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THE SOOTY SHEARWATER IN NEW ZEALAND

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The Sooty Shearwater (*Puffinus griseus*) is the most common sea bird in New Zealand waters, where there must be several million individuals. From the last few days in September to the middle of November an observer on any of the headlands of the Otago Peninsula, New Zealand, may see this species flying south in an endless stream. The flight, however, is not continuous, for many pauses are made for feeding. It is on such occasions that huge flocks are noticed resting on the waters of various bays along the coast.

This shearwater is locally known as the mutton-bird and the young are taken annually for food by those Maoris who have acquired ancestral rights. Europeans who are married to such natives also have a legal right to participate in these activities. Beginning on the first of April of each year, the season extends to about the middle of May. Although no exact tally is kept, it is estimated that nearly 250,000 birds are taken in a good season.

The term "mutton-bird" is usually reserved for *Puffinus griseus* but to the Maori several species are included. In fact anything that is edible and can be "bagged up" is a mutton-bird. In this connection species involved in southern New Zealand include a bird known as the Korure, which is either *Pterodroma inexpecta* or *P. cookii*, or both. I have not yet had an opportunity to verify this point but both species live on some of the mutton-bird islands. If they are available, the adults of *Pachyptila vittata* [=*forsteri*] are caught at this period, and the Weka (*Gallirallus australis*), too, may find its way into the preserving bags.

In the northern part of New Zealand the mutton-bird is *Pterodroma macroptera*, which is taken regularly in the Bay of Plenty area during November, though in small numbers. *Puffinus gavia* [=*reinholdi*] has probably, on odd occasions, also been used in the north (Buller, 1888:237). On the southern Australian and Bass Strait Islands the mutton-bird is *P. tenuirostris* (Wood-Jones, 1936:198).

The bulk of the field work from which the data for this paper were obtained was carried out on the small island of Whero, situated off the northeast corner of Stewart Island, New Zealand. An aggregate of twenty-nine weeks has been spent on this island between December 26, 1938, and January 26, 1943. Some preliminary observations made on the trip in 1940-41 have been published (Richdale, 1942:94-105), but since then two further sojourns of three months and two months, respectively, have resulted in the collection of a considerable amount of additional material.

In several places reference has been made to other species of petrels studied. It is hoped that such comparisons will help to make more intelligible similar behavior on the part of the Sooty Shearwater.

RANGE OF THE SPECIES

Murphy (1936:667) has shown that "the Sooty Shearwater is an abundant sea bird throughout the length of the oceans on either side of the Americas, from the lati-

tude of Cape Horn northward to arctic waters. It is particularly numerous along the Pacific coasts of North and South America." Mr. R. M. Lockley, in a private communication, stated that he sees the species occasionally from Skokholm off the coast of Wales. It would appear also that in the northern hemisphere individuals of this shearwater are present during the whole year whereas in the southern hemisphere they occur only in the breeding season.

Beck (1910:65-66) and others have seen them in every month of the year off the California coast, as at Point Pinos. The only possible out-of-season record I have is the sighting of a single *P. griseus* near The Traps just off the southeast extremity of Stewart

Fig. 13. Shearwater islands, off Stewart Island, New Zealand.

Island on August 27, 1942. My informant was a fisherman who, during the season, is also engaged in the mutton-bird industry.

The breeding range includes southern South America and the waters around New Zealand, more particularly in the south. In the former area Beck found them breeding in 1915 on an island near Cape Horn, and there are inconclusive records that they breed on the coastal tableland of northern Chile (Murphy, 1936:670-671). A doubtful record is that of their breeding on the Falkland Islands (Bennett, 1926:314). In Australia there is only one authenticated breeding locality and that is on Tasman Island off Cape Pillar, Tasmania, where there is a small nesting colony associated with the more common *P. tenuirostris* (Wood-Jones, 1936:197). There is an alleged Australian breeding record reported by Hull (1911:101). From an eggless burrow on Broughton Island off the coast of New South Wales, he took a bird which he identified as *P. griseus*. It was found in a colony of *P. pacificus* on January 29, 1911; no others were located either then or on a later visit. Dr. D. L. Serventy in a private communication remarks that it had evidently come ashore but not for breeding and also that this species accompanies the abundant *P. tenuirostris* on its spring migration down the east Australian coast. In regard to Hull's bird it is interesting to note that eggs of *P. griseus* begin to hatch on January 18. It seems obvious, therefore, that the stray at Broughton Island was a mem-

ber of the unemployed section which quite frequently occupies empty burrows at the end of January.

