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THE NESTLING OF THE SOOTY SHEARWATER

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In an earlier paper on the breeding habits of the Sooty Shearwater (*Puffinus griseus*) in New Zealand (Richdale, 1944b:102), it was necessary to withhold the story of the nestling. Accordingly, this paper will deal solely with the young shearwater from the time it begins to hatch until it leaves its island home. Data used herein were collected chiefly on Whero Island in the period from December 20, 1941, to March 14, 1942, but they are supplemented by important details gathered on a later trip of six weeks in 1943-44. In order to elucidate still further the behavior of the nestling, reference has been made to other species of petrels studied.

Several points in the paper mentioned above need discussion and elucidation. The suggestion (Richdale, 1944b:99-100) that the 1943-44 season was a late one proved wrong, for the hatching dates, as noted in table 1, were normal. In fact, three chicks hatched a day earlier than in any of the preceding years. This means that my estimation (page 100) of the average incubation period of eight weeks is correct. It will be noted (page 99) that I found no eggs in 100 burrows on Taieri Island, about 20 miles south of Dunedin, on November 20, but 24 were recovered on November 27. From November 20 to January 17 is 58 days, which means that average incubation is not longer than this and according to further information given on the same page very little less than 58, and certainly more than 51 days. Finally my remarks (page 100) that the span of egg-laying is short are correct. Hatching on Whero Island in 1943-44 of 59 chicks occupied 18 days so that eggs must have been laid in a similar or slightly shorter period.

For assistance in the preparation of this and my earlier paper I am grateful to Professor B. J. Marples of the University of Otago and to Messrs. L. J. Cameron and C. A. Fleming, both of Wellington, New Zealand.

HATCHING

Literature contains very little information relative to the day of hatching, and certainly the mythical December 25 (Cockayne, 1909:38) is far from correct. I believe the main reason for this lack is the paucity of observations on the breeding grounds at the right time. Marples (1941:6) notes that on Taieri Island an egg was chipping on January 17, 1941. From that date the final emergence of the chick could easily have taken two, or even three days. Archey and Lindsay (1924:189) found that hatching began on the Chatham Islands on January 15. Buller (1888:233) states that when he visited Whale Island in the Bay of Plenty about the middle of January he observed well-grown nestlings of *Puffinus griseus* with black quills and tail feathers protruding through their down. This statement has been copied by Bent (1922:87). In this matter it appears obvious that Buller is confused with *P. gavia* (=*reinholdi*). The field records of Falla (1934:253) and Oliver (1930:126) indicate quite clearly that the nestling of

gavia is at this stage in its growth by the middle of January, whereas that of *griseus* is not even hatched.

The information given in table 1, dealing as it does with 88 chicks over a period of four seasons, indicates conclusively the range of hatching dates. The records for the first few years for various reasons are somewhat meager. When I left the island on January 26, 1943, there were still 8 eggs whose hatching dates could not be estimated. A proportion of these were probably addled. In 1943-44, however, I found 59 eggs which hatched and gave a definite hatching range from January 17 to February 4, a period of 18 days. Seventy-two or 83 per cent of the eggs hatched in the 10-day period from January 19 to 28. There were 6 other eggs which proved on examination to be addled, making a little more than 9 per cent for this class.

Table 1

Hatching dates of Sooty Shearwater chicks

Class interval	Number of hatchings				
	1940-41	1941-42	1942-43	1943-44	Total
Jan. 17-18			1	6	7
Jan. 19-20	1	6	2	8	17
Jan. 21-22	1	2	2	12	17
Jan. 23-24	1	2	1	12	16
Jan. 25-26	1	4	2	4	11
Jan. 27-28			3	8	11
Jan. 29-30				4	4
Jan. 31-Feb. 1				3	3
Feb. 2-3				1	1
Feb. 4				1	1
Totals	4	14	11	59	88

Though it is difficult to ascertain just when the shell is first chipped, close observation at several nests indicated that after chipping began the chick took at least four full days to emerge. A case in point is the following. At 4 p.m. on January 21 I visited nest 12 for the first time since January 2 and found nearly a square inch of shell starred, but there was no hole. Guided by my experience with the eggs of other species I made a note in my book that the chick would be out next day. This was not to be, for on the succeeding two days there was no external evidence of any progress. At 2 p.m. on January 24 there was a small hole through which the chick's beak could be plainly seen. Next day at 1 p.m. the hole was much larger, allowing me to see clearly the whole of the beak. At 10:30 p.m. the chick had emerged and, except for a few tufts near the tail, the down was quite dry. It was inert and would not squeak. This chick took at least four days to emerge from when I first noticed the chipping; moreover, this cannot be an extraordinary case for I have several others which, to my knowledge, were chipping for at least three days.

Lockley (1942:35, 85) has noted that chicks of the Manx Shearwater (*P. puffinus puffinus*) emerged after two days' chipping. This period is at least 3 days for the Royal Albatross, *Diomedea epomophora sandfordi* (Richdale, 1942:255), apparently only 24 hours for *Pelagodroma marina maoriana* (1943b:108), 2½ days for *Pachyptila turtur* (1944c:37), and 3½ days for *Pelecanoides urinatrix* (unpublished).

The chick, once it is hatched, quickly dries. I have a record of a chick which had not emerged at 3:10 p.m., but at 7 p.m. was clear of the shell and entirely wet except for a few tips which were dry. It did not squeak, coughed no oil, had its eyes open, and weighed 66 grams. At 10 p.m. it was quite dry and fluffy, still had no voice, coughed no

oil, and weighed 60 grams and consequently had not been fed. At 1 a.m. it was still 60 grams but I could not be sure that it had not received a small meal. Nine hours later, it was 62½ grams and therefore had definitely been fed about 12 hours after hatching. There is no removal of the egg shells after hatching, for they are just crushed, as is true with the Royal Albatross, also.

