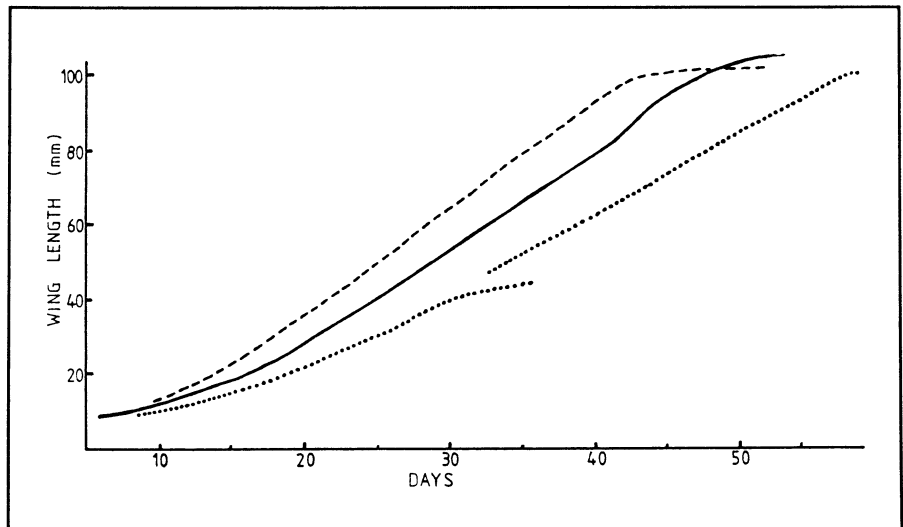
- Indicates no record.

Figure 2. Mean daily increase in wing length of chicks at Chillagoe

Average daily measurements have been smoothed by eye to show the following growth curves:-

Broods of one in the good season represented by a discontinuous line and in the poor season by the continuous line.

Chicks from broods of two represented by the first dotted line and survivors from the broods of two by the second dotted line.



than six days, probably because the second egg, which is laid approximately 50 days after the first, was already developing in the ovary.

Of 58 eggs produced by *chillagoensis* in 1985/86, 69% (40) were successfully hatched. In the dry season of 1986/87 60% (40) of 67 eggs were hatched. The average hatching success for both years was 64% ($n = 125$). Of those that failed to hatch, 78% disappeared. Another 11% were infertile and 11% broke. That some of the eggs that disappeared were infertile, cracked or addled is possible for Lack and Lack (1952) found Common Swifts usually ejected cracked eggs and sometimes ejected infertile eggs. Good eggs may be accidentally ejected due to sudden disturbance at the nest.

Nestling Development

After chicks hatched their egg shells rapidly fragmented with the pieces remaining in the nest for one to three days. Daily average wing lengths of chicks are shown in Figure 2. The data clearly shows that in the good season single chicks grew significantly faster and fledged earlier than those hatching in the poor season. The average time taken for the first flight feathers to break out of

their sheaths is 18.7 ± 0.4 days (range = 16 - 24 days, $n = 24$), when the wing measurement is between 25 and 36 mm (29.3 ± 0.06 mm). The growth of chicks from the manipulated broods of two was significantly slower than those in single broods. This disparity increased after 30 days and always ended in the death of one chick. The remaining chick then grew normally though it never caught up the time lost while sharing food with another nestling and it fledged up to 12 days later than normal. Adult wing size in both years and from both brood sizes was reached only after fledging.

The average weight of newly hatched *chillagoensis* chicks was 1.31 ± 0.01 g, (range = 1.09 to 1.6 g, $n = 52$). The daily average weight increases for the chicks show similar trends to those from wing measurements and are shown in figure 3. Adult weight is not reached until the 21st day. Chick begging calls are described in Tarburton (1987b).

