SUBANNUAL BREEDING AND MOULT CYCLES IN THE BRIDLED TERN *STERNA ANAETHETUS* IN THE SEYCHELLES

The Bridled Tern *Sterna anaethetus* breeds throughout the tropics and subtropics, usually on small rocky islets. Nowhere has its breeding biology been fully investigated. On Cousin Island, Seychelles, D. E. B. Lloyd (unpubl.) was the first to notice that laying seasons were between seven and eight months apart. From January 1973 to January 1975 I confirmed this cycle by ringing adults and recording their wing moult, and recording hatching dates.

The Seychelles are an archipelago of very small granitic islands in the western Indian Ocean (see Gaymer *et al.* 1969, and Ridley & Percy 1958, for land- and sea-birds respectively). Cousin (4° 20′ S, 55° 40′ E) is one of the smallest islands (27 ha). Since 1968 it has been a nature reserve owned by the International Council for Bird Preservation (British Section). About two-thirds of the land area is flat, covered chiefly with coconut groves which are reverting to broad-leaved evergreen forest. The remainder is dominated by a hill, *c.* 70 m high, running directly into the sea on the south and west coasts, elsewhere meeting the coastal plain. The western side of the hill is a talus slope covered with granite boulders and an open vegetation of screwpines *Pandanus balfouri*, *Euphorbia pyrifolia* bushes, ferns *Nephrolepis multiflora* and assorted sedges. The eastern slope is a series of bare rock inclines separated by low cliffs up to 8 m high, with similar but much sparser vegetation.

Bridled Terns nest in loose colonies all over the hill but mostly on broken ground. All clutches found contained only one egg, under cover, usually of a boulder but sometimes of vegetation, or else in a crack in the rock.

Adults were not caught during the day when incubating, since unprotected eggs were liable to be eaten by skinks *Mabuya wrightii* and *M. sechellensis*. Skinks were less active after dark, so adult terns were caught at night, by dazzling with a torch, then ringed, checked for primary moult and brood patch; some were also weighed and measured. Primary moult was scored by the method described by Ashmole (1962). Catching operations were carried out approximately monthly during the first 18 months of the study, only twice thereafter.

Hatching dates were used rather than laying dates because the incubation period is not known (in the closely related Sooty Tern *S. fuscata* in Seychelles, C. Feare, pers. comm., found it to be 28 days). Hatching dates were estimated from chick ages. Shortly after most chicks hatched, the eastern and southern parts of the hill were combed by day for chicks which were ringed, weighed and measured. Individual chicks could rarely be followed right through the fledging period because older ones ran and hid so efficiently that they could not be found. Hence I obtained only one complete growth curve (Fig. 1), from a chick hatched in a site from which it could not escape. Ages of all chicks measured were estimated by reference to the bill length (up to two weeks old) or wing length of this bird. Extreme variation in size between chicks of the same age, such as Ashmole (1963) recorded in Sooty Terns on Ascension, was not found, so the procedure is valid though of course data from more individuals would improve its reliability.

Regurgitated food was collected, mostly from adults at night (only two chicks regurgitated when handled), and preserved in 70% alcohol. Feeding intervals were measured by weighing chicks at two- or three-hourly intervals during a whole day, and assuming the bird was not fed during that interval only if its weight decreased. Three of the chicks used for this purpose were young ones that concealed themselves inadequately, and so could be found each time, and two were older ones that could not hide because of the limited cover available near their nests.

The term 'breeding' is used here to include all stages of the reproductive cycle from laying to the point where the chick is independent of the adult, as in the 'breeding cycle', as defined by Stonehouse (1962).

BREEDING AND MOULT

Primary moult scores, and estimated hatching dates, are shown in Figure 2. Breeding and moult overlapped substantially, primary moult ending just before the start of a new breeding attempt and beginning again when the chick hatched. Breeding and moult were both very synchronous: 95% of the chicks hatched within 16 days of the mean hatching date in February–March 1973, within 19 days in October–November 1973 and within nine days (a much smaller sample) in June–July 1974, and the average deviation of moult scores about the mean was only seven points. The fledging period was about nine weeks and the chick was fed for several weeks more, so for most of the year adults were either breeding or moulting, and for over three months in the year they were both moulting and feeding young. Two adults marked in the first breeding season (breeding success unknown) were again on eggs in the next season, confirming that individuals breed in successive seasons.