I do not believe that the Sooty Shearwater leaves its eggs uncovered as is the custom with the different species of Storm Petrel (Lockley, 1932:210; Gross, 1935:391; Ainslee and Atkinson, 1937:239; Roberts, 1940:163, fig. 7; and Richdale, 1943b:102). I have one record of an egg being left four days and subsequently hatching, but I have decided that the desertion was due to my activities. Lockley's favorite pair of Manx Shearwaters (1942:33) did not leave the egg cold for a single day either. It is interesting to note that the Laysan Albatross, *Diomedea immutabilis* (Hadden, 1941:211-212), leaves the eggs uncovered for four or five days without hatching being affected.

THE CHICK

As already stated, the earliest chicks begin to hatch on Whero Island about January 17. Though the down dries quickly the chick lacks the appearance of a fluffy little ball, as is characteristic of chicks of *Pelagodroma* and *Pachyptila*. The down is relatively shorter, being 20 mm. on the back and only 8 mm. on the head, and the bill is not lost in the down. The forehead is covered to the base of the bill over which the down tends to fall. The bill itself is slightly curved convexly in somewhat the same manner as that of the young Royal Albatross chick (Richdale, 1939:fig. 3). Most of the bill is a uniform light blue gray (39h) in color with three lighter shades as the tip is approached along the culmen. The ramicorn is a light violet gray (40n). The rest of the lower bill is light blue gray (39h) with a lighter shade at the dertrum, a term applied to the tip of the lower mandible. The egg tooth is white. At hatching the eye is fully open. The color chart used for describing the down and other features of the chick was Radde's International Farben-Scala. The figures and numbers in parentheses are those used in the chart whereas the description in words is my own description of colors corresponding to Radde's symbols.

As near as I could match it, the down of the dorsal parts is a dark carmine gray (42d). The under parts are a medium neutral gray (31k) with traces of a lighter shade (31s) here and there. In front and at the sides the tarsus is a light violet gray (40σ), but the back is much darker (40g). The toes are the same two colors on top and underneath, respectively, and the webs are pinkish. At the tips the claws are whitish and on the ridges there is a bluish tinge (30p).

The chick soon overcomes its initial inertness and bites severely, at the same time coughing up very vile smelling oil; but it seldom squeaks. Frequent feeding during the first week will give the belly a rotund and taut appearance. Fleas are not long in making their presence felt and up to a dozen ticks may be found adhering between the toes.

By the beginning of the second week the average chick, though showing little outward change, will have added considerably to its hatching weight of from 60 to 80 grams. There is a perceptible elongation of the head as the long down of the forehead now does not overhang the base of the bill. The down of the upper parts appears slightly lighter in color probably because it is not so compact. The tarsi and feet are decidedly darker in color. The egg tooth is still present and the chick continues to bite severely and to cough up oil. On the eighth day the sheaths of the secondary down feathers are just visible on the scapulars. In most of the other species of sea-birds I have studied this appearance occurs on the seventh day, but with *Pelecanoides* it is the sixth day.

The mesoptyle quickly covers the body, appearing in normal chicks that are being well fed on the tenth day on the forearm and on the thirteenth on the hand. On the basis of nine records, the egg tooth disappears between the ages of 11 and 22 days.

In the third week the bill has darkened a little more and the unguis (tip of upper mandible) and the dertrum have become sharply defined. The face and bill are longer, resembling more those of an adult shearwater. The mesoptyle has grown so much that the protoptyle is long and loose, giving the chick a beautiful appearance. The various colors of the tarsi and feet have darkened still further. By this time the chicks which have all been handled daily have become tame, but there are considerable individual differences in behavior.

Up until the fifth week there is very little external change. The chick elongates in body and becomes fluffier and still more beautiful. Many of the chicks have been undergoing long periods of fasting interspersed with short intervals of heavy meals. The duration and number of these fasts have had an effect on the growth rate of the feathers. Between the ages of 31 and 35 days, in normal chicks, feathers appear on the scapulars and quickly spread all over the body. Two days later they will be noted on the forearm and three days after that on the hand. As the protoptyle falls off, the mesoptyle is seen to be slightly darker than the former.

When I left the island on March 14 the oldest chicks were in their eighth week. The growing feathers were loosening the down. Two of the chicks acquired tails on the 49th day and two others on the 50th day. In the most advanced chick and the one which received the most food, the primaries were just protruding through the down on the 52nd day.

The following table provides data which can be utilized by other workers to enable them to estimate the age of Sooty Shearwater chicks found on areas they may visit. These are records of normal chicks which were vigorous, fat, and healthy. It must be remembered that any interference with the chick's food supply or with its health will increase the periods given in the table. These differences are more in evidence as the chick gets older.

Table 2

Data for estimating age of shearwater chicks

Age in days	Remarks	Number of birds
8	Mesoptyle on scapulars appears	9
10	Mesoptyle on forearm appears	9
13	Mesoptyle on hand appears	7
11 to 22	Egg tooth disappears, average 17½ days	7
31 to 35	Feather quills on scapulars appear	7
33 to 37	Feather quills on forearm appear	7
36 to 40	Feather quills on hand appear	7
49 to 51	Feather quills on tail appear	4
51	Tips of primaries show through down	1
38	Length of longest primary, 3 mm.	
41	Length of longest primary, 12½ mm.	1
44	Length of longest primary, 22½ mm.	

Of the activities of chicks from March 14 to May 9 I have no records from personal experience. From April 1 the mutton-birders are on the islands pulling the fat, fluffy chicks from the burrows and killing them. From May 1, the chicks are caught on the surface at night. When on Whero from May 10 to 17, 1941, I discovered that the only four burrows under observation which contained chicks the previous January were

empty; three contained down feathers, indicating that the chicks had evidently survived. The youngest of these was hatched on January 25 and the oldest on January 20. The former therefore left the burrow in something less than 106 days. On the nights of May 11 to 16 I saw 12 chicks on the surface, the majority still with varying amounts of down adhering. The chick shown in figure 9 carries the greatest amount and may not have flown for at most another 10 days, that is, May 21.

