Migration and Breeding Strategies of the Black Noddy, Fiji

M.K. TARBURTON

Department of Botany and Zoology, Massey University, Palmerston North, New Zealand

Received 22 September 1985, accepted 29 May 1986

The recovery of six Black Noddies *Anous minutus* from the Solomon Islands 10 to 96 months after they were banded on Vatu-i-Ra, Fiji, raises the question as to whether these birds migrate.

It was previously accepted that the Black Noddy was a sedentary species in the south-west Pacific (King 1967; Frith 1976; Serventy *et al.* 1971) and less numerous than the Brown Noddy *Anous stolidus* throughout its range (Tuck 1980). Both species show variation in migratory behaviour and Diamond (1978) shows that the Black Noddy is resident at three oceanic breeding locations and migratory at four. Diamond (1978) also demonstrates that in nine tropical seabird locations, breeding migrant species outnumber breeding resident species to a greater extent than pelagic feeders outnumber inshore feeders. This means that, as Brown Noddies are pelagic feeders, they will normally outnumber Black Noddies, which are inshore feeders. But because migration sustains a larger population than that supported by pelagic feeding, Black Noddies may outnumber Brown Noddies on those islands where only the Black Noddy migrates.

The advantage of migration to the Black Noddy should be greatest on islands such as Vatu-i-Ra. Here large inshore feeding areas mean that the Black Noddy need expend little energy to reach its feeding grounds, whereas the Brown Noddy must expend more energy to reach its food in the open ocean. The advantage thus gained by the Black Noddy might be increased if non-breeding birds migrate, leaving the local feeding areas to the breeding birds. This theory fits my previous observation (Tarburton 1978) that 80 pairs of Brown Noddies, and 4550 pairs of Black Noddies, nest on Vatu-i-Ra.

The availability of preferred nesting sites and the proximity of other nesting colonies would also affect the proportion of nesting Brown and Black Noddies. As there are numerous unused nesting sites on Vatu-i-Ra, apparently suitable for Brown Noddies, it is likely that their low numbers are largely caused by a shortage of available food rather than a shortage of nest sites. However, the Polynesian rats *Ratus exulans*, which inhabit Vatu-i-Ra, may prey more heavily on the ground nesting Brown Noddy than on the tree nesting Black Noddy. Kepler (1967) and Fleet (1972) have shown that, although the Polynesian rat eats nestlings of seabirds as large as an albatross, they only do so when their preferred vegetable diet is not available.

In Fiji the Brown Noddy predominates only on small

TABLE 1 Estimation of population size (Schnabel's method; Seber 1982).

Date	Total number trapped (A)	Number newly marked	Number already marked (B)	A × B	Σ (A × B)	Number of recaptures (C)	C	Population estimate $\frac{\Sigma (A \times B)}{C}$
13. 7.74	446	446	0	—	—	0	—	—
2.12.74	261	259	446	116 406	116 406	2	2	58 203
3.12.74	262	247	705	184 710	301 116	15	17	10 865
4.12.74	179	176	952	170 408	471 524	3	20	23 576
5.12.74	22	22	1128	24 816	496 340	0	—	—
6.12.74	359	348	1150	412 850	909 190	11	31	29 329
2.10.75	245	236	1498	367 010	1 276 200	9	40	31 905
3.10.75	18	18	1734	31 212	1 307 412	0	—	—
4.10.75	376	366	1752	280 586	1 587 998	10	50	31 760
14.11.76	811	770	2118	1 732 524	3 320 522	48	98	33 883
								Progressive average = 31 360
14.12.81	365	349	2888	1 054 120	4 374 642	16	114	38 374
15.12.81	363	345	3237	117 503	5 549 673	18	132	42 043
14.12.81	433	418	3582	1 551 006	7 100 679	15	147	48 304
								Average of all estimates = 34 824

0158-4197/87/0150 + 3

sand cays such as Nuku-i-Cikobia, where 400 pairs breed (Tarburton 1978). Such sites are adjacent to open seas, which makes them attractive to Brown Noddies but, as they have no shrubs or trees and lack large inshore areas, they are not suitable for Black Noddies. Brown Noddies nesting on vegetated islands, adjacent to deep seas, tend to equal the number of nesting Black Noddies. An example is Vetua where 1000 pairs of Brown Noddies nest in trees, along with a similar number of Black Noddies (Clunie 1985). There are no records of Black Noddies nesting on flat ground, though they do use cliff ledges at Macauley Island in the Kermadecs (Merton 1970) and on Ascension (Ashmole 1962).