In New Zealand, the popular belief is that mutton-birds breed only on islands near Stewart Island, but this is incorrect. They nest on several islands off the east coast of northern New Zealand between the Three Kings Islands, their northernmost breeding station in New Zealand (Fleming, private communication), and the Bay of Plenty (Sandager, 1890:290; Sladden and Falla, 1928:283; Falla, 1934:251; Buddle, 1941: 58). Near Wellington they breed on Kapiti Island (Buller, 1888:232; Wilkinson, 1931: 232; Kirk and Wodzicki, 1943:7) and Mana Island (Fleming, private communication). At Okarito, well down the west coast of the South Island, there is a further record (Rept. Ornith. Soc. N. Z., 1940:5). On the Otago coast at various points, including Moeraki Island, Otago Peninsula, Taieri Island, and Rainbow Island off the Catlins coast, I have found them breeding.

At Stewart Island and its outlying islands, and on the mainland coast north of Foveaux Strait, the species is very common. On the Snares it is more numerous still, but as the island is a bird sanctuary and a light-house reserve, it is not worked by "birders." The identity of the species there has been definitely established as *griseus* by Stead (1932:67). The Sooty Shearwater is recorded on the Auckland Islands by Waite (1909:563), and by Wilson (1907:80) who saw huge flocks in Laurie Harbour in March, while Chapman (1891:504) in January, 1890, had a similar experience in the south just before entering Carnley Harbour. Filhol (1885:52) states that on Campbell Island the birds breed in thousands, while Hamilton (1895:562 and 574), Campbell (1900:894), and Falla (1937:206) have noted them on Macquarie Island. On the Chathams, Fleming (1939:401) states that they are still common. I can find no record of their occurrence on Antipodes Island where they most likely breed.

Finally, there is a record according to Buller (1888:233), Bent (1922:90), and Oliver (1912:220; 1930:122) of their existence on Norfolk Island. I do not think this is correct. Buller refers to Crowfoot (1885:268) whose observations and records, notably the small egg measurements, are clearly not referable to *griseus*. Oliver apparently relies on Hull's record (1909:648) for assigning *griseus* to Norfolk Island. Hull's egg measurements, 2.58 × 1.78 and 2.6 × 1.6 inches, are much smaller than any I have recorded. If *griseus* does breed on Norfolk Island, it would indeed be unusual for a subantarctic species, whose presence even off the Auckland coast is strange.

THE PRE-LAYING PERIOD

It has not been possible for me to glean much information about this portion of the Sooty Shearwater's breeding cycle. Beck states (1910:66) that in 1907 off Point Pinos, California, he saw a gathering of fully 20,000 on November 4, and he considers this to be a late date for such large numbers. Bent (1922:86) remarks that "the southward movement of this species [*P. griseus*], which is really its spring migration, begins in September and the bulk of the flight is over before the end of that month, though it is still to be found here in diminishing numbers during October and November on both our Atlantic and Pacific coasts." On the same page he quotes another observer writing in 1902 to the effect that there is a sudden decrease in the numbers of shearwaters off Monterey, California, in September.

It would seem then that the bulk of the birds usually leaves northern waters by the end of October. In the course of my several visits to Stewart Island between August 20 and September 3 I have never seen a shearwater, nor has there been any sign whatsoever of spring cleaning of the burrows. On September 10, 1874, at Campbell Island,

which is south of New Zealand, Filhol (1885:53), found many uncleaned burrows but no sign of inhabitants. Guthrie-Smith (1914:17) when on a large mutton-bird island on September 22, 1911, saw no trace of the birds. On October 2, however, he noticed that they had arrived and were quite numerous (*op. cit.*: 19-27). An observer on Stewart Island notes (Rept. Ornith. Soc. N. Z., 1940:5) that off Southwest Cape at Stewart Island he saw one bird on September 22, 1939, and three days later about a dozen. This area is in close proximity to the most densely populated mutton-bird islands. My own observations over many years off the Otago Peninsula indicate that the birds first appear at the very end of September and continue flying past till about the middle of November, although during the final two weeks their numbers are relatively small.

In 1943 I first noticed them on September 25 in some hundreds only, spread evenly as far as the eye could see in every direction. They could not be seen from shore on September 19. Mr. T. Middendorf, while fishing in his launch on September 14 and 15, saw about thirty or forty between Taieri Island and Nugget Point. By sea, these places are twenty and fifty-five miles south of Dunedin. He was not out again until September 29 when the birds were quite numerous. Between September 11 and 14, another friend, also in a launch, some 100 miles below Dunedin, did not observe the species at all.

To sum up, it is apparent that the Sooty Shearwaters reach their main breeding ground at Stewart Island and islands to the south during the last week of September, while at the same time there are still large numbers left in the northern hemisphere.