From May 11 to 21, 1942, I was on Herekopare Island while the mutton-birders were at work. Unfortunately, it was a very poor season when over the whole Stewart

Fig. 9. Young Sooty Shearwater caught outside the burrow at night on May 11, 1941. This is about ten days from time of flying.

Island area only about 50 per cent of the normal catch was acquired. Only 37 chicks were caught in that period, 13 of these on May 17 and none at all for the remaining three nights. Ten of these L3 were clear of down. In this section I am not considering what the Maoris call *kihakas*. These are very light birds abnormally covered in down which are found toward the end of every mutton-bird season wandering about on the surface at night; they never survive to leave their island home.

Reports of the Maoris on the most thickly populated islands with reference to the 1943-44 season infer that button-birds were no longer available after May 13. This was, according to them, most unusual and to me seemed to indicate that the chicks were fed more regularly that year.

It appears then that nestling shearwaters begin to fly from the last week of April to approximately May 21. This means that they are ashore a minimum period of 95 days if my estimates are correct. Of course, the individual range of age at flying will

vary considerably and might be as much as three weeks. In the Royal Albatross, for instance, I have recorded the range from 220 to 251 days (1943b:337), in *Pachyptila turtur* from 44 to 55 (1944c:165), in *Pelecanoides* from 47 to 59 (unpublished), and in *Pelagodroma* from 52 to 67 (1943b:335). For the Manx Shearwater, Lockley (1942: 103) gives 72 days as the nestling stage. If this were the case in the Sooty Shearwater the Maoris would find chicks flying on arrival at the islands on April 1. This does not occur.

ATTENTIVENESS OF PARENTS

The most outstanding aspect of the relations of parent and chick is the length of time chicks are left unfed.

Table 3

Presence of adult with the chick during the day

Age in days	Nest									
	1	2	3	4	5	6	8	9	10	11
1	ad[a]	ad	ad	ad	ad	ad	ad	ad	ad	ad
	fd	fd	fd	fd	fd	fd	fd	fd	fd	fd
2	nad	ad	ad	ad	ad	ad	nad	nad	ad	nad
	fn	fn	fn	fn	fn	nfn	?	fn	fn	fn
			fd	fd	nfd	fd			nfd	
3		ad	nad	nad	nad	nad	ad		nad	ad
		nfn	fn	fn	fn	fn	?		fn	fn
		nfd								nfd
4		nad				ad	nad			nad
		nfd				fn	?			fn
5						nad				
						fn				
6						ad				
						fn				
						nfd				
7						ad				
						fn				
8		ad				nfd				
		fn				nad				
		fd				fn				

Key: fn, fed during previous night. nfd, not fed during day.
nfn, not fed during previous night. ad, adult present.
fd, fed during day. nad, no adult present.

In the foregoing table, for ten nests, I have recorded the occurrence of the parent with the chick in the daytime in the first few days following hatching. After the occasions listed, the parent was never found again with the chick in the first 52 days when I was present on the island. A parent was always in attendance during the first daylight hours after hatching, and in every case the chick was fed before 9 p.m. that day. On the second day only six of the ten chicks under observation were attended by a parent and eight of the nine that were being weighed had been fed. On the third day only three had adults with them but two of these chicks had been alone the previous day. With the exception of two chicks the parents were not present again during the day. With one of these exceptions (nest 2) the parent was again in attendance on the eighth day; the chick after having received a substantial meal during the night was again fed in the daytime.

The chick of nest 6 had a parent with it five times during the first seven days of its life. At 9 p.m. on its first day, chick 6 weighed 101 grams—an enormous weight—and

must have been fed recently. On the following day at 9 a.m., its weight was down to 93 grams, an indication that unlike the other chicks, it had received no food during the night. At 9 p.m. that day its weight had advanced to 111 grams, indicating that it had received a meal that day. The weight of 113 grams on the third morning seemed to prove that the second parent had not visited the nest, otherwise the meal would have been considerably heavier, probably nearer 40 than 2 grams. On the fourth morning the chick's weight had risen to 149 grams from 108 the night before and the parent, probably the second one, was with it during the day. Next morning it was alone and weighed 160 grams, this being 22 grams in excess of the previous night. On the sixth morning the weight had risen to 212 grams from 149 grams twelve hours earlier, and although the parent was again present no meal was delivered during the day. On the seventh and final day an adult was again present and the chick weighed 255 grams, having advanced from 194 grams.

This chick certainly received good attention. The weights at 9 p.m. on the seventh day for the other seven chicks averaged 135 grams and ranged from 79 to 187 grams. Further, chick 6 registered the heaviest weight of all the chicks for the whole period of my field study, being 1070 grams on its 47th day. The good meals it received early in life may have accounted for this.

My method of discovering whether or not a chick had been fed was to weigh it at 9 a.m. and 9 p.m. each day. Of all the petrels I have studied in this manner—Royal Albatross (1939:475-483 and 1942:255-262), *Pelecanoides* (1943a:35-36 and unpublished data), *Pelagodroma* (1943b:112), *Pachyptila turtur* (1944c:41)—the Sooty Shearwater seems to spend the least time with its nestling during the day. *P. turtur*, however, in this respect does not lag far behind.

Lockley (1942:37, 38, 73) mentions two cases of the appearance of the parent with the chick during the day. In the first, the chick was attended daily for the first six days and then again three days later for the last time. In the second case another chick was attended daily up to the eighth day with the exception of the sixth day and then not at all for the rest of its time ashore.

With the exception of *Pelecanoides*, I have noticed that parent petrels, within my experience, seldom attend the chick together, and the Sooty Shearwater from my limited records taken in 1942-43 seems to follow the same behavior. Of 26 visits paid to burrows at night after the chick was hatched on 14 occasions no bird was present, on 10, a single bird was found, while on two occasions both parents were with the chick. In one case the chick was attended by an adult all day, but in the second case the chick had been alone for that time.

In 1943-44 with 59 chicks under observation (see table 1) on the island until February 12, I searched for parents far more diligently and only on one occasion did I discover two adults with a chick. This corroborates very strongly the deductions of the previous year. To illustrate still further this absence of birds from breeding burrows, on February 5, 1944, I investigated after dark 42 burrows harboring chicks and found not a single parent. At an additional 18 burrows without chicks only one bird was present.