The Nestling Period

The average age at fledging in the good season was 46.1 ± 0.08 days ($n = 8$) and in the poor season was 51 ± 1.3 days ($n = 5$). This difference is significant ($P < 0.01$; $t =$

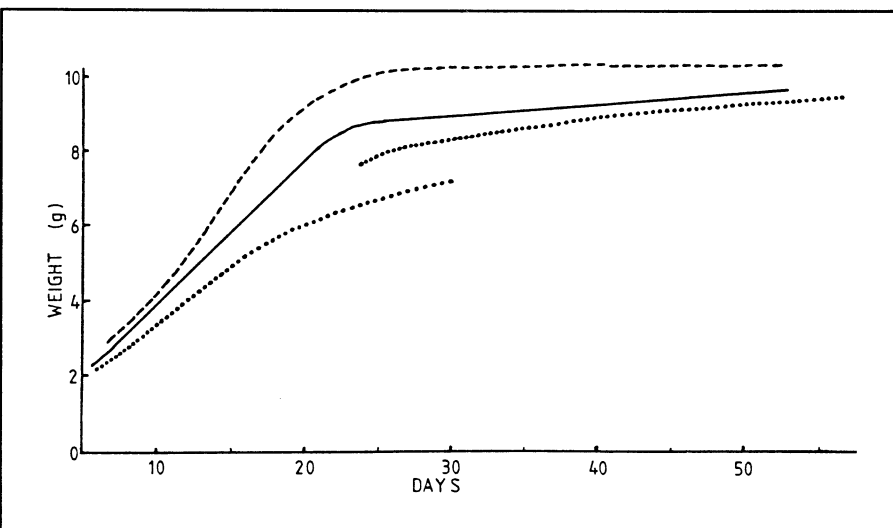


Figure 3. Mean daily increase in chick weight at Chillagoe.

Average daily weights for single-brood chicks in the good season are represented by the discontinuous line and for the poor season by the continuous line. Chicks from broods of two are represented by the first dotted line and survivors from broods of two by the second dotted line

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3.15, $df = 11$) and so it is clear that *chillagoensis* is struggling to raise a single chick in dryer years. The nestling period is similar to those of other Apodidae having similar incubation periods.

The average wing length at the time of fledging was 101.6 mm which is 95% of adult wing length. The minimum wing length at fledging (range = 91.3 - 108 mm), was 85% of adult wing length.

Fledging Success

Chillagoe birds raise a second brood of one whereas Fijian birds raise only one brood of two. This means the Chillagoe birds raise an average of 0.9 chicks per season which is very close to the average of 1.1 chicks that Fijian birds raise per season. However in poor seasons such as the 1986/87 season, when fledging success in *chillagoensis* was only 50% ($n = 18$) and hatching success rate was reduced from 69% to 60%, the breeding success achieved was only 30% a brood and therefore only 0.6 chicks per season.

Chick Mortality

The major cause of chick deaths was from falling out of the nest. Because of the chicks' resistance to starvation, many of the chicks picked up from the ground and placed back in the nests recovered. It is presumed that Childrens Pythons *Liasis childreni* and Brown Tree Snakes *Boiga irregularis* were responsible for the disappearance of some of those that fell from the nest as these were seen near the nest sites. Rats may also prey on fallen chicks for John Barton of QNPWS has reported seeing rats in several caves. There was no evidence of predation upon chicks in the nests, almost all of which were in totally dark sectors of the caves. It appears that snakes cannot reach most nests, which are placed high on smooth concave surfaces. This view is supported by Vince Kinnear (pers. comm.), who has watched Childrens Pythons fall off the smooth wall as they have tried to reach the nests. Subsequently, I observed a Childrens Python on the wall adjacent to the nests in Mudlark Cave, but as all the nests still contained their egg or chick, it was evident that the python had not been able to cross the smooth overhanging wall that surrounds the colony. I have also seen a 1.5 m Brown Tree Snake fall from the smooth wall above the nesting colony in New Southlander Cave. Evidence that the tree snake could only cross the smooth wall where it did not overhang was that there were only two empty nests and these were the only ones on vertical rather than overhanging wall.