Oliver states (1930:122) that the mutton-birders contend that on the southern journey the young precede the older birds. I am not convinced that this is so. There is a considerable amount of erroneous matter written pertaining to this shearwater, especially in the lighter literature, due to too much reliance being placed on the tales of the mutton-birders. As these people are on the nesting islands only during the six weeks at the end of the season, it is hardly possible that they have acquired their information from direct observation. The fallacy, still believed, that all mutton-birds lay their eggs on November 25 is an example. My researches on the Royal Albatross (*Diomedea epomophora sandfordi*) indicate that in the main it is the breeding birds which tend to arrive first, with the non-breeding birds more in evidence a little later on. Lockley (1942:24), dealing with the Manx Shearwaters (*P. puffinus puffinus*) has stated that there is no set order and that "old males and females might arrive first, or they might follow young birds which apparently had never bred before." Some years earlier (1935:107) he gave evidence supporting his theory "that the non-breeders . . . return late to the breeding grounds."

As I have never been on the breeding grounds when the birds arrive, I am not in a position to say what happens. The pre-laying period would appear to last about a month, as I have found with other petrels that I have studied. Although there is a considerable amount of activity during October, not all the burrows are cleaned out nor are all the new ones begun then. The earliest date I have camped on the breeding grounds is December 1, after which I noticed a great amount of spring cleaning of old burrows by birds without eggs or chicks—birds that I term "unemployed." In the early stages it is important to distinguish the two classes of birds, that is, those which will ultimately breed successfully that season and those which, for some unknown reason, will not.

My belief, supported by my studies of penguins and the Royal Albatross, is that breeding shearwaters are already paired when they arrive and that any courtship subsequently indulged in is merely routine, perhaps serving to maintain the pair bond, and that the decision to breed together is not the result of this behavior on the nesting

grounds. All the evidence I have been able to collect on banded birds indicates that this is definitely true in the Royal Albatross. I do not believe that breeding shearwaters spend much time on the surface of the ground or in flying about the colony; they are mainly in their burrows. Further, their cries do not supply much of the vocal noise that is heard on the islands up to the end of January, and especially in October and November.

The unemployed birds are the noisy and active ones, wandering over the surface of the ground, and indulging in courtship actions with their weird vocal accompaniment. It is these birds, too, which fly about and call out far into the night, issuing from their burrows some two hours before it is time to depart and indulging in an uncanny dawn chorus that is common until the end of January. Frequently I have seen them in pairs and trios. Perhaps this is the true courtship period when individuals, becoming acquainted with each other, may decide to breed together in the next season. Of course, they may arrive at a decision while at sea, and it may even be made, in some cases, during their sojourn in northern waters. Many of my views are contrary to those expressed in the literature, but a close study of banded penguins and petrels has led me to disagree with many written opinions.

Reference to the behavior of another species of petrel may be of interest at this stage. After the customary year's holiday following the raising of a chick, the female of a pair of Royal Albatrosses returned without her mate some time before, in normal circumstances, she was due to lay. She did not produce an egg that year, but for three months at spasmodic intervals was observed receiving attentions from three unmated males. Two of these were marked in previous seasons and were then known to be unemployed. In the following season she returned "married" to one of these banded males and reared a chick with him. At the time of her departure from land the previous season I could not determine which was the successful suitor; it may be that the affair was settled at sea.

There is plenty of evidence that this species locates and associates with its mate at sea. Time and time again I have seen a pair of Royal Albartosses arrive together to feed a chick in spite of the fact that they had last fed the chick separately. I believe that facts like these should receive serious consideration when one is working out courtship behavior of other petrels. The Sooty Shearwater may quite well behave in a similar manner.

To sum up, the apparently large population of unemployed birds must be carefully considered when interpreting the behavior of any species of petrel, not only at the prelaying stage but also during incubation and when there are small chicks. Observers frequently have noted freshly excavated burrows when, unknown to them, laying has ceased for that season, and they have wrongly concluded that laying is more protracted than it really is. I have known Royal Albatrosses to build excellent nests some weeks after laying by other birds has ceased. The noting of coition, or attempted coition, at such a period would lead to faulty conclusions. Roberts (1940:232) makes the following interesting comment: "The Wandering Albatross (*Diomedea exulans*) continues to copulate regularly even after the young have hatched." It may be asked what was the status of the birds behaving in this way? Did they belong to the unemployed section or to the section with eggs or young? If the Royal Albatross were being considered, it would certainly not be the latter.

INCUBATION

Generally speaking the burrows of the shearwaters on the island of Whero are found only in the sedge and *Stilpocarpa* areas where the soil is deep (up to eighteen inches),

and where it seems to be possible to make a sufficiently long burrow under the roots. A map indicating the zones of vegetation on the island appears in my introductory paper on Whero (1942:88). The burrows vary in length from one foot to about four feet and are excavated in the soft peaty soil. Most of them are single units but there are places where two or more have a common entrance. Situated near the end of the

Fig. 14. Huts of the mutton-birders. Note dense vegetation under which the birds burrow.

burrow, the nest is constructed somewhat roughly of any handy vegetation which has been dragged in. Above the sitting bird there usually exists only a thin layer of soil which easily gives way to the foot if care is not taken. One large white egg, which soon becomes very much soiled, is laid.