FEEDING AND RELATED TOPICS

Table 4 presents feeding data based on eight chicks studied in the season of 1941-42 when I was on the island from December 20 to March 14. Each chick was weighed twice daily, the quantity of food received each night being determined by the difference in weight between the evening and the following morning. Nights on which chicks were not fed are also noted. Weights indicated by an asterisk represent the amount of food

Table 4

Nights fed and amount of food in grams given to eight chicks in 1942

Nest	Hatched	January											February					
		21	22	23	24	25	26	27	28	29	30	31	1×	2	3	4	5	6
1	Jan. 19	31	29	21	25	nf	nf	78	88	56	3	35	nf	nf	nf	nf	nf	90
2	Jan. 19	nf	nf	nf	nf	55	4* 20	5	6	28	nf	nf	60	68	42	31	nf	nf
3	Jan. 26						2* —	7* 6	−2	19	41	32	54	13	53	54	24	30
4	Jan. 20	3* 7	0	33	23	47	nf	nf	nf	nf	nf	63	77	32	35	26	69	nf
5	Jan. 20	11	3	23	nf	nf	nf	53	44	44	19	53	nf	nf	nf	nf	92	85
6	Jan. 20	18* nf	2	41	22	63	61	8	73	23	nf	nf	nf	nf	nf	184	202	118
7	Jan. 19								76	nf	nf	nf	nf	nf	nf	nf	nf	116
8	Jan. 25													nf	nf	nf	114	nf

	February																	
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	170	85	nf	nf	nf	nf	nf	nf	nf	nf	nf	75	110	nf	180	150	60
2	nf	nf	nf	121	63	nf	nf	110	nf	nf	nf	115	63	nf	nf	15	nf
3	nf	67	nf	53	nf	nf	nf	134	59	99	70	50	nf	nf	187	85	85
4	nf	155	104	nf	38	50	nf	nf	nf	nf	nf	nf	nf	160	75	70	50
5	nf	120	nf	nf	nf	nf	nf	nf	nf	nf	nf	132	180	120	nf	120	110
6	63	60	nf	nf	nf	nf	nf	nf	nf	224	125	115	100	45	80	55	nf
7	82	110	nf	207	nf	55	nf	nf	nf	nf	nf	nf	nf	nf	205	30	300
8	90	70	145	95	10	nf	nf	nf	nf	nf	nf	95	205	−5	nf	120	90

	February					March									
	24	25	26	27	28	1	2	3×	4	5	6	7	8	9	10	11
1	nf	nf	nf	nf	nf	nf	nf	nf	90	50	135	nf	240	nf	145	35
2	nf	205	20	nf	50	nf	nf	nf	nf	nf	260	40	nf	nf	nf	nf
3	nf	nf	nf	nf	nf	nf	nf	165	150	75	nf	75	35	100	35	nf
4	nf	nf	nf	100	80	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	145
5	100	nf	nf	nf	nf	nf	nf	nf	nf	nf	245	60	185	55	nf	nf
6	nf	nf	nf	nf	175	nf	25	225	50	50	85	nf	nf	nf	nf	nf
7	nf	120	75	nf	nf	nf	nf	nf	100	85	35	100	30	105	nf	nf
8	nf	210	nf	nf	nf	110	125	nf	nf	nf	nf	nf	nf	170	70	70

Key: *, food given to a chick during the day by a guarding parent; ×, means full moon; nf, means not fed during night. A minus sign prefixed by a figure indicates that though the chick was fed, the morning weight was less than the previous evening weight.

given by a guarding parent during the day, and this occurred several times the first few days. The amount of food as shown by the table varies from 0 to 300 grams, but it must be remembered that these weights, owing to the methods used, will be slightly less than the actual weights.

The data for table 5 were compiled from figures given in table 4, and also from three additional chicks which died early. It will be observed that 70.3 per cent of the

Table 5

Weights of 192 meals given to 11 Sooty Shearwater chicks in 1941-42, grouped into class intervals of 20 grams

Class interval in grams	Number of meals	Percentage	
0 to 19.9	27	14.1	
20 to 39.9	33	17.2	
40 to 59.9	29	15.1	70.3
60 to 79.9	28	14.7	
80 to 99.9	18	9.4	
100 to 119.9	18	9.4	
120 to 139.9	11	5.7	
140 to 159.9	6	3.1	23.4
160 to 179.9	5	2.6	
180 to 199.9	5	2.6	
200 to 219.9	6	3.1	
220 to 239.9	2	1.0	
240 to 259.9	2	1.0	6.3
260 to 279.9	1	0.5	
280 to 299.9	0	0.0	
300 to 319.9	1	0.5	

meals received weighed less than 100 grams, that 23.4 per cent were under 200 grams, and that 6.3 per cent exceeded 200 grams. The heaviest meal was one of 300 grams, the next heaviest, 260 grams. After the sixth class interval there is a rapid reduction in the number of meals in each group as the weights per meal increased. In addition to the 192 nights noted in the foregoing table, when meals were given, there were 215 other nights when the 11 chicks remained unfed, representing 52.8 per cent of the total nights they were being weighed. The individual range in number of nights when chicks were not fed varied from 35.6 to 60.5 per cent.