Adult Mortality at the Nesting Caves

Although snakes cannot reach most swiftlet nests adult birds are not free from predation by snakes. I have watched Childrens Pythons position themselves on the wall adjacent to narrow sections of cave passage through which swiftlets must fly to reach their nests. Numerous

elongated scats containing swiftlet flight feathers in the vicinity of such pythons in Golgotha Cave, Project 31 Cave, September Cave and in the tube connecting Christmas Pot and Squeeze Pot, indicated that the python's ambush method was successful.

There are also other predators at Chillagoe. The entrance to Swiftlet Cavern is a low crawl from a daylight chamber of Royal Arch Cave and the ground was littered with swiftlet feathers. John Barton and Lionel Leafe (cave guides with QNPWS) had seen cats in the vicinity and were convinced they were preying on the swiftlets. A pile of flight feathers but no scats generally indicates cat predation. That the subsequent laying of baits for the cats was successful is indicated by the reduction of swiftlet feathers at the cave entrance and the increase in the size of the breeding colony the following season (1986/87). Similarly fresh feather piles were observed at Clam Cavern, Swiftrimelt Cave, Hercules Cave and Project 31 Cave. A pile of decaying feathers was seen in the entrance to September Cave indicating that cats had discontinued killing swiftlets at that site.

On 25th January 1986 I was watching about 50 swiftlets feeding very close to some rocky pinnacles, above Oto-beaswiftlet Cave, which I had discovered just that day. There had been an exchange of birds through the cave entrance when a Brown Goshawk *Accipiter fasciatus* landed in a nearby tree. The birds responded suddenly and in unison by rapidly dispersing in all directions. About five to ten minutes later the swiftlets began to reassemble overhead at an altitude of about 130 m from where they made a call (a high pitched "shree") I had not heard before.

In a separate incident a Brown Goshawk left a tree near the swiftlet entrance to Guano Pot on 20th January 1986 to make an unsuccessful stoop at a swiftlet that was flying steeply and slowly out of the cave entrance. The next day another Brown Goshawk sat outside the entrance to Tarby's Swiftlet Pot. All three observations of Brown Goshawks near entrances to Swiftlet breeding caves were at the time when most first-brood chicks were taking their first flights. The young Swiftlets are much slower than adults when leaving cave entrances and it is likely that Goshawks are able to take young birds in this situation. On 4th January 1987 I saw a Brown Goshawk scatter the swiftlets over Gordale Scar Pot and Tarby's Swiftlet Pot when it caught an individual out of the flock. Four days later an unidentified falcon circling approximately 80 m above the same two caves caused abnormal behaviour (mainly erratic flying) in the swiftlets and so it is possible that falcons as well as goshawks take swiftlets.

That swiftlets enter and exit at high speed, is further evidence of the swiftlets' vulnerability to predators at this point. By timing *chillagoensis* over a measured eight metres at the entrance to Tarby's Swiftlet Pot, the

average speed was determined to be 37 km/hr. the maximum speed recorded was 111 km/hr which is similar to that (106 km/hr) recorded for Fijian swiftlets entering Waterfall Cave in Fiji (Tarburton 1986a).

Nest Sanitation and Ectoparasites

From the first day, nesting White-rumped Swiftlets defecate over the low front rim of their nest, thus leaving the nest free of faecal contamination. Thus although a variety of insects inhabit the swiftlet nests at Chillagoe none was abundant except towards the end of January when a tiny feather louse covered some chicks.

Louse flies (Hippoboscidae, *Myophthiria* spp.) appear to be the exceptions and are numerous on chicks and adults at Chillagoe. By collecting and recording the number of Louse-flies found on the chicks or in their nests, the data in Table 2 were accumulated. These data indicate that this ectoparasite is least common on 1 - 10 day-old chicks with a peak density on 21 - 30 day-old chicks.