When working among the burrows from December 20 to the end of January, I noticed that those containing an incubating bird are not easily seen, for the entrance is overgrown by vegetation. Soil excavated in the spring had long since disappeared either through the action of wind or by being covered with plant growth. The appearance of the burrows of unemployed birds presents a strong contrast, for the entrance is wide open with a mass of soil in front. The condition of the first type of burrow is corroborative evidence that there is little activity in these burrows; what movement there is is confined to the comings and goings of the incubating birds which pursue their course without any dallying.

I can recollect having read somewhere that shearwaters require a dark place in which to nest, but I do not think this is correct, for on Whero I have found a few birds in the western sedge area incubating just within the opening of the burrow. The entrance in all cases was barely noticeable but the bird must have been exposed to considerable amount of light. The absence of Wekas and predatory animals on the island may be an influencing factor.

A perusal of the literature gives the impression, which I believe is erroneous, that the laying period is somewhat protracted. Campbell (1900:894) states that on Macquarie Island it occurs in the latter part of November whereas Hamilton (Falla, 1937: 206) found laying still proceeding on that island on December 11. Sandager (1890:291) says the period is from the beginning of December to the middle of January on Mokohinau Island (Hauraki Gulf). Sladden and Falla (1928:284) give late November or early December for the laying of the eggs they examined on the Alderman Islands (Bay of Plenty). Bent (1922:90) gives nineteen New Zealand records of egg dates between November 16 and April 28 and ten more between November 19 and 26. On Herekopare Island, off Stewart Island, Guthrie-Smith (1914:41) found no eggs in a few burrows examined on November 23, 1911, but he could feel the egg inside one bird. Later (p. 43), he states that eggs may be obtained from November to February, and possibly earlier and later. Cockayne (1909:38), states that all eggs are laid on November 25 wherever the female may be, whether on land or at sea. Guthrie-Smith was able to explode this myth when he visited Herekopare during this vital period. The careful observations of Filhol (1885:53) indicate that on Campbell Island on November 15 there were several recently laid eggs. Fleming (1940:5) noted clean, fresh eggs in a small colony on Hen Island between November 25 and December 4, 1939. Finally, the only shearwater egg I have found early in the season was discovered on the surface of the ground at Taiaroa Head, Otago Peninsula, on November 7, 1936.

From my own observations, recorded in the next paragraph, I am of the opinion that practically all the eggs appear during the last two weeks in November. Such a restricted laying period occurs in several other birds I have studied. With *Pachyptila turtur*, seventy-five chicks under observation in 1941-42 all hatched within eighteen days. Twenty-two Royal Albatross eggs have been laid within a span of thirteen days in eight seasons. My figures for the Yellow-eyed Penguin (*Megadyptes antipodes*) are 174 eggs all laid within a period of twenty-three days in six seasons.

In order to gather first-hand information regarding egg-laying I visited Taieri Island each week from November 6 to 27, 1943. One hundred Sooty Shearwater burrows were marked and examined on each occasion. On November 20 no egg was found and there were very few shearwaters in the burrows as compared with the two previous weeks. A week later, November 27, twenty-four of the burrows contained eggs, twenty-one held a single bird, three a pair of birds, while fifty-two were empty. The eggs were all considerably soiled, indicating that laying had occurred some days earlier. One egg was quite brown so that it was probably laid on November 21. When examined, not one egg, including the brown one, showed any sign, to the eye, of a developing embryo. This confirms my previous impression that with petrel eggs it is not safe to assume that such eggs have just been laid. I do not think that many more of the burrows would acquire eggs. It is of interest to note that these eggs appeared very close to November 25.

Because of my egg record of November 6 and Filhol's of November 15, I had expected eggs earlier and am wondering if 1943 was a late season. The Royal Albatross in 1943 was fully eight days later in laying than in all previous seasons when it has been under observation. For example, the earliest record is November 6 as against November 14 for 1943.

When I arrived on Whero on December 1, 1942, my impression, although I was not able to check it up fully, was that all the eggs had been laid for that season. On Whero, covering three seasons, the earliest hatching date was January 18 with most of the chicks out by January 31. During April the mutton-birders take the chicks from the burrows, but after May 1 they are obtained on the surface at night with the aid of a torch. By May 21 there are very few of these birds left so that the season is really over.

These remarks demonstrate that the range in time of departure is short. Since the hatching and departure periods each covers a space of not more than twenty-one days, it seems reasonable to assume that egg-laying occurs within such an interval also. In my earlier paper on Whero Island (1942:92) I stated that hatching appeared to take several weeks. This view must now be modified.