The Black Noddy, an inshore feeding species, has a long incubation period (35 days, compared to 24 days as predicted from the weight of the egg [Whittow 1980]) and a small clutch size (one egg); these are adaptations characteristic of pelagic feeders (Lack 1968). Both adaptations would increase the amount of food Black Noddies could deliver to their chicks on Vatu-i-Ra because the number of trips per day between the large feeding area and the chicks is reduced. Reduction of the distance travelled to and from feeding grounds increases the feeding rate and reduces the amount of food lost to frigate birds.

If these advantages are consolidated by migration during the non-breeding season, when most mortality is postulated to occur (Lack 1966; Diamond 1978; Ricklefs 1980), then the Black Noddy may outnumber Brown Noddies breeding at Vatu-i-Ra. While Ashmole (1963) agreed that food is the only factor likely to be generally effective in limiting seabird numbers, he thought it improbable that food shortage outside the breeding season could exert a density-dependent control on the population. However, Lack (1966) pointed out that Ashmole's proposal would only limit breeding birds, leaving non-breeders and immatures untouched. Lack's suggestion would only be effective if non- breeders and immatures were feeding in areas remote from and unaffected by the factors causing a food shortage in the breeding area.

TABLE 2 Survival of adult Black Noddies

Year	Number of banded birds present (10 October)	Number still present one year later	Percentage survival
1974	27	14	52%
1975	85	68	80%
1976	68	19	28%
1977	43	43	100%
1978	43	42	98%
1979	42	40	95%
1980	40	39	98%
1981	39	8	21%
1982	8	8	100%
Total	395	281	Average = 75%

Further adult life expectancy $= \frac{2 - m}{2m}$

$= \frac{1.75}{0.5}$

$= 3.5$ years

(Lack 1968; m = mortality)

The six Black Noddies recovered from various islands along the Solomon Islands archipelago had travelled 1400 to 2900 km. Three were found in September, two in October and one in November. This brief three month span contrasts with the eight months over which six Fijian recoveries were made, as well as my observations on Vatu-i-Ra that showed many Black Noddies roost there throughout the year. This suggests a seasonal movement of part of the population to the Solomon Islands. The Fijian recoveries, made at 88 to 160 km from Vatu-i-Ra, were made in March, May, July, August and two in October. Because the Black Noddy is seen throughout the year in Fiji, a partial migration to the Solomons would be concealed, as have similar migrations in the Wedge-tailed Shearwater *Puffinus pacificus* (Blakers *et al.* 1984) and the Huttons Shearwater *P. huttoni* (Serventy *et al.* 1971).

If seabirds breeding in Fiji only left when driven by the random movements of cyclones they should be recovered from different island groups within the cyclone season (December-April). Six Black Noddies were recovered from outside of Fiji in four different years (1975, 1980, 1981 & 1983) outside of the cyclone season and only from the one island group, which suggests that the recovery of the noddies signifies more than an accidental occurence resulting from abnormal weather. That these Noddy recoveries represent a pattern is further supported by the recovery from Tonga (the opposite direction to the Solomon Islands) of a Red-footed Booby *Sula sula* that I had also banded in Fiji. The south-easterlies that prevail in the region could aid the flight of the birds from Fiji to the Solomons at most times of the year, but by spending September to December in the Solomons their return flight would benefit from westerly winds that blow for a few weeks at a time, most commonly during December to March (Krishna, Nadi meterorological office, pers. comm.).

Further evidence of migration comes from the number of birds using Vatu-i-Ra during the discreet breeding seasons, as estimated during 14 banding visits between July 1974 and December 1983. These estimates, which range between 10 885 and 58 203, averaged 31 360 up until November 1975, and 34 824 up until 1983 (Table 1). Both these averages are well above the 9000 birds derived from my estimate of 4550 nests, in turn based on a count of approximately one quarter of the nests. By taking the 71%

survival rate, derived in Table 2, and applying it to the means of the 1974 and 1975 estimates, we reduce the estimated population to 19 079. This means half the population was missing in the 1974 breeding season.

Five of the six birds recovered from the Solomons were at least one year old when banded, and so were at a minimum age of six to seven years when found. This means the movement is not likely to be a juvenile dispersal because this species probably starts breeding at 2-4 years of age (Lack 1967). The sixth was a flying juvenile when banded and so was nearing the end of its first year when recovered at Yandina in the Solomon Islands.

