The Australian

BIRD BANDER

The Breeding Cycle of the Wedge-tailed Shearwater on Mutton Bird Island, N.S.W.

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The Wedge-tailed Shearwater *Puffinus pacificus* breeds on most of the islands off the coast of eastern Australia, yet despite its abundance and the numerous references to its presence, little critical work has been reported. A study was initiated on Mutton Bird Island, Coffs Harbour, New South Wales (30° 18′ S, 153° 09′ E) in September 1969 to determine the breeding cycle of this shearwater, and the findings of this study to date are reported in this paper.

Mutton Bird Island is connected to the mainland by a breakwater and is easily accessible. The shearwater colony occupies the upper slopes where the low vegetation cover is mainly Blue Wandering Jew *Commelina cyanea* and a vine—the Dusky Coral Pea *Kennedia rubicunda* with grasses and small herbaceous plants. The soil depth is not great and most burrows are an arm's length and horizontal.

Banding commenced in 1960 and 33 visits were made by 14 banders between 1960 and 1969. These activities provided a useful population of banded birds, many of known age, and additional birds were banded in this study.

Methods

Four breeding seasons from the birds' arrival in August and departure in May have been studied since 1969, the most detailed work being in 1969-1970 (35 banding visits) and 1970-1971 (49 banding visits). Visits were made in every month, frequently weekly. Most visits were at night and at least one was made during the day each month. When the birds were absent from 6 May to 12 August 1970, nine visits were made at regular intervals. In 1971-72, 33 banding visits were made but regular weekly visits were not made in 1972-73; however, nine visits were made over four months.

The island was usually visited for about two hours just after dusk when birds had arrived. Generally, four persons visited on each occasion and torches were used to find birds, which were placed in bags to await examination. The location of each bird, whether on the surface or in a burrow with mate, egg or chick, was noted, as was the weather, time and in 1971 and 1973, state of moult. During 1969-1971, females were determined by palpation of the egg within the bird just prior to laying. In 1971-72, birds were weighed and culmen, tarsus, wing and tail measurements made.

A different area of the island was examined each visit to avoid excessive disturbance, but the whole island was examined each month. In all, 2233 nestlings (including runners) and 9748 adults (including free-flyers), (a total of 11 981) have been banded on the island to 30 June 1973.

Monthly Activities

The monthly activities are summarized in Fig. 1 and further details are given in the following

text. On 24 July to 7 August 1970 a fire swept the island, burning the vegetation and soil on about 60 per cent of the burrow area. The birds returned five days later, and there was a high mortality of adult birds on arrival (see p. 8). No successful breeding occurred in burnt areas because ash made burrowing impossible.

August

The first visits in 1969 were made during the day of 17 August and night of 18 August, when most burrows appeared to be occupied and large numbers of birds were on the surface. In 1970 the first birds returned between 4 and 12 August, and the initial indications of burrow cleaning were seen on 15 August. In 1971 birds were found on the nights of 9 and 10 August and in 1972 were caught on 2 August. Burrow digging and cleaning of old burrows was accompanied by 'chorus-like' calling between pairs, with harsher and more excited calling when territorial disputes occurred. Pairs formed and were caught together at burrow entrances. Six of 50 birds examined on 18 August 1973 were moulting tail feathers. Birds usually return in August, some within the first week and probably half or more by the middle of the month.

September-October

The maximum number was present in September. Most burrows were occupied and dug out with one or both birds of a pair resting at the burrow entrance. Much calling still occurred as immature birds apparently sought to establish territories. On 30 September 1973, a four year old bird (160-79355) was seen fighting with a bird of unknown age and breeding status (161-17923).

Copulation frequently occurred on the surface at burrow entrances in the cleared space created by excavated earth. Usually by the end of spring this space was covered by plant growth. Some burrows, particularly those on steep slopes, may not have this earth platform, and in such cases birds have been observed copulating just inside the burrow. Copulation was observed as early as 18 August 1969 and as late as 17 October 1970. In October the colony was still noisy at night and some burrow cleaning still occurred. Mostly, pairs were found in burrows and the counts for 18, 21, 22 October 1972, when 134 were captured in burrows, were 88 paired and 46 single birds. In 1973 tail moult only was found on 4 September, 12 of about 50 birds examined, and on 30 September, one of about 100.