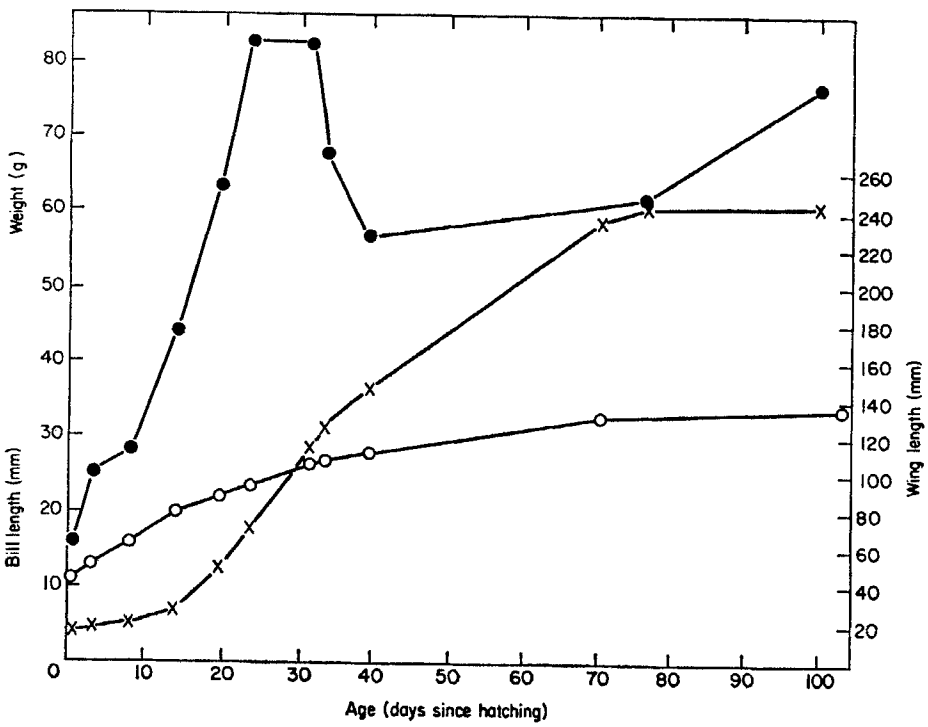

FIGURE 1. Growth of a Bridled Tern chick, March–July 1973. (●) weight; (○) Bill length; (×) wing length.

Three nesting periods and parts of three moulting cycles were recorded during the study. The intervals between mean hatching dates in successive seasons were 231 and 258 days, and between identical moult scores 290 and 222 days. The differences between these measures are attributed to a serious food shortage (to be described in detail elsewhere) that affected all terns (Bridled, White or Fairy Tern *Gygis alba*, Brown and Black Noddies *Anous stolidus* and *A. tenuirostris*) on Cousin, and probably throughout the

Seychelles and Amirantes (pers. obs.; C. J. Feare, pers. comm.), between January and May 1974. Bridled Terns not only failed to breed during this period but many left the island altogether. The possible extent of their dispersal in search of food is suggested by the recovery of an adult, ringed on Cousin on 14 November 1973, 1780 km west near Pemba Island on 13 May 1974. This is a particularly striking movement in view of the species' marked tendency to feed close inshore around Cousin.

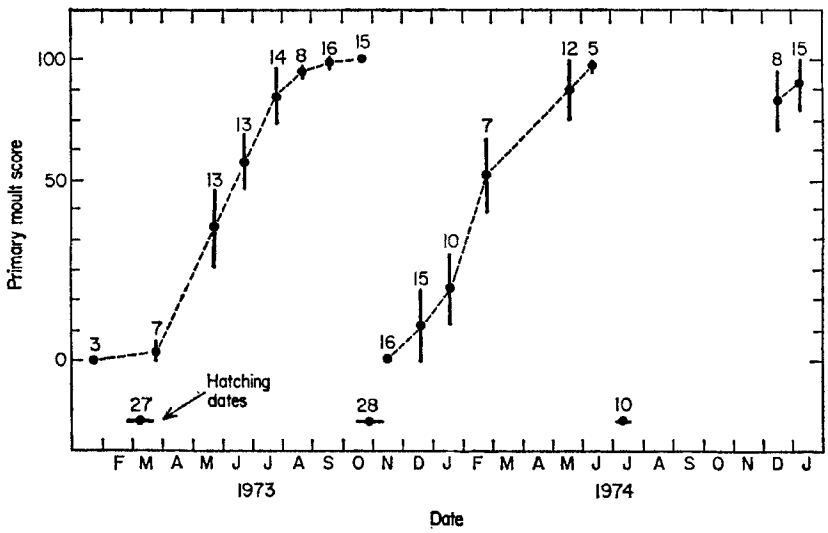

FIGURE 2. Primary moult in relation to hatching dates. (- - -) Mean moult scores; vertical bars show one standard deviation either side of mean. Horizontal bars show one standard deviation either side of mean hatching dates. Sample sizes shown above mean (hatching dates) or upper limit of variation (moult scores).