If we take November 23 as the beginning of the incubation period and January 18 as the beginning of hatching, this means that incubation requires at least eight weeks, or a little longer if the 1943-44 season was a late one. The time required by the Royal Albatross is seventy-eight to seventy-nine days (Richdale, 1942:170). Lockley (1942: 103) states that the average for the Manx Shearwater is fifty-one days but he also

Fig. 15. Adult Sooty Shearwater.

quotes elsewhere in the text several records of up to fifty-six days. My longest incomplete record is from December 6, 1942, when a nest was first found, to January 19, 1943, when the chick hatched, a period of forty-four days. I do not know the date on which the egg was laid, but the chick was one of the first hatched that year. From the literature there is very little information to be gleaned regarding the incubation period.

As regards the length of time an adult incubates before being relieved I have not much information. In my earlier paper (1942:100) I have noted that one partner sat for as long as thirteen days before change of guard was effected and that its mate was in charge probably for at least ten days before this.

In 1942-43 I kept sticks across the mouth of a burrow from December 6 to January 20, but during this time I merely looked at the sticks and did not inspect the birds at all for fear they would desert. On the fifth day after placement of the sticks, they were knocked down, then four days later and so on at intervals of 4, 4, 2, 3, 6, 8, 2, and 5 days, making in all 43 days. From this it would appear that change of guard occurred more frequently than previously indicated, but at the same time allowance must be made for the possible entry of unemployed birds, as I did not examine the bands of the incubating birds.

Lockley's records are somewhat similar to mine. His observations (1942:32) on one pair of Manx Shearwaters indicate that shifts of three, four, and five days occurred, the sexes alternating. In a subsequent year (*op. cit.*:82, 84) one bird sat for ten con-

secutive days, beginning two days after the egg was laid, while not long after that the mate had a turn of nine days. Lockley also states that they fasted during these periods and I am sure that this is correct. It is interesting to note that I have a record span of fourteen days for a Royal Albatross (1942:253), seven for *Pachyptila turtur*, and five days for *Pelagodroma marina maoriana*. In *Peleconoides urinatrix* the change occurs nightly (Richdale, 1943:31).

In color the eggs are white and present considerable variation in size and shape, a feature which has been noted by others (Sladden and Falla, 1928:284; Murphy, 1936: 667).

Measurements and weights of eggs of Sooty Shearwater taken on Whero Island

	Number	Mean	σ	Probable error of mean	Range
Length in mm.	72	77.38	2.94	.23	72 to 88
Width in mm.	72	48.26	1.77	.14	44 to 52
Weight in grams	65	92.93	8.47	.7	70 to 115

Eggs showing the extreme measurements, with the weights in parentheses, are as follows: **88** × 49 (115 fresh), **72** × 48 (82), **72** × 48¼ (81), **72** × 45½, 76½ × **52**, and 76¼ × **44¼** (77). The longest egg was 5 mm. longer than the second longest. The weights which were taken of eggs in all stages of development show a considerable amount of variation. The measurements of the eggs with extreme weights are 74½ × 45½ (70) and 88 × 49 (115 fresh). The average weight of twenty-five eggs known to be fresh was 95 grams, and of forty at an undetermined stage of incubation was 88.5 grams. One egg which appeared very long and narrow when found, measured 80½ × 45¾ mm., and weighed 89 grams. I noticed that the egg shells were thinner and more easily broken than those of barn-door fowls.

Egg measurements given by other observers

Authority	Number	Average	Sizes	Remarks
Bent (1922:86)	34	74 × 48	**81.7** × **49.2** 79.0 × **53.4** **58.5** × **42.5** **60.5** × **42.0**	Extremes are in boldface type
Sandager (1890:291)			**82¾** × **47¾** **75** × **43¾**	largest smallest
Murphy (1936:667)	9	74.4 × 47.2	**81** × **45** **70¾** × **50¼** **67¼** × **44¼**	Extremes are in boldface type
Buller (1905:103)	1	59¼ × 46¾		Stewart Is.
Falla (1937:204)	1	80½ × 50		Macquarie Is.
Oliver (1930:122)	4	75¾ × 49¾	**70** × **50** shortest egg	Chatham Is. and Campbell Is.
Wood-Jones (1936:199)	5	75 × 47.6		Tasman Is.

In the main the measurements given by other writers are the same as mine but there are one or two which are considerably smaller. Bent's last two measurements fit in more with very large Prion eggs, one of Murphy's is a little short, whereas Buller's seems far too short to be that of a normal egg.

