# Short Communications

## Timing of Primary Moult in the Tropical Seabird *Sula abbotti*

BARRY J. REVILLE[1], JEFF D. TRANTER & HUGH D. YORKSTON
*Australian National Parks & Wildlife Service Christmas Island, Indian Ocean, W.A. 6798*
[1]Present address: *Australian National Parks & Wildlife Service, GPO Box 636, Canberra, ACT 2601*

*Emu* **90**, 266-268

Received 21 April 1989, accepted 4 August 1989

### Introduction

The great majority of birds breed at least once each year (Lack 1968). The tropical seabird Abbott's Booby *Sula abbotti* is one of the few species which cannot breed annually as a successful breeding attempt requires 16-17 months from taking up the nesting site to independence of the fledgling (Nelson 1971, 1978; Nelson & Powell 1986). Pair members arrive at their nest site from March onwards; eggs are laid from April to September with a June peak; chicks hatch from June to November and fledge between November Year One and March Year Two; most surviving fledglings became independent from June to October Year Two.

In tropical seabirds such as the Sooty Tern *Sterna fuscata* and White Tern *Gygis alba*, moult and breeding are largely exclusive; presumably because both activities are energetically demanding. Moult takes 4-8 months and prevents continuous breeding (Ashmole 1963, 1965, 1968). Abbott's Booby was thought to follow a similar pattern: 'moult is suspended during the main part of the breeding season and resumed during the last stages of feeding the juvenile, though the sample is too small to allow a firm judgement' (Nelson 1978). This is appropriate if successful pairs always lay at biennial or greater intervals, since 6-8 months are available for moult between independence of the fledgling hatched in Year One and the start of the breeding season in Year Three. However, it is now known that some pairs will lay in the same year that the fledgling becomes independent, i.e. Year Two (Nelson & Powell 1986). In such cases, there is no opportunity for completion of moult exclusive of breeding activities.

Consequently, we sought to determine whether moulting of primary feathers overlapped with most breeding activities rather than being postponed until late in the breeding attempt.

### Methods

*Examination of individuals*

Abbott's Booby breeds only on Christmas Island, an Australian Territory in the eastern Indian Ocean (10°25'S, 105°42'E). As nests are built on thin lateral branches of rainforest trees 30-45 m above the ground, very few adults of known breeding status have been caught. Since July 1983, 15 adults have been found wandering on the forest floor, after falling from the canopy. Two of the females had vivid pink bills which is typical of breeding females during the pre-laying period and early incubation. One other female was captured with her almost independent fledgling when their tree was blown down. The breeding status of the other 12 birds is unknown. Primary moult was scored using the 0-5 scale developed by Ashmole (1962).

*Collection of fallen primaries*

Since July 1983, we have visited the same 500-600 nest sites every two weeks to record breeding activity (Reville *et al.* 1987, 1990). Observations were made from the ground with binoculars. Most nest trees contained only one (86%) or two (12%) nests, hence it was usually possible to decide from which site a feather had fallen. Each feather was identified as primary, secondary, rectrix or other, then recorded, labelled and removed from the area.

### Results

*Individual primary moult records*

Of the 15 adults examined, 11 were in primary moult with 1-3 primary feathers per wing growing at the same time (examples in Table 1). Birds in moult were found at all times of year (Table 2).

The innermost primary was changing from pin to brush on each wing of a fledgling caught on 24 May, two months before independence.

*Fallen primaries*

Moulted primaries were found in substantial numbers only from August through December (Fig. 1). Only parents with a dependent chick visited the island from December to late March. However, most pairs were attending their nest site by May and laid their egg during June and July (Fig. 2). At sites containing breeding pairs, few moulted primaries were found before the date of laying. The number moulted increased following laying, reaching a peak from 4-6 weeks after hatching (Fig. 3).



0158-4197/90/04266 + 2 $2.00

TABLE 1 Examples of adults in primary wing moult. Innermost primary is #1. Moult score: 0 = old feather, 1 = missing or in pin, 2 = brush to 1/3, 3 = 1/3 to 2/3, 4 = 2/3 to full-grown, 5 = new, full-grown.

| Date | Sex | Left wing #1 2 3 4 5 6 7 8 9 10 | Right wing #1 2 3 4 5 6 7 8 9 10 |
|---|---|---|---|
| 15 May | M | 5 5 2 0 5 5 3 2 0 5 | 0 5 5 2 2 0 0 5 3 0 |
| 7 May | F | 5 5 5 5 5 4 0 0 0 4 | 5 5 5 5 5 2 0 0 0 0 |
| 25 July | F | 5 0 5 5 5 5 0 5 5 5 | 5 5 5 5 5 5 0 5 5 5 |
| 29 Oct. | M | 0 5 5 0 0 5 5 0 0 0 | 0 5 0 5 0 0 0 3 0 0 |
| 21 Mar. | F | 0 0 3 0 0 0 0 5 0 0 | 0 0 5 0 0 0 0 4 0 0 |
| 1 June | F | 5 0 0 0 5 0 0 0 0 3 | 0 0 0 0 0 0 0 0 0 3 |
| 27 Oct. | F | 5 5 5 5 5 0 0 0 0 1 | 5 5 5 5 0 0 1 0 0 0 |