TABLE 1

Number of Shearwaters captured on Mutton Bird Island from October to December 1969

Date	Birds handled	No. of workers	Hours worked
20.10.69	140	4	2
3.11.69	121	4	2
17.11.69	43	4	2
24.11.69*	35	4	2
30.11.69	205	7	2
1.12.69	196	7	2
8.12.69	56	2	1

* First eggs laid

TABLE 2

Recoveries of banded Shearwaters on Mutton Bird Island during November 1970

Date	Number of recoveries	Adults known to have bred
2.11.70	20	9
16.11.70	13	4
19.11.70	9	1
23.11.70	15	6
30.11.70*	27	14

* First egg laid between 24 and 29 November.

November—Pre-egg Laying

Throughout November fewer birds were present. A decline in numbers started in early November and was most noticable in a two-week period from the middle of the month, as may be seen for 1969 in Table 1. Figures for other seasons showed a similar sharp drop in numbers occurring in mid-November with low catches continuing till the middle of egg-laying, after which the numbers returned to that of late October. In 1970, banding recoveries showed that few adults known to have bred were present during the ten days before egg-laying commenced (Table 2).

November-December—Egg-laying

The numbers increased rapidly at the end of November and both birds of a pair were again present. Data from 1969 and 1971 indicated that egg-laying probably occurred within a period of