Each season a number of deserted eggs was found, many of them on the surface

of the ground, clean and fresh. At the mouths of some of the burrows or just inside were others, very much soiled, for they had evidently been incubated, but nevertheless they were in an edible condition. Also, for some unknown reason, eggs are sometimes scratched out. As an example, on January 29, 1942, one was discovered on the verge of chipping just inside a burrow entrance, and there was no bird in the burrow. The next day at 3 p.m. a bird, which I then banded no. 7, was alone in this burrow. At 2 p.m. on December 25 following, no. 7 was again in the burrow, this time in the company of an unmarked bird. As there was no egg present, both these birds would be members of the unemployed section.

At another burrow which was found empty on first inspection on December 19, 1942, there was plenty of evidence that the birds had been scraping in the loose material, in which I found an egg buried. It is obvious that something occurs at times to upset the normal behavior of the sitting bird.

THE NESTLING STAGE AND NORTHWARD MIGRATION

Owing to the considerable amount of material collected, details concerning the nestling stage must await a future paper. Suffice it to say that the earliest hatching within my experience occurred on January 18. An outstanding feature of the chick's life

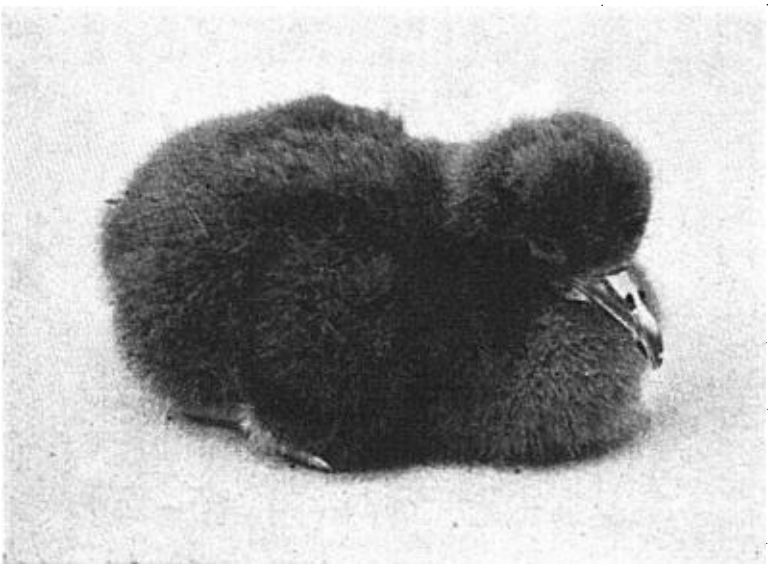

Fig. 16. Sooty Shearwater one day old; January 20, 1942.

in the burrow is the length of time, in one span, that it is left fasting, the greatest I noted being ten days. It is therefore of interest to recall Lockley's discovery (1942:126) that Manx Shearwaters may feed up to 600 miles from their nesting ground while in possession of egg or chick.

As far as I have been able to ascertain the first chicks begin to fly at the very end of April. In that event normal chicks would appear to remain in the burrow not less than ninety-five days. By May 21 practically all that are able to leave land have set out.

It has been said that on the northward migration the old birds precede the young, but I do not think that the order is as sharply defined as this. I am firmly of the opinion

that during the first three or four weeks the flight is made up chiefly of unemployed birds, which according to my observation constitute more than 50 per cent of the population. When I was on Whero on March 14, 1942, I recorded that the nightly arrival of shearwaters dropped to less than 20 per cent of the numbers in December and January, and only half of the number of arrivals for the last week of February. From these observations it will be seen that the unemployed birds were beginning to leave the breeding grounds early in February, and by the first two weeks of March were practically all gone, evidently preparing offshore for the journey north.

I do not think breeding birds leave before the last week in April for the simple reason that, until then, they must be feeding their chicks. In making this statement I am assuming, not without good reason, that the alleged "starvation period" at the end of the chick's life ashore is not very long, probably very little more than a week. This means that at the end of April and during the first two weeks of May breeding birds and fledglings will be flying north together with very few of the unemployed group. At the end of the migratory departure the migrants will probably be predominantly fledglings.

I do not know exactly when the migration begins, but it must be about the end of March. Huge numbers were seen on April 1, 1938, near Shag Point (Rept. Ornith. Soc. N. Z., 1940:5), which is nearly 200 miles north of the main breeding grounds. On April 11, 1936, I observed an endless stream flying north all day near Dunedin. Loomis (1918:132) notes that in California they arrived in strength during the latter part of April and in May. Bent (1922:88, 90) gives the arrival for both sides of the North American continent as May. Loomis (*loc. cit.*) also observes that on February 27, 1907, seventy-five were seen by Mr. Beck and he thinks they formed the vanguard of that year's migration. It is certainly a most unusual record if that is so.

The latest date I have seen shearwaters on the wing at Stewart Island is May 18, 1941, when three solitary individuals were observed. They were probably fledglings.