This evidence for a regular partial migration of adult Black Noddies from Fiji to the Solomon Islands needs to be weighed against the evidence (Table 3) for a non-annual breeding season. It is clear that Fijian noddies breed at eight to 10 month intervals and, because some adults are in the Solomon Islands when breeding is taking place at Vatu-i-Ra, individual birds may not breed in successive breeding bouts. This would explain why the estimated population is twice the size of that which is breeding at any one time. Breeding and non-breeding birds are not competing for food in the breeding area, which may explain why the Black Noddy can maintain such a large population on Vatu-i-Ra. Similar breeding intervals have been shown in some Ascension Island noddies (Ashmole 1962), however the season there is extended and firm data are scarce. Probably the most studied Black Noddies in the Pacific are those at Heron Island. These are very different in that they breed regularly during the southern spring (Serventy *et al.* 1971; Frith 1976).

TABLE 3 Breeding observations for the Black Noddy on Vatu-i-Ra

Date	Stage of breeding	Reference
1963 June	Reoccupying & rebuilding	Barritt (1979/80)
1966 Sept.	Breeding	Shorthouse (1967)
1974 July	1 old nest (birds moulting)	Tarburton (1978)
Dec.	Eggs, nestlings & flying juveniles	Tarburton (1978)
1975 Oct.	Older nestlings & flying juveniles	Tarburton (1978)
1976 Nov.	Nil	Tarburton (1978)
1981 June	Eggs, nestlings	This paper
Aug.	Large nestlings	Langham (pers. comm.)
Dec.	No nesting, some old eggs remaining	This paper
1983 June	Older nestlings & flying juveniles	Tolhurst (pers. comm.)
Dec.	Fresh eggs & females carrying eggs	This paper

References

Ashmole, N.P. (1962). The Black Noddy (*Anous tenuirostris*) on Ascension Island. *Ibis* **103b**, 235-273.

Ashmole, N.P. (1963). The regulation of numbers of tropical oceanic birds. *Ibis* **103b**, 458-473.

Barritt, M.K. (1979/80). Seabird observations in Fijian waters. *Sea Swallow* **30**, 22-36.

Blakers, M., Davies, S.J.J.F. & Reilly, P.N. (1984). *The Atlas of Australian Birds.* Melbourne University Press, Melbourne.

Clunie, F. (1985). Seabird nesting colonies of the Ringgold Islands. *Domodomo* **3**, 95-109.

Diamond, A.W. (1978). Feeding strategies and population size in tropical seabirds. *Am. Nat.* **112**, 215-223.

Fleet, R.R. (1972). Nesting success of the Red-tailed Tropicbird on Kure Atoll. *Auk* **89**, 651-659.

Frith, H.J. (ed.) (1976). *Readers Digest Complete Book of Australian Birds.* Readers Digest, Sydney.

Kepler, C.B. (1967). Polynesian rat predation on nesting Laysan Albatrosses and other pacific seabirds. *Auk* **84**, 426-430.

King, W.G. (1967). *Seabirds of the tropical Pacific Ocean, Preliminary Smithsonian identification Manual.* Smithsonian Institution, Washington D.C.

Lack, D. (1966). *Population Studies of Birds.* Clarendon Press, Oxford.

Lack, D. (1967). Interrelationships in breeding adaptations as shown by marine birds. *Proc. Int. Ornithol. Congr.* **14**, 3-42.

Lack, D. (1968). *Ecological Adaptations for Breeding in Birds.* Methuen, London.

Merton, D.V. (1970). Kermadec islands expedition reports: a general account of the birdlife. *Notornis* **17**, 147-149.

Ricklefs, R.E. (1980). Geographic variation in clutch size among passerine birds: Ashmoles hypothesis. *Auk* **97**, 38-49.

Seber, G.A.F. (1982). *The Estimation of Animal Abundance and related Parameters.* Griffin, London.

Serventy, D.L., Serventy, V. & Warham, J. (1971). *The Handbook of Australian Sea-birds.* Reed, Sydney.

Shorthouse, J.F. (1967). Notes on seabirds on Vatu-i-Ra Is. Fiji. *Sea Swallow* **19**, 35.

Tarburton, M.K. (1978). Some recent observations on seabirds breeding in Fiji. *Notornis* **25**, 303-316.

Tuck, G. (1980). *A Field Guide to the Seabirds of Australia & the World.* Collins, Sydney.

Whittow, G.C. (1980). Physiological and ecological correlates of prolonged incubation in seabirds. *Am. Zool.* **20**, 427-436.