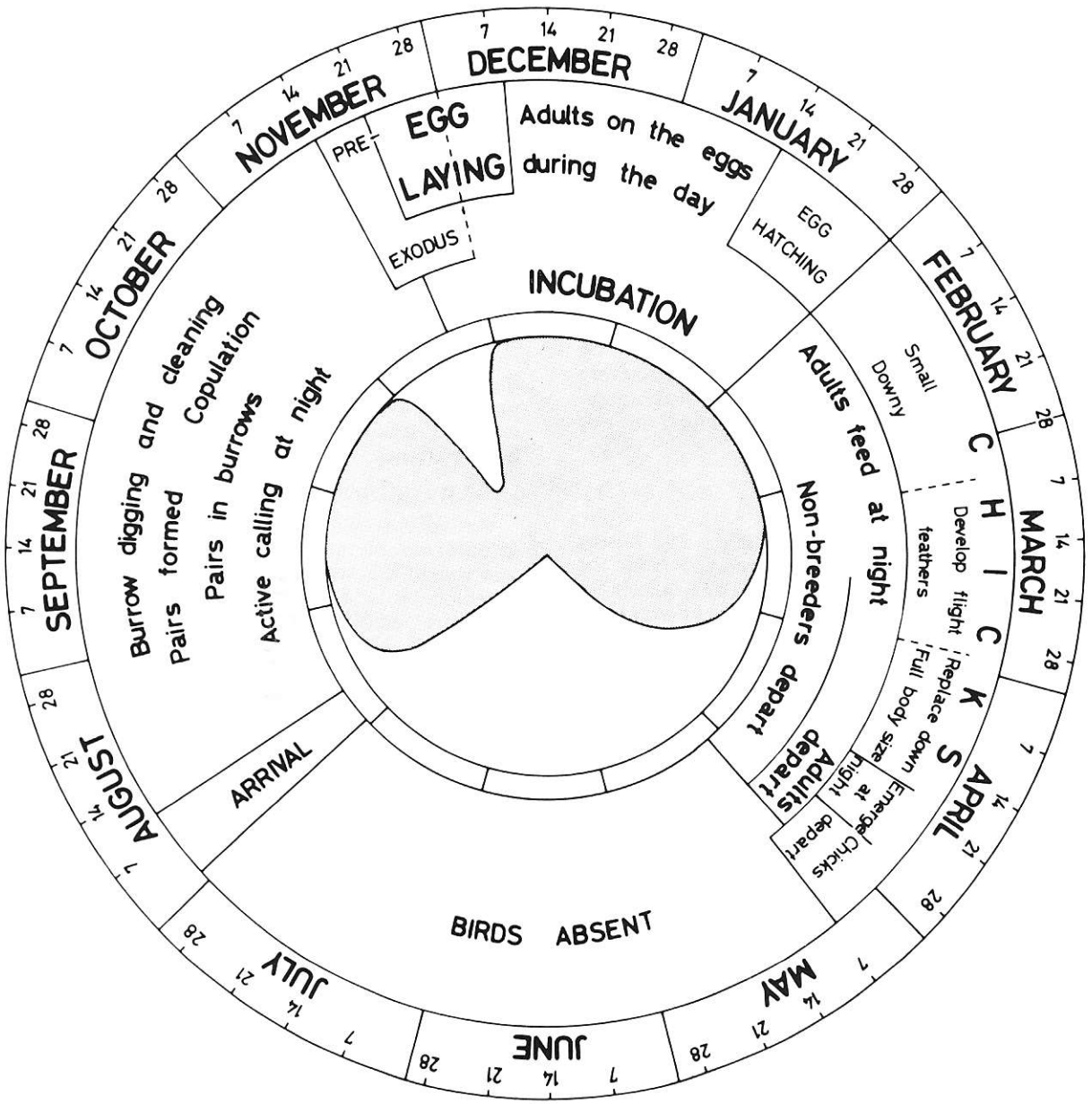

Figure 1.—*Summary of the Annual Breeding Cycle of the Wedge-tailed Shearwater on Mutton Bird Island, N.S.W. Shaded area represents the relative numbers of birds present in the colony at night.*

ten days. In 1969 the first egg was found on 24 November and the last female (carrying an egg) on 1 December. In 1970 the first eggs were found on 29 November, none having been found during the previous visit on 23 November. The following day (30 November) 42 females were found but only 16 were found on 5 December. A small egg was found on 5 December and the last female ten days later. In 1971 R. Floyd and A. La Spina marked and checked all 36 burrows daily in a selected area. They found the first egg on 23 November and the last on 3 December.

Only a few eggs were found on the surface in most years and usually these were eaten by predators within a day, except in 1970 when large numbers of birds without burrows laid on the surface. In 1971 there appeared to be severe competition for burrow space, and the consequential mergence of burrows often resulted in two eggs being found together.

December-January

One adult at a time incubated the egg during the day until hatching which occurred from the middle to the end of January. In 1973, no chicks were found in the 51 occupied burrows examined on 13 January but on 14 January of 18 burrows examined, two contained live chicks only, two contained adults with chipped eggs and the remainder were adults with egg.

Only small chicks were found in the first week of February in 1970 and 1971. During this period the vegetation was normally high and lush, giving good cover to the burrow entrances.

The body moult of adult birds appeared to occur in summer. On 13 and 14 January 1973 all the incubating adults examined were moulting their body feathers. The head only was examined carefully; 50 per cent of the crown feathers were new and scattered over the crown. This differed from the chicks, whose crown feathers emerged from the centre outwards and from the forehead towards the crown.

February

The adults left chicks during the day and returned to the island just after dusk. The majority arrived in a half-hour period between 19:00 and 20:00 hours (Eastern Standard Time). During this month, two parents were sometimes found in a burrow with the chick.

March-April

ADULTS WITH CHICKS

Chicks increased in size rapidly and were still covered in down in March. The down was usually grey, but shades between grey and a distinct rust-red were found in 1970 and 1973. During daylight visits in 1973, 343 chicks were banded and 15 had rust-red down, a similar proportion to that found in 1970. These were found particularly in the burrows of the mid-southern slopes. Flight feathers emerged in March and by mid-March the pins had broken. Occupied burrows were often recognisable by the shed down and sheathing, and some were very damp from excreta. The chicks had a distinct fast chatter at night when the adult was present. Body feathers emerged when chicks were about the same size as the adults, by which time only one adult was found with the chick. The burrow was too small to accommodate the chick and both parents.

NON-BREEDING BIRDS

Active burrowing was observed after February in unfavourable areas where the soil was shallow and rocky; this was probably carried out by non-breeding birds. Pairs were occasionally found in otherwise empty burrows, for example, three pairs on 5 March 1970 were found because of their calling. On each of three daylight visits, 17 March 1973, 25 March 1973 and 21 April 1973, singe adult birds only were found in burrows in the less favoured burrow areas. A gradual decline in numbers, particularly surface birds, indicated that unsuccessful breeders and immature birds had started to leave from the end of March to early April.

April-May

As the summer vegetation died, some burrows partly collapsed. Where this interfered with access for feeding the chick, usually the burrow was re-excavated. Likewise adults attempted to renew burrows which had collapsed when people walked on them.

Chicks were fed less frequently and fewer parents appeared to return on moonlight nights. Many chicks were so fat by mid-April that they were difficult to remove from the burrow. Moulting of body down commenced with the upper parts and head. On the head it extended from the centre of the crown outwards, the last areas being a collar around the neck and the belly.