GENERAL OBSERVATIONS

Nightly arrival of shearwaters on Whero Island.—In my earlier paper (1942:97) is a table indicating the nightly arrival of Sooty Shearwaters during the first hour, grouped into five-minute intervals. From this survey, lasting for thirty-four consecutive nights from December 22, 1940, to January 24, 1941, much interesting information, which need not be repeated here, was gleaned. During the three months' trip in 1941-42 a survey was made again but in three periods of seventeen, twelve, and sixteen days, respectively, as shown on the dates given in the table below.

Summary of nightly arrival of adult Sooty Shearwaters in 1940-41 and 1941-42

Season	Date of period	Number of days	Number of birds	Nightly average		Range
1940–41	Dec. 22–Jan. 7	17	897	52.8	51.2	36-74
	Jan. 8–Jan. 24	17	844	49.1		37-78
1941–42	Dec. 20–Jan. 5	17	956	56.2	54	25-82
	Jan. 21–Feb. 1	12	611	50.9		37-84
	Feb. 22–Mar. 1	8	181	22.6	16.6	7-44
	Mar. 2–Mar. 9	8	84	10.5		8-14

Similar results were obtained in both seasons during December and January, except that in the latter season the number of arrivals shows a greater daily average. This is interesting in view of the fact that 1941-42 was a very poor mutton-bird season. Many are the fantastic theories which have been put forward to explain the cause. In 1941-42 the mutton-birders claimed that the birds did not visit the islands that season and that the burrows had not been cleaned out. They also stated that owing to the number of

ships sunk many birds were destroyed on the southward migration by oil. If conditions on the other breeding areas were similar to those on Whero the lack of young birds was due to some other cause which cannot be arrived at by guesswork.

In January of both years it will be noted that there is a slight decrease in the number of birds. In my previous paper (1942:98) I stated that this was due to the fact that unemployed birds were beginning to depart from the island toward the end of January and that my nest records showed fewer unemployed birds in burrows. This was also applicable in both 1941-42 and in 1942-43. Furthermore, I stated that after January 20 the total would tend to increase, assuming that the chicks would be fed frequently by both parents. But in this statement I was in error. At the time I was not aware that the chicks fasted for many days at a stretch.

It is unfortunate that I did not keep any records between February 2 and 21, 1942, for shortly after I began again it was apparent that the number of birds returning nightly had fallen off considerably. For the first eight days, beginning February 22, the average per night was 22.6 birds and for the last eight days it was only 10.5. It must be remembered, too, that this period represented one of rapid growth for the chicks. Moreover, it seems obvious, that those birds coming home were largely, if not exclusively, parents. This will explain the reason, too, why the mutton-birders when on the islands in April and May do not see very many adult shearwaters. Further, it is questionable whether they are correct in their assumption that the parents, as a result, have deserted their chicks for that season.

Some of the individual nightly arrivals will be discussed in detail in an endeavor to find out any causes for these results. On December 21, 1941, 82 birds came home between 9 and 10 p.m. with 61 on each of the preceding and succeeding nights. There had been a heavy westerly wind till the middle of the afternoon when it dropped, but there was no apparent cause for the return of this large number of birds. On December 26, only 25 came in with 66 and 42 birds the preceding and succeeding nights, respectively. This represented the lowest total for both seasons in December and January; the weather conditions, too, were similar to those of five days earlier.

On January 26, 1942, the record number of 84 was counted with 47 the previous night and 53 the following one. The range for the other eleven nights in this period varied from 37 to 59 birds so that 84 was an outstanding figure. Again there was no apparent reason and weather conditions were similar to those experienced on December 21. Eight of the nine chicks being weighed were fed. Since there were only three other chicks, to my knowledge, in this area and with allowance for having missed several, it is obvious that the unemployed population is considerable.

The smallest total was 7 birds on February 28, with 27 the preceding and 18 the following night. On February 28 only one of the eight chicks surviving in the area was fed. The nights of February 27 and March 1 were very cloudy with a strong southwest wind, whereas on February 28 there was a strong northwest wind with nine-tenths cloud. I am inclined to the opinion that any wind with a southerly tendency brings home more birds, but further investigation on this point is needed.