Feeding of Young

From observations on nestlings for one full day in both the good season (18 and 19th December 1985, n = 20) and the poor season (22nd December 1986, n = 9) feeding rates of 5.2 ± 0.28 ($\bar{x} \pm$ S.E.) per day for the good season and 2.9 ± 0.5 for the poor season were determined. Fijian birds left their caves by 0430 hours and most did not return to roost until after dark, whereas those at Chillagoe shortened their foraging by about an hour at each end of the day. However, there are two factors which prevent *chillagoensis* from raising two chicks simultaneously. The first is that the density of available prey is much below the density of that available in Fiji (Tarburton 1987a). The second is that the irregularity of extreme wet and dry periods throughout the breeding season at Chillagoe means that the abundance of prey is very low at times and species such as termites are not flying each day for they only fly a day or two after each period of rain ends.

Raising a Second Brood - a New Method

Whereas it is common for perching birds (passerines) to produce two or more clutches per breeding season it is

not common for swifts to do so (Lack 1956). That *chillagoensis* produces a second clutch makes it an unusual apodid. That it utilizes heat from the first nestling to incubate the second clutch (Tarburton and Minot 1987) means it is the first bird to be recorded using such a strategy. Such behaviour was not aberrant as 85% (n = 140) of nestlings near to the age of fledging (having wings longer than 70 mm) were incubating an egg.

When incubating nestlings were removed from the nest and then returned, they resumed an incubating posture over the egg that was typical of that of their parents. They settled over the egg rather than making any effort to move the egg aside or flick it out of the nest. thus, the presence of an egg in the nest was sufficient stimulus to release incubation behaviour in the nestling.

The strategy of utilizing the warmth of the first chick to hatch the second egg not only allows both parents the freedom to feed all day but it also reduces (by three weeks) the time required to raise two chicks consecutively. The first benefit would help overcome food shortages during dry spells, while the second would help raise the two chicks within the short time that rain and insect prey are available in sufficient quantities to raise a chick.

Moult in the Breeding Season

The synchrony of breeding and moulting in this species is discussed more fully in Tarburton (1986a) where possible benefits of this uncommon combination are suggested. Data in Table 3 show that moult of the primaries begins for most Chillagoe birds in late November or early December. Moult follows immediately upon egg laying and because of the difficulty of sexing individuals it is not certain whether one sex starts before the other.

If the rate of moult in the primaries of Chillagoe birds continues as it does during December and January (Table 3), then moult of the primaries takes about 120 days to complete.

Adult Morphology

The average wing length of 300 adult *chillagoensis* was 107.1 ± 0.1 mm (range = 101 - 103). This was signifi-

TABLE 2
NUMBERS OF LOUSE-FLIES ON CHICKS AT 10 DAY AGE INTERVALS.

Period (days)	0-10	11-20	21-30	31-40	41-50
x/nest at Chillagoe	1.0	1.5	5.9	4.0	3.1
n	46.0	38.0	26.0	20.0	10.0
SE	0.21	0.23	0.78	0.74	0.78

TABLE 3
PROGRESS OF MOULT IN THE PRIMARY FLIGHT FEATHERS

	29 Nov -8 Dec	9-18 Dec	19-28 Dec	29 Dec -7 Jan	8-17 Jan	18-27 Jan
No examined	108	97	87	106	50	55
No not in moult	23	9	1	0	0	0
No in moult:-						
P1	58	17	2	3	-	-
P2	20	29	30	10	2	-
P3	6	14	27	36	10	2
P4	1	18	14	33	20	10
P5	-	7	13	13	16	31
P6	-	2	3	1	2	10
P7	-	-	-	-	-	2
P8	-	-	-	-	-	-
P9	-	-	-	-	-	-
P10	-	-	-	-	-	-

Note: Pn = the number of the most recently moulted (smallest or missing) flight feather.