Table 6

A comparison of five species of petrels as to number of nights nestling chicks remain unfed

Species	Number of cases	Average percentage of nights unfed	Range	References to papers (Richdale)
Pachyptila turtur	17	22.75	12.5 to 47.6	1944c:45-46
P. vittata (= *forsteri*)	12	34.8	12.5 to 56.3	1944a:194-195
Pelagodroma marina maoriana	16	31.3	16.4 to 59.0	1943b:220-221
Pelecanoides urinatrix	11	2.75	0.0 to 10.5	Unpublished
Puffinus griseus	11	52.8	35.6 to 60.5	Present study

In table 6 I have grouped data relative to the irregularity of the feeding process in all the petrels I have studied on Whero. Those for *Pachyptila turtur* and *Pelagodroma* are complete from hatching to departure. At the time I studied *Pelecanoides* I was not with this species for its whole shore period and my work was confined to a series of older and younger chicks. I have shown (1943a:98) that from a grand total of 370 pairs of daily weights of 14 chicks, there were only 10 occasions, excluding the two or three when a chick remained too long after it was due to leave, when a chick was not fed. The figure 10.5 per cent given in table 6 is based on a chick weighed only during its last 19 days ashore when it was fed on every night except the last two. This in all probability raised the percentage beyond the true level. Thus, it was only rarely that a

chick of *Pelecanoides* was not fed. Only one chick was weighed for its full time of 48 nights in the burrow, and on only three of them was it not fed.

In regard to *Pachyptila vittata*, the range of records obtained for 12 chicks from their last 15 to 26 days in the burrow (average of 18.7 days) was taken at the end of 1942 when I was on the island during the latter part of the season. A tendency for the occurrence of a short fasting period at the end may cause the average given in the table to be a little higher than it should be.

The average of 52.8 for the Sooty Shearwater, which is much higher than that for any of the other petrels, was taken during the chicks' first 52 days ashore with probably more than 40 days to follow before departure from the nest. If, as is alleged, there is a long starvation period at the end, this percentage would rise still higher.

Table 7

Data relative to the irregularity of the feeding process in the Sooty Shearwater

		Nights when not fed			Quantity of food received			
Nest	Days in burrow	Number of times not fed	Number of days weighed	Percentage of days not fed	Number of nights when fed	Amount received in grams	Average in grams for each night fed	Average per day in grams
1	52	27	50	54	23	1981	86.13	39.62
2	52	30	50	60	20	1381	69.05	27.62
3	45	16	45	35.6	29	1857	64.03	41.27
4	51	28	50	56	22	1442	65.55	28.84
5	51	29	50	58	21	1854	88.28	37.08
6	51	23	50	46	27	2292	84.88	45.84
7	52	26	43	60.5	17	1831	108.29	42.58
8	46	21	38	55.3	17	1784	104.94	46.97

The foregoing table deals with eight chicks, watched in the season of 1941-42 from date of hatching toward the end of January to the middle of March. It will be noted that chick 7 was not fed on the greatest percentage of nights. In spite of this, the average amount of food it received per meal was greater than that for any of the other chicks, being 108.29 grams. On the 50th day it attained its greatest morning weight of 940 grams. When the average per day, including all days weighed, is taken, the weight is not the greatest, being only 42.58 grams.

In contrast to the above is the chick at nest 2 which was not fed for 60 per cent of nights when it was weighed. It received the lowest aggregate amount of food (1381 grams), with a daily average of only 27.62 grams. When the average amount per meal is computed it proves to be a comparatively high figure (69.05 grams). This chick, however, must have been unhealthy, for all records indicated that growth was retarded. Recalling table 2, where certain age characteristics of normal chicks are given, with chick 2 the mesoptyle appeared on the scapulars on the 10th day, on the forearm three days later, and on the hand on the 21st day; the egg tooth did not disappear till the 40th day; at the time of last inspection on its 52nd day the chick showed no sign of scapular feathers. In normal chicks of this age, tail quills are emerging.

Chick 3, for which the percentage of nights unfed is lowest, did not receive, as might be expected, a large total amount of food; as a matter of fact, the actual average per meal (64.03 grams) was the lowest of all the chicks. Thus, there seems to be a tendency, as is the case with *Pelagodroma* (Richdale, 1943b:220), for chicks which remain unfed to make up the deficiency when the parents do arrive. There is a further

tendency, too, for the average amount of food received per night ashore to level up when the amount of food received is divided by the total number of weighings including the nights unfed, as shown in table 7.

Table 8

Length and number of spans in days between feedings of eight chicks

Chick	Days										
	1	2	3	4	5	6	7	8	9	10	Total
1	3	1			1			1	1		7
2	1	4	1	2	2						10
3	4	1	1				1				7
4	1	1	1		1		1			1	6
5	2	1	1	1					2		7
6	1				3		1				5
7	3	1			1			2			7
8	3		2			2					7
Total	18	9	6	3	8	2	3	3	3	1	56

Table 8 presents data on the length and number of spans when the chicks were not fed. It must be remembered that I did not handle the parents of these chicks so that my activities could not have influenced the above results. Chick 4, from the 41st to the 50th day inclusive, a period of ten days, remained unfed. The weight of this bird dropped from 660 grams to 425 grams at 9 p.m. on the eleventh night, the last night I weighed the birds, when it received 145 grams of food. Prior to this it had experienced two fasts of five and seven days, respectively.

Chick 5 fasted for two periods of nine days each. The first occurred between the 21st and 29th days, when the weight dropped from 360 to 196 grams; the second occurred between the 37th and 45th days, when the weight dropped from 760 to 485 grams. The first fast was followed by meals of 132, 180, and 120 grams, respectively, which were quite substantial. The second was succeeded by amounts of 245, 60, 185, and 55 grams before a subsequent fast.

Chick 9 was fed during the first five days of its life. Then for the next eight nights it received nothing and eventually succumbed. After dark, on the tenth night, that is, its fifth night without food, hearing it squeak I found it at the entrance of its burrow vainly waiting for the arrival of its parents. On the 13th day it was almost paralyzed, though still able to emit a faint squeak; in that fast period it dropped from 141 to 68 grams.

Chick 2 nearly met its death due to a lengthy early fast. At 9 p.m. on the day after hatching it weighed 96 grams. Four nights later at 9 o'clock, having received no food in that time, it had dropped to 61 grams. Naturally it was very weak, squeaking very little and not fighting at all. On the following day at 9 a.m. it weighed 116 grams; thus, it must have received its own weight in food! Its vigor was quickly restored, too, for it made many attempts to bite me. On the following morning its weight had risen to 126 grams. A parent remained with it all that day. At 9 p.m. its weight was 130 grams; apparently it had been fed during the day. This occurred on the eighth day, a time when it is unusual for parents to be with chicks. The longest fasts this chick experienced were two of five days. It was the "runt" of the colony, as already explained, and possibly the severe early fast was responsible for its poor health.