Population of Sooty Shearwaters on Whero Island

	1940-41	1941-42	1942-43
Breeding birds banded	5	11	33
Breeding birds not banded	11	27	47
Unemployed birds banded	8	19	110
Birds which deserted eggs	6	4	12
Unbanded parents of chicks found on surface	16	....	....
Totals	46	61	202

Population statistics.—In working out population figures it is possible that I have counted a bird twice. For example, "birds which deserted eggs" and "unbanded parents of chicks found on surface" may have been caught and banded in either of the two succeeding seasons. The duplication, if any, cannot be very great. The figure 202 shown for 1942-43 does not represent all the birds accounted for that season. There are twelve others not included as they were banded the year before. This brings the total birds for 1942-43 up to 214; 161 of these were residents of the western face which is a little less than half the area of the island occupied by shearwaters. In all, records were taken at twenty-seven nests with breeding birds and at forty-three burrows containing only unemployed birds. There must have been several other breeding burrows which were not found, and there was certainly a considerable number of further unemployed burrows not recorded. I merely recorded those which happened to contain an unemployed bird on the day I first inspected the burrow. While working the area between December 22 and 29, I noted as many as thirty-eight additional clean but empty burrows. It will be realized, I think, that the population of the western face could be reckoned as easily 250 birds. The rest of the island which was not worked thoroughly contained, to my knowledge, thirteen burrows with eggs and twenty unemployed burrows recorded as holding birds. I have every reason to believe that the population of the second portion of the island is as dense as that of the western face, and I consider that 200 birds is not an over estimate. This makes a total of 450 for the whole—fifty more than I gave previously (1942:91).

Miscellaneous notes on behavior.—Attempts have been made by several writers to record in written language the cries of the shearwaters, but to me none has been realistic enough to recall the weird noises made by these birds. It is most difficult. I am always reminded of the groans of a man in great pain. Certainly the *tea-tea-tea* sound, said very quickly, is not, as recorded by Buller (1888:233), one of the calls of the shearwater. It is difficult to believe that the Maori name of Titi is derived from this source as stated by Buller. These two statements have erroneously been copied by Bent (1922:88). Buller (1905:102) also gives the amazing report that "they [mutton-birds] go into the bush at night and rob the nests of small birds, taking either eggs or young; and they will also attack meat if hung out of doors."

The various petrels are so numerous on Whero that it always amazes me that there are not frequent collisions. Only once, on December 21, 1941, have I witnessed a collision between two shearwaters. This was accompanied by a loud crack and a cry from one of the birds, but it did not fall to the earth. On another occasion, when it was relatively dark, I saw an early arrival circle its landing place several times before coming straight in to land, but on the way it hit a dead upright tree trunk and fell to the ground. This incident makes me believe that the shearwater does not possess special night vision. On another occasion I saw a bird collide with a dead branch and fall to the ground. Ainslee and Atkinson (1937:241) noted that collisions in mid-air often occurred in the Leach Petrel (*Oceanodroma l. leucorhoa*).

Only once during my long sojourns on Whero have the shearwaters fished close inshore. That day I was able to observe carefully their method of diving. With the wings partly extended they disappeared under the water and rose again with the wings in the same position, from which they frequently took flight. The hand was bent back almost at right angles to the forearm when the bird dived and re-appeared.

Weights and measurements.—The bill was measured with dividers from the base of the bill where it touched the feathers to the tip. The depth was taken at the base of the bill and the width on the cutting edges immediately below the base of the bill. To measure the wing I placed a ruler at the extreme end of the carpal flexure and with the

primaries flattened and straightened along the ruler measured to the tip. In dealing with the tail the ruler was placed at the bases of the central retrices and extended to the longest feather.

Weights and measurements of 100 Sooty Shearwaters taken on Whero Island, December 20, 1942, to January 11, 1943

	Mean	σ	Probable error of mean	Range
Bill length	41.86 mm.	1.56	0.10	38½-45½
Bill depth	14.75	0.56	0.04	13½-16¼
Bill width	13.88	0.57	0.04	12½-15¼
Wing	304.00	6.9	0.46	287-322
Tail	89.61	2.66	0.18	84-99
Toe and claw	67.55	2.17	0.14	62-74
Claw	10.66	0.67	0.04	8½-12
Weight	787 gms.	64.00	4.26	666-978

Average and extreme measurements of Sooty Shearwaters by other observers

Authority	Region	Number	Bill length	Wing	Tail	Tarsus	Toe and claw
Murphy (1930:9)	Atlantic and Pacific coasts of North and South America	40	38-45.6 (41.7)	280-309 (293)	84-99.2 (89.4)	52.5-59.5 (55.4)	50.9-71.5 (63.1)
Loomis (1918:137)	Coast of California	78 ♂	40.1-47.3 (43)	282-314 (301)	80-94 (88)	50.3-56.9 (53.3)	60-69.4 (65.2)
		87 ♀	38.3-45 (41.8)	281-318 (299)	81-97 (89)	50-55.7 (53)	60-68 (64.2)

A comparison of the measurements of 100 birds all taken on a single small breeding island off Stewart Island with those given by Murphy and Loomis from the American coasts supports Murphy's conclusions about the species. He states (1930:8; 1936:669) that "the world-wide individual variation proves to be approximately the same as the individual variation of a fully representative series from a single locality" and further "it seems clear that all Pacific and Atlantic specimens are indistinguishable from the New Zealand form."

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