cantly ($t = 14.4$, $P < 0.001$, $df = 400$) smaller than the wing of Fijian birds. That my average measurement is also significantly ($t = 12.8$, $P < 0.001$, $df = 350$) larger than that taken by Pecotich (1982) on the same population is perhaps explained by the use of different methods of measurement. The average weight of 300 adult *chillagoensis* was 9.3 ± 0.04 g (range = 7.9 - 12.1 g). This is significantly ($t = 15.4$, $P < 0.001$, $df = 400$) heavier than Fijian birds and significantly ($t = 10.0$, $P < 0.001$, $df = 350$) lighter than the average weight given by Pecotich (1982) for the same population some years previously.

As *chillagoensis* weighs more than the Fijian subspecies and yet has a shorter wing, suggests that selection pressures have been operating on *chillagoensis* to reduce wing length, and/or on *assimilis* to increase wing length. The latter is more likely for, the Fijian birds forage further and longer each day than *chillagoensis*. It also appears likely that heavier weight has been selected for in *chillagoensis* as it is to its advantage to have a good body store of energy when food can be in short supply at any time of the year due to the erratic savanna rainfall and the long dry winters.

Feeding Method and Analysis of Prey

The White-rumped Swiftlet breed during the wet season, when insects are generally accepted as being more abundant. However the density of potential prey (caught in a sweep net in areas where swiftlets were found feeding) is shown to be significantly lower than that taken during the breeding season in Fiji. Swiftlets spend the whole day feeding and only land inside the caves when they have returned to their nest. At Chillagoe they normally fed above the tree tops though where grassed areas had been watered in the dry season the repeated circling flight of birds feeding low over these lawns was very noticeable.

Planthoppers (homoptera), flies (diptera), social insects (hymenoptera) and termites (isoptera), were the most numerous prey in 44 food boluses. These samples were taken from parent White-rumped Swiftlets while delivering them to their chicks inside six Chillagoe caves. Numerically the main food items were planthoppers (47%) and flies (24%).

The number of insects in each food bolus ranged from 7 to 587 ($\bar{x} = 149$). The average weight of a bolus was 0.33 g (range 0.11 - 0.62 g). The average length of all prey was 3.6 mm, which is larger than the average length of available prey (2.2 mm). The number of prey "species" ranged from 2 to 83 ($\bar{x} = 40$) per bolus. Altogether, 303 invertebrate "species" were recorded in food boluses. Most were insect species but spiders were fairly common.

Flight Behaviour

One of the best ways to understand something of the swiftlets ability in flight is to compare a number of its flight abilities during feeding flight with those of the Welcome Swallow *Hirundo neoxena* a common bird over much of the rest of Australia. As gliding uses less energy than flapping a comparison of these activities is a good place to start. The average length of time in each glide for the Swallow (1.5 s) and the Swiftlet (1.2 s) was not significantly different ($t = 1.94$, $P < 0.05$ $df = 63$). However, since the time spent flapping by Swallows (17.6 s) was considerably longer than that spent flapping by Swiftlets (1.8 s), it is clear that the Swiftlet glides more than the Swallow when feeding. Two other factors also show that the Swiftlet conserves energy better than does the Swallow. Firstly, feeding Swallows have a significantly faster wing-beat rate (0.57 s) than the feeding swiftlet (0.47 s) ($t = 3.8$, $P < 0.001$, $df = 34$). Secondly

Swallows rest from flying by perching for an average of 3.0 minutes after an average flight time of 2.45 minutes compared with the Swiftlet, which does not perch at all throughout the day in the non-breeding season. Even in the breeding season parents take only one to three rests (lasting one to 20 minutes) at their nests.

During travel flight, differences between these species were even greater. The Swiftlet beats 4.7 times a second and the Swallow 5.8 times a second. The Swiftlet glides for much longer (10.4 s) than the Swallow (1.0 s), but beats for much shorter periods (4.4 s) than the Swallow (39.8 s). A Swiftlet that started flapping overhead rarely flew out of sight in the same flapping sequence, whereas Swallows in travel flight usually did so.