Other chicks appeared to die because neither parent appeared with food. Chick 11 was found dead on February 1, after a fast. On the following night an adult was in the

burrow, and on the night of February 2-3, there was a second bird. Of course, I do not know for certain whether or not they were parents of chick 11. They may have been wandering, non-nesting birds, but these were not numerous at this date. Chicks of the Manx Shearwater are also known to undergo fasts before the parents desert them finally (Lockley, 1942:85).

With respect to irregular feeding, it is of interest to note the important discoveries of Lockley (1935:105-107; 1942:126) regarding the feeding grounds of Manx Shearwaters under his observation. In May and June, 1939, he obtained six ringing returns which showed that some of his birds were feeding in the Bay of Biscay, 600 miles away from where they had nests and eggs at Skokholm, an island off the coast of Wales. When one compares the long absences of Sooty Shearwaters from their nests during the incubation and nestling periods with Lockley's findings, it seems likely that the birds breeding on Whero feed at a considerable distance from their nesting area. Irregular feeding of nestlings, although not with such long periods between feedings, also occurs in some species of storm petrels (Richdale, 1943b:222-223).

In an attempt to discover if weather conditions have any relation to the number of chicks fed on any one night I made a survey covering eight chicks on the last 38 nights of my stay on the island. No chicks were fed on one night only; a single chick was fed on four nights; two chicks were fed on eight nights, three on seven, four on ten, five on four, six on two, seven on one, and eight on one night. The average number of chicks fed per night was 3.4. On the night of February 21-22, when all eight chicks were fed, it had been rough all day with an east wind. Throughout the day, more birds than usual were off-shore, and they were particularly plentiful toward evening. On February 12-13, a calm, dark night, not one chick was fed. The day of February 7 was sunny with a very strong southwest wind, which died down in the evening; that night no less than seven of the eight chicks were fed. From this survey it appears that weather has little influence on occurrence of feeding, for the number of chicks fed fluctuated considerably, even when weather conditions were much the same over Whero. If, as suggested, parents feed several hundred miles from their breeding grounds, it may be that weather over distant areas may be a determining factor.

Table 9

Average weight and number of meals given to eight chicks during successive four-day periods

Class interval in days	Number of meals	Average weight in grams	Class interval in days	Number of meals	Average weight in grams
1- 4	22	13	29-32	16	126
5- 8	22	38	33-36	17	103
9-12	22	44	37-40	10	111
13-16	13	62	41-44	9	149
17-20	17	107	45-48	17	101
21-24	13	86	49-52	7	108
25-28	7	105			

To construct table 9 the nightly meals were put down in columns according to the age of the eight chicks under study. Thus, the first column recorded the weight in grams of the food received by each chick on the first day after the hatching; the second column the amount received by each on the next, and so on. The columns were then grouped into sets of four each, the totals of each set found and divided by the number of feedings which occurred.

Table 10

Average weights of meals given to eight chicks at various periods

Occasions when weights taken	Number of cases	Average in grams
Following 1 or 2 nights without food	25	100.5
" 3 or 4 " " "	9	103.1
" 5 or 6 " " "	9	139.8
" 7 or 8 " " "	5	168.8
" 9 or 10 " " "	3	149.3
1st meal after a fast	50	122.9
2nd " " " "	37	91.5
3rd " " " "	26	89.1
4th " " " "	14	51
5th " " " "	10	42.2
6th " " " "	3	84.6
7th " " " "	1	55

Table 10 was prepared to determine whether or not the average weights of food given are influenced by periods of fast and by successive meals. Owing to the large percentage of nights when chicks remained unfed, the number of cases is somewhat low. The results would seem to indicate, however, that meals after a fast increase in size in proportion to the length of that fast. With respect to successive meals after a fast, the first is most decidedly the heaviest and thereafter, as they succeed one another, there is a tendency for the meals to become lighter. The number of cases given also indicate quite clearly that chicks of the Sooty Shearwater are not fed very many nights in succession before there is a fast. Of 55 when chicks were fed on consecutive days (table 4), 69 per cent of these periods did not exceed 3 days and 91 per cent were less than 6 days. The average was 3.15 days and the range from 1 to 12 days. One chick was fed on each of 12 days following hatching. The next longest periods were one of 8 days, one of 7, and two of 6 days each.

In concluding this section I should like to mention the "starvation period" through which chicks of petrels are supposed to pass at the end of their life as fledglings. My researches with the Yellow-eyed Penguin (*Megadyptes antipodes*) and five species of petrels, *Diomedea, Pelecanoides, Pelagodroma, Pachyptila turtur,* and *P. vittata,* indicate that it is practically non-existent and that in every species mentioned some of the chicks were fed the night before they left the nest. Under these circumstances I feel that I am justified in being sceptical about the "starvation period" of the Sooty Shearwater. As yet, too small a number of chicks has been studied to settle this point, According to Cockayne (1909:38), "about the middle of April the old bird ceases to feed the young one, which, gradually losing its excessive fat in consequence, becomes vigorous, . . ." In a footnote on the same page this writer expresses doubt regarding the reliability of his informant's insistence that all mutton-birds lay on November 25. Such an informant is not likely to be any more accurate about events in the middle of April. In an earlier paper (Richdale, 1942:171, 172, 261) I have shown how fat chicks of *Pelecanoides* lose weight at the same time that they are still being fed. The same appears to be true of *Pelagodroma* and the two species of *Pachyptila,* and possibly of *Puffinus,* also.

It has already been shown that during its first 52 days in the burrow a chick of the Sooty Shearwater may fast over several long periods of as many as 10 days. Possibly one such fast precedes the time of departure of the chick from its burrow. In the Manx Shearwater, according to Lockley (1930:204-214; 1931:204; 1942:85), a short fast

does occur prior to departure from the burrow. If this is true of the Sooty Shearwater, then there would appear to be a moderate starvation period, but it is not as long as we have been led to believe. I have already given evidence of reduction in weight during a fast, but the whole of the loss of weight prior to first flight does not occur during the final fast in the burrow.