TABLE 2 Number of primary feathers in moult by calendar month.

| Month | Left wing | Right wing |
|---|---|---|
| January | 1 | 1 |
| February | | |
| March | 1[2] | 1[2] |
| April | | |
| May | 3, 0, 2[1] | 3, 0, 1[1] |
| June | 1, 2, 1[1] | 0, 2, 1[1] |
| July | 0 | 0 |
| August | 1 | 0 |
| September | *[3] | |
| October | 0, 0, 3, 1 | 0, 1, 1, 1 |
| November | 1 | 2 |
| December | | |

[1] Female with vivid pink bill.
[2] Female feeding late fledgling.
[3] Two birds part way through moult (Chasen 1933).

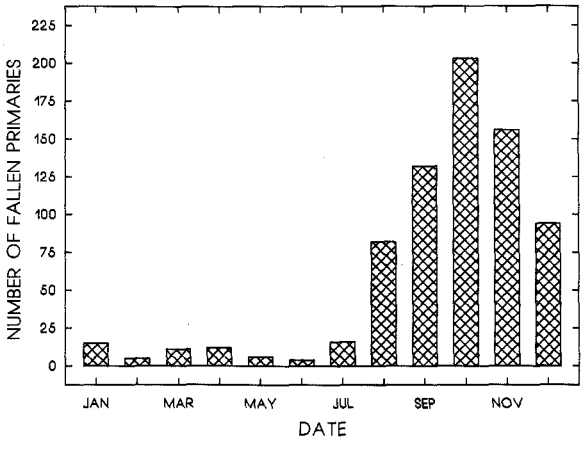


FIGURE 1 Numbers of moulted primary feathers found beneath breeding sites, 1983-87.

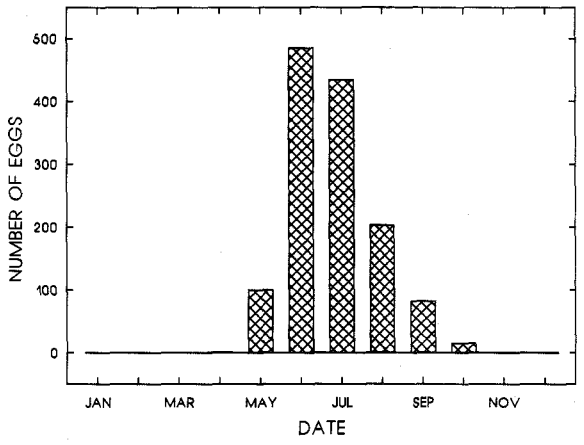


FIGURE 2 Laying dates, 1983-87.

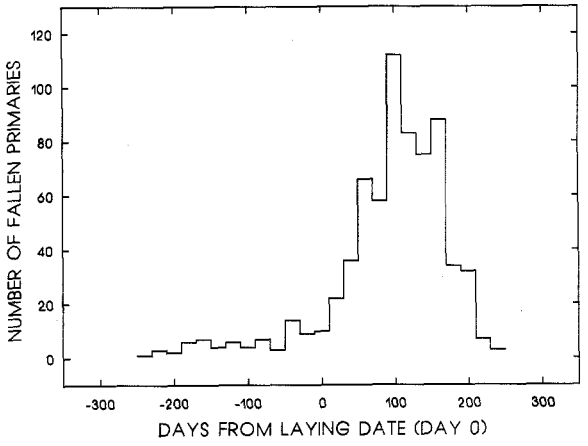


FIGURE 3 Numbers of moulted primary feathers found beneath successful breeding sites before and after laying date (Day 0), 1983-87. Incubation period = 56 days, hatching to fledging = 152 days, fledging to independence = 210 days.

## Discussion

Primary moult in most gannets and boobies can be described as continuous, staged and descendent (Nelson 1978). The first post-juvenile moult wave begins with the shedding of the innermost primary and progresses outwards; however, second and third moult waves begin at the innermost primary before all the distal feathers have been replaced. Consequently, three generations of feathers may co-exist in the wing with two or three growing feathers at widely separate points. Our results indicate that this is the pattern followed by Abbott's Booby.