This food shortage evidently slowed the moult, and delayed breeding, in Bridled Terns on Cousin. Such severe shortages are probably not common; D. E. B. Lloyd did not record one in the two years January 1971–January 1973, and the laying dates of Sooty Terns in Seychelles over 32 years, recorded by Ridley & Percy (1958), show exceptionally late dates, such as might be due to severe food shortages, in only two years (1947 and 1950). Hence the normal breeding interval for Bridled Terns is most likely 231 days; the following interval, spanning the food shortage, was 258 days, about 12% longer. The first moulting period (290 days) also spanned the food shortage and was about 31% longer than the second (222 days). Probably moult was delayed more than breeding because most of that moulting period fell during the food shortage whereas the next breeding attempt was due to start only just before the shortage evidently finished. The usual breeding and moulting intervals are therefore likely to be close to those of 231 and 222 days, respectively, recorded in this study; the small samples involved do not justify stating the average length of a normal sexual cycle (*sensu* Stonehouse 1962) more precisely than about $7\frac{1}{2}$ calendar months.

WEIGHTS AND MEASUREMENTS

Biometrics of adults and eggs are given in Table 1. Weight varied so much that the apparently lower weights in January and September were not significantly different from those at other times.

The eggs were lighter and shorter than those described by Schönwetter (1967). The egg weight relative to body weight (20·7%) is similar to other tern species reported by Lack (1968).

FOOD

Complete analysis of the 38 samples must await identification of the fish species. A preliminary analysis showed that the main prey was small fish, crustacea and water striders *Halobates* sp. 98% of fish measured were less than 4 cm long and 62% less than 2 cm. The only marine tern known to take such small prey is the Blue-grey Noddy *Procelsterna cerulea* on Christmas Island, Pacific Ocean (Ashmole & Ashmole 1967) which is a very much smaller bird (mean weights: Blue-grey Noddy 45·4 g, Bridled Tern 95·7 g).

TABLE 1

Weights and measurements of adult Bridled Terns and their eggs. Weights were recorded on a Pesola spring balance, to the nearest 0·5 *g (birds) or* 0·25 *g (eggs). Wing length was measured with a stopped* 30 *cm steel rule, from the carpal joint to the tip of the longest primary, without straightening or flattening the feathers, to the nearest* 1 *mm. Eggs were measured with vernier calipers to the nearest* 0·1 *mm. All values are given to the same accuracy as that to which they were measured*

		Month (1973)						
		Jan.	Mar.	May	June	July	Aug.	Sept.
Weight (g)	*n*	2	7	11	13	14	7	15
	Mean	92·5	95·0	94·0	97·5	99·0	96·0	92·5
	s.d.	10·5	2·0	6·5	5·5	5·0	11·5	6·0
Wing length (mm)	*n*	7						11
	Mean	238						247
	s.d.	4						6
		Weight (g)			Length (mm)		Breadth (mm)	
Eggs (Aug. 1974)	*n*	6			6		6	
	Mean	19·75			41·5		31·3	
	s.d.	0·75			1·0		0·5	

Bridled Terns were commonly seen feeding close inshore, often in mixed flocks with Fairy Terns and Black Noddies. Inshore feeding was confirmed by regular weighing of five chicks in March 1973. Twenty-two out of 34 chick-weighings, 2·2 hours apart on average, showed increases in weight.

DISCUSSION

Many tropical sea-birds breed at intervals of less than 12 months (references in Ashmole 1971, Nelson 1970), but previously only the Sooty Tern on Ascension was known to do so synchronously (Ashmole 1963). Sooty Terns on Christmas Island (Pacific Ocean) and Swallow-tailed Gulls *Creagrus furcatus* in Galapagos are intermediate in this respect, the former population breeding synchronously twice a year but successful breeders every 12 months (Ashmole 1965), and the latter breeding in sub-colonies, each nesting synchronously at 9–10 month intervals but out of phase with other sub-colonies (Harris 1969a). In all other cases where individuals breed at sub-annual intervals, nesting in the population as a whole is continuous. Sooty Terns on Ascension moult after the chick fledges, whereas on Cousin Bridled Terns start moulting when the chick hatches. Perhaps the most striking contrast between the two species is that Bridled Terns breed synchronously and sub-annually in Seychelles where Sooty Terns breed annually, although Sooties are capable of breeding elsewhere and have an extremely adaptable breeding cycle (Ashmole 1965).