At first they sat at burrow entrances, then they emerged fully from the burrow at night and exercised their wings; some wandered over the surface and returned to any burrow for shelter during the day. Within a few days the chicks started to leave the island, the exodus being completed in about 10 days. In 1970 the first birds were seen at burrow entrances on 16 April and were emerging on 17 April; the first bird left the island just after dusk on 28 April. Some adults remained till 4 May, and there were only chicks left on 6 May when 20 were banded. In 1971 the last adults were captured on 20 April, only runners were captured on the surface on 29 April and all birds had left by 3 May. The last runners were found on 5 May in 1972 when three were banded. In 1973 adults were still feeding chicks on 21 April and one chick was observed at the burrow entrance. On 22 April many chicks had emerged and were exercising their wings. During the day of 23 April, some runners were found in burrows with younger chicks who were making warning calls similar to the territorial dispute call of the adults. Within a few days the first chicks were leaving the island and one was recovered on the beach on 25 April.

May-June-July

All birds left the vicinity of the breeding island rapidly, a few stranded birds being found no more than two days after the last birds had left the island. In 1970 the last fledged chick was found on 8 May and released at sea on 9 May. In 1971 a stranded chick was found on 2 May, but none was found on the island on 3, 4, 6 and 7 May. Regular visits were made in May, June and July 1970 after the chicks departed. Visits of at least an hour were made at night, and day visits were also made in July. In both 1970 and 1971 the island was deserted till the first week in August.

Recoveries of Banded Birds

Since 1969, 38 of the 418 incubating adults banded in November and December 1960 have been recovered 50 times. These are the oldest known breeding birds on the island, and probably are more than 19 years old (see p. 9). Of the chicks banded before 1969, only in 1965 (321) and 1967 (82) were significant numbers banded. The number of nestlings banded in 1965, 1967, 1969 to 1973 is shown in Table 3 with recoveries after fledging and away from the breeding island. The months of recovery on Mutton Bird Island of living birds one to six years old may be seen in Fig. 2.

Two birds banded in 1970 were recovered in their first year, that is in the first season after their leaving the island. One bird banded in 1971 was recovered the following season in August with the first arrivals. No second or third year recoveries have been made. Two birds banded in 1967 and three birds banded in 1970 have been recovered in their fourth year; these birds were on the surface. None of the five birds recovered in its fifth year was recorded as breeding although one was found in a burrow. Birds six years and older were probably breeding. The fire made recording of breeding status difficult to determine for the six birds banded in 1965 and recovered in their sixth year; two

TABLE 3

Recoveries of Shearwaters of Known Age

Year banded	1965	1967	1970	1971	1972	1973
Number banded	321	82	756	127	129	830
Initial takeoff:						
Local recoveries April-May dead or stranded	1	—	25*	2	—	6†
Remains left by Sea Eagle	1	—	—	1	—	—
Recoveries in later years	2**	—	1‡	—	—	—

* Includes 16 live birds

† Includes 2 live birds

** 160-94425—dead, Mutton Bird Island, 6.9.70
160-94290—dead, Tweed Heads, N.S.W. 23.2.69

‡ 160-79095—live (died later), Philippines 8.8.73

were caught on two occasions. There have been three birds recaptured in the seventh year, one in August, one with mate in October and another in burrow in early November 1971. One bird (160-94231) has been recaptured breeding in its eighth year when it was found with egg in January 1973 and with chick in April 1973.

Mortality

CHICKS

Relatively few nestlings perish on the island. Considerable losses of young birds occur during the exodus from the island. Weather conditions at this time appeared to determine the number lost, as seen when comparing the year 1970 to 1973 in Table 3. In 1970 the still heavy, weak, inexperienced birds, often still with belly down, were assisted by the wind in making their initial takeoff. There were 12 banded birds reported stranded or dead on the mainland, and another 13 stranded birds were banded and released on the island. One of these birds was recovered on the mainland again the following day. Birds thus stranded on the mainland usually perished. Few chicks have been recovered after their initial exodus. Only two dead recoveries away from the local area have been made and both these birds were in their fourth year. The number of dead birds recovered in the local district just after fledgling was 16 out of 2179 banded, which was higher than the figure of 9 out of 18 689 for the Short-tailed Shearwater (Serventy 1961).

Of the eight bands recovered amongst the remains at the feeding site of a White-breasted Sea Eagle *Haliaeetus leucogaster*, two were from birds banded as nestlings. These recoveries indicate that the initial takeoff can be hazardous for the young birds. Some poorly developed chicks, probably of late hatchings or poorly fed, perish at the burrow, as was seen in May 1969 and 1970. Living chicks stranded on the mainland sought dark situations as described by Gibson and Sefton (1955).