In the Masked Booby *S. dactylatra*, primary moult is

temporarily arrested before egg laying and resumes during incubation from the points where it had stopped (Dorward 1962). A similar pause occurs in Gannets *S. bassana*, Brown Boobies *S. leucogaster* (Nelson 1978) and Red-footed Boobies *S. sula* (Diamond 1974). Although we have no recaptures to confirm that this pattern holds for Abbott's Booby, the paucity of moulted feathers collected from sites during the pre-laying and early incubation periods suggests that moult is temporarily suspended before laying and resumes during incubation. The absence of moulted feathers during April, May, June and July must indicate a genuine pause in moult since many pairs were regularly attending their nest site during this period. In contrast, the decline in moulted feathers from October through March does not necessarily indicate cessation of moult. It may reflect only the shorter amount of time spent by the parents at the site once the chick is no longer guarded. Failed breeders desert the island from November onwards (Nelson 1978).

The second half of the year when most moulted feathers were found was also the time of coolest sea surface temperature and best food availability. Pairs which laid early and hatched their chick at the start of the cool water period had higher breeding success than those which laid later in the season (Reville *et al.* 1987). Suspending moult in the pre-laying period presumably makes more resources available for laying by the female and courtship and nest-building by the male, thus allowing earlier laying. A limit to early laying is imposed by the warm sea surface temperature of February and March when food is scarce, as indicated by starvation of dependent fledglings (Nelson & Powell 1986).

It is surprising that the resumption of primary moult is not delayed until the chick is well grown as most mortality of chicks occurs in the first few weeks after hatching (Reville *et al.* 1987). Presumably, the ability to breed more frequently by minimising the exclusive time for moult compensates for the increased energetic demand and risk to the chick's survival. Similar considerations must apply to the other Sulidae which moult at this time, since the period immediately after hatching is generally considered to be the most energy intensive (Ricklefs 1983 *cf.* Nelson 1978). The energetic cost of moult in seabirds is poorly known: estimates range from 10-50% of existence metabolism (Wiens 1984). Its impact will be least in species which spread moult over a long period (Furness & Monaghan 1987), such as Abbott's Booby.

## Acknowledgements

Our study is jointly funded by the Australian National Parks and Wildlife Service and the Phosphate Mining Corporation of Christmas Island. We thank J.M. Cullen, P. Green, J.B. Nelson and J.D. Ovington for comments on the manuscript.

## References

Ashmole, N.P. (1962). The Black Noddy *Anous tenuirostris* on Ascension Island. Part 1. General Biology. *Ibis* **103b**, 235-273.

Ashmole, N.P. (1963). The biology of the Wideawake or Sooty Tern *Sterna fuscata* on Ascension Island. *Ibis* **103b**, 297-364.

Ashmole, N.P. (1965). Adaptive variation in the breeding regime of a tropical sea bird. *Proc. Natl. Acad. Sci.* **53**, 311-318.

Ashmole, N.P. (1968). Breeding and molt in the White Tern (*Gygis alba*) on Christmas Island, Pacific Ocean. *Condor* **70**, 35-55.

Chasen, F.N. (1933). Notes on the birds of Christmas Island (Indian Ocean). *Bull. Raffles. Mus.* **8**, 55-87.

Diamond, A.W. (1974). The Red-footed Booby on Aldabra Atoll, Indian Ocean. *Ardea* **62**, 196-218.

Dorward, D.F. (1962). Comparative biology of the White Booby and the Brown Booby *Sula* spp. at Ascension. *Ibis* **103b**, 174-220.

Furness, R.W. & Monaghan, P. (1987). *Seabird Ecology.* Blackie & Son Ltd., Glasgow.

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

Nelson, J.B. (1971). The biology of Abbott's Booby *Sula abbotti*. *Ibis* **113**, 429-467.

Nelson, J.B. (1978). *The Sulidae: Gannets and Boobies.* Oxford Univ. Press, Oxford.

Nelson, J.B. & Powell, D. (1986). The breeding ecology of Abbott's Booby *Sula abbotti*. *Emu* **86**, 33-46.

Reville, B., Tranter, J. & Yorkston, H. (1987). *Monitoring the Endangered Abbott's Booby on Christmas Island 1983-86.* Australian National Parks & Wildlife Service, Occasional Paper 11.

Reville, B.J., Tranter, J.D. & Yorkston, H.D. (1990). Impact of forest clearing on the endangered seabird *Sula abbotti*. *Biol. Conserv.* **51**, 23-38

Ricklefs, R.E. (1983). Some considerations of the reproductive energetics of pelagic seabirds. *Studies in Avian Biology* **8**, 84-94.

Wiens, J.A. (1984). Modelling the energy requirements of seabird populations. In: *Seabird Energetics* (eds G.C. Whittow & H. Rahn) pp. 255-284. Plenum Press, New York.