The three most striking features of Bridled Terns' cycle—subannual nesting, synchrony and overlap between breeding and moult—will be discussed in turn.

If food does not fluctuate annually there is no advantage in breeding annually, and many tropical sea-birds breed as fast as possible, the moult occupying the time between breeding attempts (Harris 1969b, Ashmole 1971). Species which do breed annually and synchronously on Cousin—the two noddies and Wedge-tailed Shearwaters *Puffinus pacificus*—take different food from Bridled Terns (Diamond, in prep.) so possibly their food varies seasonally while Bridled Terns' does not.

Recent reviewers of tropical sea-bird biology (Harris 1969b, Nelson 1970, Ashmole 1971) have differed as to why nesting should be synchronous, but have agreed that synchrony is achieved by social displays, as it probably is in Bridled Terns which court socially. Yom-Tov (1975) suggested that the survival value of breeding synchrony may be the avoidance of intraspecific interference; I suggested the same effect in frigatebirds *Fregata minor* and *F. ariel* on Aldabra (Diamond 1975), but it is unlikely to operate in Seychelles Bridled Terns because no intraspecific interference has been observed in them. Predator-swamping is a possible function of synchrony in some species, but unlikely here as the only native predators are skinks which take unprotected eggs. This probably occurs only when the birds are disturbed, a rare occurrence in natural conditions. Ward & Zahavi (1973) suggested that synchronization in birds which feed in flocks enhances the amount of information on food availability to the whole population, and on present evidence this seems the most likely function of breeding synchrony in Bridled Terns.

Overlap of breeding and moult cannot be due to a superabundant food supply, as it presumably is in those Arctic sea-birds which moult while breeding (Lack 1967), since food is unlikely to increase predictably every 7½ months. Brown Noddies and Black-naped Terns *Sterna sumatrana* also moult while feeding young (Dorward & Ashmole 1963, Harris 1969b, Diamond 1971a,b) but, unlike Bridled Terns, nest annually. Thus at present there seems no general explanation for overlap between breeding and moult in tropical sea-birds.

Finally, the biology of Bridled Terns may be compared briefly with Sooty Terns, since the species are closely related and have been assumed to have similar biology (Lack 1967). Both species lay one egg; Sooties nest in extremely dense and often huge colonies, Bridled in smaller, looser aggregations; Sooties are pelagic feeders, Bridled inshore. Lack (1967) pointed out that inshore feeders generally have a larger clutch than pelagic feeders. Bridled Terns, like Sooties, lay only one egg per season, but the sub-annual cycle on Cousin means that each pair lays 1·6 eggs per year against the Sooty's 1·0, thus increasing fecundity while retaining a single-egg clutch. Lack (1967) also suggested that pelagic feeders nest in larger colonies than inshore feeders because the latter need to space themselves out along the shoreline to be nearer their respective feeding areas. However the larger colonies of pelagic feeders are best regarded simply as a consequence of their greater numbers, which are due in turn to their larger feeding areas (Diamond, in prep.).

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A SECOND BREEDING COLONY OF WAVED ALBATROSSES *DIOMEDEA IRRORATA*

The long held assumption that the Waved Albatross *Diomedea irrorata* is endemic in breeding to the Galapagos Islands (Harris 1973) is no longer valid. A small breeding colony of these albatrosses is present on Ecuador's Isla de la Plata. This 'famous haunt of ocean fowl' (Murphy 1936: 309) lies 27 km offshore the mainland at 1° 16′ S, approximately 6′ of latitude north of Hood Island and more than 900 km east of this, the only known breeding site in the Galapagos. There are similarities in the topography, climate, and features of the vegetation of the two islands.

The first record for I. de la Plata appears to be that of Murphy (1936: 312) who inspected the skin of a Waved Albatross 'shot during November 1924' by the keeper of the island's lighthouse. Little significance has been accorded this specimen, since the island lies at the perimeter of the pelagic range of the species.

While I was at Isla de la Plata in March 1974 Sr Sacarias Intrialgo, the only permanent resident, described a large seabird, which could only have been an albatross, as occurring on the island. On 15 March we searched the Punta Machete area (at the northwest tip of the island) where he had been accustomed to seeing the birds. We found none on this occasion, although he had seen them there several days previously, but during a subsequent