ADULTS

Mortality of birds on the island appears to be light. Only in 1970 were birds found dead in the months of August to October. This may have been caused by ash from the fire, which was dry and blown by the wind and scattered when the birds were digging. A total of 35 banded birds and over 70 unbanded birds was found dead. The fresh carcases examined showed no signs of injury or obvious signs of disease. No dead recoveries in this period have been found in other years, and dead birds lying in the vegetation would have been seen. A common cause of death is predation by the Sea-Eagle, probably in the period of incubation and from March till departure for the nestlings.

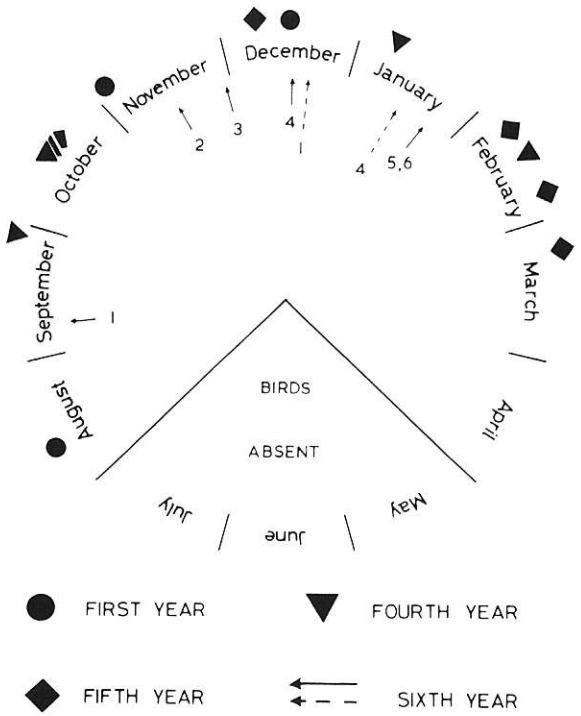

Figure 2.—*Recoveries of one to six year old birds on Mutton Bird Island.*

Discussion

The Wedge-tailed Shearwater on Mutton Bird Island returns in the first week of August and prepares for egg-laying until early November when a short exodus occurs in which there is an overlap between birds of different breeding condition. Egg-laying commences in late November and by early December all birds likely to be successful breeders have returned. Most eggs have hatched by late January and chicks are ready to leave by late April. No birds are found on the island after the first week in May.

This contrasts with the Short-tailed Shearwater *Puffinus tenuirostris* the biology of which

has been summarized by Serventy, Serventy and Warham (1971). This species returns to its breeding islands around the south of eastern Australia 6-7 weeks later, in September, and there is a distinct exodus of all birds prior to egg-laying. Both species appear to commence egg-laying about the same time in late November and the incubation period seems similar. After the departure of the adults the 'starvation period' of chicks of *P. pacificus* appears shorter and the distinct exodus of adults and their chicks which occurs with *P. tenuirostris* was not seen. The breeding cycle of *P. tenuirostris* is clearly more synchronised than *P. pacificus* and is probably a consequence of its adaptations for long migrations. However, recent recoveries of *P. pacificus* from the Philippines in April, July (Purchase 1973) and August*, and the lack of sightings off the New South Wales coast during June and July (Rogers, unpublished data) together with the lack of recoveries on the Australian coast during June and July (Purchase 1972) suggest that *P. pacificus* is also migratory. Furthermore the moult is of the type associated with migratory birds (Marshall and Serventy 1956).

First year *P. pacificus* visited the island with the first arrivals, during and just after the pre-egg laying period, whereas the first visits of *P. tenuirostris* of a similar age are brief and late in the following season in February after hatching. *P. pacificus* of 1-5 years age were not breeding and their scattered recoveries on the island in all months of the breeding season suggest that it is unlikely that surface birds may be assigned age groupings according to the month of their presence, as is possible with *P. tenuirostris* (Serventy 1957).

Birds have been found breeding when seven years old and successfully when eight years old. The data on the age of commencement of breeding are inadequate as yet, but do suggest that it may be different from that for *P. tenuirostris* which is 5-7 years for females (average 5.3 years), and males 5-8 years (average 6.6 years) (Serventy 1967).

Biological differences between species of shearwaters which exploit different ecological situations are to be expected, and the present study has shown that there are differences in their breeding cycles. It is hoped that it will be possible to continue such comparative studies and thus reveal the extent of the differences in the adaptations of these common Australian shearwaters.

* The bird, 160-79095, was banded as a chick and was in its fourth year (Table 3).

Acknowledgements

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