WEIGHTS AND MEASUREMENTS OF THE GROWING CHICK

In table 11 below are given weights, at 9 a.m. and 9 p.m., of eight chicks of the Sooty Shearwater during the first 52 days of their life in the burrow. In working out the data for the table all the weights concerned were put down in columns representing the age of the chick, so that each column contained 16 weights, two for each day. The eight morning and the eight evening weights were then totalled and averaged separately, and so on for each day. The averages were then divided up into class intervals of four days and the average of these four averages was taken. In this way the daily fluctuations caused by extra heavy or extra light meals were smoothed out. Owing to the considerable frequency of non-feeding on many nights and to the irregular amounts of food transferred on other nights, a daily graph reveals many peaks and hollows.

It will be noticed from the table that except for a drop at the age of 41 to 44 days, the weights continued to increase to the end of the period of study, indicating that a general plateau had not yet been reached. A plateau is not to be expected since feathers have only begun to grow.

Table 11

Weights in grams of eight chicks of the Sooty Shearwater during their first 52 days ashore

Class interval in days	9 a.m.	9 p.m.	Difference
1- 4	93.77	90.38	3.39
5- 8	141.4	132.62	8.78
9-12	201.52	188.94	12.58
13-16	225.15	211.62	14.53
17-20	308.81	288.78	20.03
21-24	390.31	373.53	16.78
25-28	389.87	387.18	11.69
29-32	501.84	482.65	19.19
33-36	616.75	593.75	23.00
37-40	667.97	646.25	21.72
41-44	629.53	612.09	17.44
45-48	717.88	698.63	19.25
49-52	762.81	740.10	22.71

Graphs of the daily weights of all eight chicks were made. In all cases during the 52 days that records were taken, the lowest point of a depression reached after a fast was nearly always higher in succeeding fasts. This is amply shown in the two records in figure 10, which represent chick 6, which attained the heaviest weight, and chick 2, which, as explained before, appeared to be subnormal and weighed less than all other chicks. Neither of these graphs shows very long fast periods. Chick 1 suffered two periods of nine and eight days, chick 5 two periods of nine days each, and chick 4 seven- and ten-day periods, which make the depression sweeps much more spectacular (see table 8).

In the graph (fig. 10) showing meals and fasts of chick 6, there are only five periods of fasting and five of feeding. With all other chicks, the number of fastings and feedings was greater; chick 2 (fig. 10) had the most, a total of 20, that is, its alternate meal

and fast periods were shorter than those of any other chick. For the first nine days chick 6 received, on consecutive days, a total of 311 grams of food followed by a five-day fast; in the next five days it received 627 grams followed by a seven-day fast, then 744 grams in seven days followed by a five-day fast, and a single meal of 175 grams followed by a single-day fast. Lastly, a five-day period when 435 grams were delivered ended with a five-day fast corresponding to my last five days on the island. Chick 2

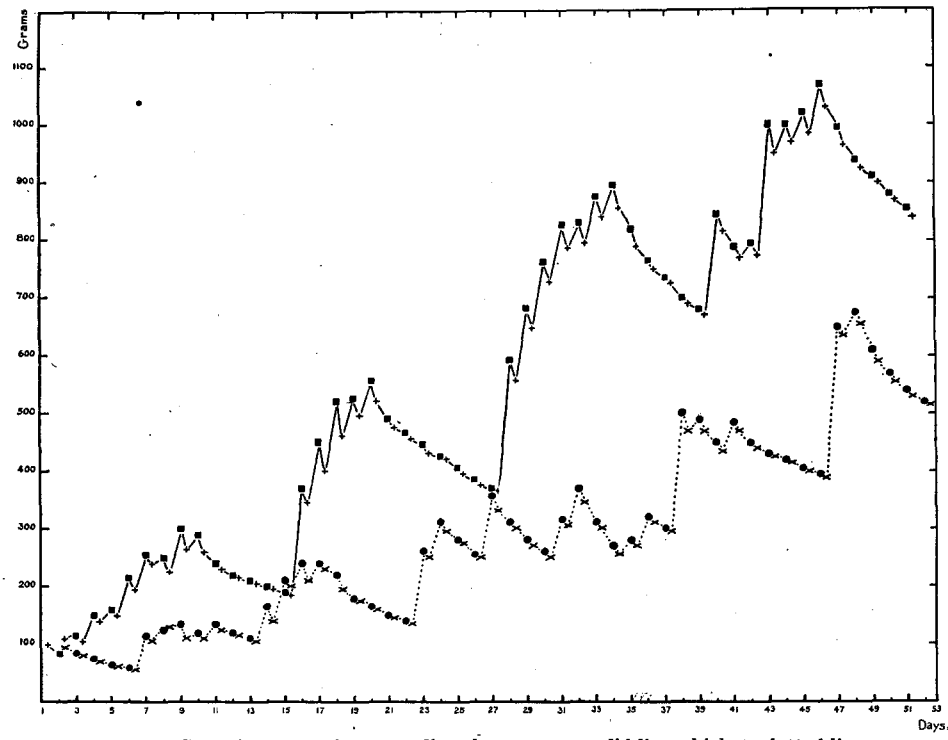

Fig. 10. Growth curves of two nestling shearwaters; solid line, chick 6; dotted line, chick 2. Solid symbols indicate weights at 9 a.m.; crosses, weights at 9 p.m.

had more meal periods interspersed with shorter fasts—much shorter than those of other chicks. The growth of chick 6 was relatively slow until the 47th day when its weight increased after a five-day fast from 390 to 650 grams. This may have been the turning point in its life, but unfortunately soon after this I left the island. Thus, the fate of this nestling was not determined; perhaps it was a *kihaka*.