Visual differences in the flight of the two species were obvious. Swiftlets fed from 10 cm to 130 m above the ground. This is considerably higher than the altitudes at which the Swallows fed (from nearly zero over water to 30 m).

A second difference is that when gliding the Swallows held their wings slightly closed and close to the body, whereas Swiftlets held their wings well away from the body resulting in the characteristic sickle-shaped curve.

A third difference is the amplitude of the wing beat. The Welcome Swallow almost always use large amplitude strokes, whereas the Swiftlet only uses such strokes in tight manoeuvres and slow flight, especially in caves.

A fourth difference occurs when feeding flight is in a straight line: Swallows exhibit a regular undulation but the Swiftlet does not. Rather, Swiftlets change altitude irregularly, sometimes pulling up to a halt to catch prey and then diving down again to gain air speed. The tail is often fully spread in this activity and it is considerably larger than that of the Swallows' forked tail and must aid in performing the manoeuvre.

Fifthly, deviation to the side is infrequent and gradual in Swallows, but not in the Swiftlet. A gliding Swiftlet may quickly drop one wing to swerve sideways; or if the insect prey is further to the side the bird may rapidly twist the body and tail to bring the momentarily gaping mouth in line with the prey.

A further difference is that only Swiftlets fly in total darkness. Audible clicks are used to guide their way in the dark.

Although the Swiftlet conserves energy by gliding more and having a slower wing-beat, it also reaches higher speeds and altitudes and spends more time in flight each day than the Swallow.

CAVING ACTIVITIES AND THEIR POSSIBLE EFFECT ON BREEDING SUCCESS

If speleological activities in caves containing breeding colonies of White-rumped Swiftlets were only carried out in daylight hours between May and September, persons engaged in these activities would rarely even see a Swiftlet in the caves. Under these circumstances cavers would be most unlikely to affect the Swiftlet population numbers at all. This is because the birds are not breeding and rarely use the caves for diurnal roosting during these months. Using the caves at the same time as the birds may not necessarily be as harmful to the swiftlets as some have thought. However, the likelihood of harm to the reproductive effort of breeding birds is proportional to the knowledge and care taken by the cavers concerned.

Where colonies need to be closely approached during the breeding season (October to March) the rapid departure of the birds from their nests that causes some eggs to be kicked out of the nests can be prevented. **A quiet and slow approach where light is either kept off the nests or brought onto them slowly** will give the incubating birds time to move off their egg before departing. This will reduce or even prevent egg loss.

Handling chicks or eggs does not prevent parents caring for them. This means cavers can pick up freshly fallen eggs and chicks and replace them. If you saw them fall and can identify and reach the nest from which they came they are best returned. If you cannot identify the nest from which they came you can increase their chance of survival by placing them in an empty but glistening nest. These are the nests that have recently been receiving maintenance and to which parents will return at the latest by nightfall. Both eggs and chicks can endure hours without incubation and yet show no ill effect.

Not all eggs on the guano under a colony will be viable as some may be infertile, cracked or dead. Shining a light into the egg will show its condition and whether it is worthwhile replacing in a nest. If an egg appears sound and there are no empty nests above it then one of the large chicks (distinguishable from adults by having light edges to the flight feathers and wing tips that do not extend beyond their tail) may have kicked it out. Replacing it under a large chick that is without an egg will increase its chance of hatching.

Catching adults should not be attempted unless you have a good reason and a written permit from QNPWS (Brisbane). Catching adults at the nests or keeping them off their nests for too long may cause them to desert their breeding effort. To prevent desertion only the minimum period required should be spent in the vicinity of the nests. Attempting to catch adults on their way to the nests will often cause them to regurgitate the food they are carrying for their chick and so causes depletion

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of the chick's food supply. If this happens too often or at critical times such disturbance could be fatal to the chick.

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