Some points of interest about the weights and weight increases may be noted. Of the eight chicks which were weighed daily, the one at nest 6 attained the heaviest weight of 1070 grams on its 47th day; the lowest peak-weight attained by any chick was that of chick 4 which reached 660 grams on the 40th day. The greatest weight of chick 2, the *kihaka,* was 675 grams on the 48th day. On the 37th day chick 8 reached its heaviest weight, 910 grams; chick 6 was next heaviest, weighing 760 grams. Chick 2 weighed only 300 grams and was easily the weakest.

The largest increase in weight in any one night was that of chick 7 on its 36th day when it advanced from 550 to 850 grams, an increase of 300 grams. On the 25th day at 9 p.m. this chick weighed 540 grams and was not fed for the eight following nights;

thus, at 9 p.m. on the 33rd day, it weighed 365 grams, having dropped 175 grams. During the next three nights it received 205, 30, and 300 grams, respectively, rising to 850 grams, an increase of 133 per cent at 9 a.m. on the 36th day. It will be seen that a 365-gram chick received 535 grams of food in three nights.

The results of an earlier eight-day fast by this chick are also worth noting. On the tenth day at 9 p.m. it weighed 285 grams. After the fast it weighed 161 grams at 9 p.m., having dropped 124. In the succeeding three nights it received 116, 82, and 110 grams, respectively, and finally weighed 425 grams, a total increase of 164 per cent. Thus, in three nights this 161-gram chick received 308 grams of food.

Chick 5 had a similar experience. On its 20th day at 9 p.m. it weighed 336 grams, after which it was not fed for nine days and weighed 196 grams at 9 p.m., having dropped 140 grams. During the next three nights it received 132, 180, and 120 grams, respectively, rising to 590 grams or 120 per cent; this chick received 432 grams of food in three nights. During a second fast period of nine nights it dropped from 720 grams on the 36th day to 485 grams on the 45th day, a drop of 235 grams. In the three succeeding days it received 245, 60, and 185 grams, respectively, rising to 935 grams, an increase of 93 per cent. Thus, in three nights it received 490 grams of food.

A final example is that of chick 6 which advanced on its 17th day from 187 to 371, that is, its weight was almost doubled after a five-day fast. During the next two nights it received 202 and 118 grams, respectively, receiving in all 504 grams and advancing to 520 grams at 9 a.m. on the 19th day. The increase in three days was 125 per cent.

In summary, it is apparent that owing to the irregularity and relative infrequency of feeding, the weights of nesting Sooty Shearwaters fluctuate considerably. Further, it is evident that weight at any particular time is not a satisfactory index to the age of a chick, for on a succeeding day it may be almost double, or in three days treble, its previous weight.

Weekly average measurements and weights of eight chicks, from day of hatching to their 50th day ashore, are summarized in table 12.

Table 12

Average weekly measurements and weights of eight chicks

Feature	1st	8th	15th	22nd	29th	36th	43rd	50th day	
Bill	19.27	21.07	22.72	25.31	27.96	31.06	33.43	35.17	mm.
Nostril to tip	12.11	13.47	15.22	17.20	19.12	21.43	23.37	24.66	
Wing	26.41	30.10	34.50	45.50	55.50	72.87	92.50	115.00	
Toe and claw	24.5	27.57	31.70	36.62	43.53	50.06	55.70	58.04	
Claw	4.61	5.00	5.65	6.10	7.28	7.84	8.37	8.73	
Weight	75	155	223	362	446	666	634	738	grams

It has already been shown that chick 2 was a retarded individual and possibly a *kihaka*. Its weekly weights and measurements are included in the averages in the above table. Those for its 50th day, given for comparative purposes, are as follows: bill, 29 mm.; nostril to tip, 19; wing, 62; toe and claw, 46; claw, 7; and weight 570 grams.

Additional data on size and weight of chicks are given in table 13, which is based on 8 chicks on the island of Whero, May 11-13, 1941, plus 22 and 5 chicks from Herekopare, studied in the periods May 15-17, 1942, and May 7-8, 1943, respectively. All were caught on the surface at night; some had a considerable amount of down on

belly and breast, while 10 were entirely free of down. Three others, definitely *kihakas,* are not included in the table.

Table 13

Measurements and weights of 35 chicks of the Sooty Shearwater taken in May

Feature	Mean	σ	Probable error of mean	Range
Bill length	41.74 mm.	1.67	.18	39- 44¼
Wing	295.75	10.17	1.13	276-315
Toe and claw	68.4	1.97	.22	65- 71
Claw	11.27	.58	.06	9- 12¼
Weight	659 grams	128.4	14.3	430-970

Table 14 has been prepared from data given in table 13 dealing with 35 chicks and from other data in my earlier paper (Richdale, 1944b:106). The purpose of this table is to show to what extent, if any, the chicks continue to grow after leaving the nesting area. It should be noted, however, that exact dates of departure of the chicks from the island were not known. The only measurement likely to be affected seriously by this lack would be length of wing, which, according to my measurements on other petrels, continues to grow until time of departure. Presumably this is true of the Sooty Shearwater, also. Hence, the wing measurements would tend to be somewhat shorter than at the time of departure. Weights, on the other hand, would, if a starvation period is in force, tend to be somewhat greater.

Table 14

A comparison of size and weight of 100 adults and 35 chicks of the Sooty Shearwater

Feature	Difference	Probable error of difference	Type of bird with longer measurement
Bill length	.12 mm.	.21	adult
Wing	8.25	1.22	adult
Toe and claw	.85	.27	chick
Claw	.61	.07	chick
Weight	128.00 gms.	14.92	adult

Before recognizing a difference between means as significant, I have ruled that it must be at least four times the value of the probable error of the difference. Applying this rule, the differences in bill length and in toe with claw are not significant; the difference in wing length probably is significant even when allowance is made for additional growth prior to departure, as discussed above. The difference in weights, provided the sample of chicks is not too small, is decidedly significant. It will be noted that the claw of the chick is significantly longer than that of the adult; this is to be expected, as the claw of the chick is worn very little.

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