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OBSERVATIONS ON SALT BALANCE AND BEHAVIOR OF LAYSAN AND BLACK-FOOTED ALBATROSSES IN CAPTIVITY

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In January, 1958, we had the opportunity to observe on Midway Island in the Pacific Ocean the behavior of the two species of albatrosses that breed there: the Laysan Albatross (*Diomedea immutabilis*) and the Black-footed Albatross (*D. nigripes*). While engaged in this, we checked briefly for evidence of activity of the nasal gland in these birds. Schmidt-Nielsen and co-workers (1957, 1958) reported that the nasal gland in cormorants, gulls, pelicans and penguins excreted a concentrated salt solution which dripped from the tip of the beak after administration of salt loads. Since the nasal gland is well developed in albatrosses (Bennett, 1834; Technau, 1936), it seemed reasonable to believe that this gland might function similarly in them.

The birds were, therefore, observed with this in mind, and it was noted that after fighting among the Black-foots, or occasionally during the ritual dancing, some of the birds showed drops of fluid at the tips of the beaks. Furthermore, during a local harassment campaign, many of the birds in the treated area were actively dripping. This suggested that the gland could be activated by "stress" or excitement.

On returning to Pennsylvania State University, we decided to obtain some of the birds for a study of the nasal gland, and through the kindness of the United States Navy we received eight live albatrosses, four of each species. This paper describes the methods devised for keeping the birds in captivity and presents some observations on their behavior.

MAINTENANCE OF BIRDS IN CAPTIVITY

Marine birds have proved to be notably difficult to keep alive and healthy in captivity (Pallesen, 1940; Hadden, 1941; Plath, 1943). Laysan and Black-footed albatrosses had not previously been kept in captivity for more than a few months, and most of these died within a few weeks. An examination of privately shared records of feeding and handling of these birds (Malcolm Davis) indicated to us that most of these efforts had failed because of three factors: (1) the birds were usually force-fed; (2) they were given invertebrates, such as squid (*Loligo* sp.), for food; and (3) they were given fresh water instead of sea water to drink.

The rationale behind this is the following. The studies of Schmidt-Nielsen and his colleagues indicate clearly that the nasal gland of marine birds removes excess NaCl and some KCl from the blood. The gland does not, however, remove divalent cations, such as magnesium and calcium ions. As a matter of fact, NaCl is preferentially excreted by the nasal gland no matter what sort of osmotic load is imposed. Theoretically, at least, this should make possible the drinking of sea water by the birds. We had noted that excitement or "stress" caused the nasal gland to become active when ordinarily it would not be. Thus, "stress," such as force-feeding, could force the sodium level of the blood down. The typical pathology seen in the captive albatrosses before death was a progressive lassitude and seeming anaesthesia, with no observable lesions. This suggested that the birds were suffering from a decrease in the ratio of sodium ion to divalent cations in the blood. If this were true, the feeding of invertebrates, such as squid, which

have a much higher level of magnesium and calcium with respect to sodium than have vertebrates, would intensify the problem for the birds (see tables 9 and 11 in Prosser, 1950; tables 38 and 53 in Spector, 1956). Furthermore, if only fresh water were available for drinking, the birds would have no means for restoring the sodium concentration by drinking sea water.

On the basis of this reasoning, we decided that: (1) the birds would not be force-fed, thus reducing the "stress," (2) they would be given only vertebrate food, namely fish, which has the ratio of sodium ion to divalent cations much more like that of the blood of birds, and (3) they would be given sea water to drink. It is worth noting that there are a few reports in the literature on the salutary effects of sea water on marine birds in captivity (for example, Townsend, 1927), but these were not based on physiological knowledge.

The eight birds arrived on April 18, 1958, and were housed in an abandoned henhouse (20 × 10 ft.) on one of the university farms. This had wooden walls and a concrete floor covered with dry sawdust. There were five small windows; one at each end and three near the roof along one side. There were no facilities for heating, but the weather was pleasant at first.

We had no natural sea water available and were not yet equipped to produce large quantities of artificial sea water. Accordingly, a large wading tank holding about 30 gallons, which was furnished for possible swimming or bathing, was filled with ordinary well water. Artificial sea water was supplied in a bucket, in the belief that the birds would be able to select this for drinking, if needed.

Frozen blocks of trash ocean fish were obtained through the kindness of officials of The Pennsylvania State Fish Hatchery at Pleasant Gap, Pennsylvania. After thawing sufficiently to allow the fish to be separated but still individually frozen, the fish were cut into pieces about 4 to 6 inches long and 1 inch on a side. These were offered by hand to the birds. The Black-footed Albatrosses quickly learned to feed this way. One was feeding regularly within the first two days, the second in three days, the third within five days, and the last within a week. The Laysan Albatrosses, in general, proved difficult to induce to feed. As was later discovered, this was the result of our ignorance of differences in feeding behavior between the two species. If proper techniques had been used, the Laysan Albatrosses would certainly have been no more difficult to train than the Black-foots. The feeding behavior will be described in detail later.

At this time, we had no idea how much salt was required by the birds. On the basis of published reports on the nasal gland, it seemed possible that they could meet this requirement from the fish itself, provided they were not force-fed. This seemed to be supported by the fact that the Black-foots remained in reasonable health, while the Laysans, which were not feeding, gradually declined. Within six days (April 26) one of the Laysan Albatrosses was dead, after showing a gradual depression, dropping from an upright stance to squatting on the ankles (with the tarsometatarsal portion of the leg flat on the ground), and becoming generally inactive. Unfortunately, however, the interpretation of this series of events was confused by the fact that the weather suddenly became unseasonably cold, and there was some question as to the possible contribution of this to the death.

Two other Laysans were declining rapidly. It was now noted that they were drinking mainly the fresh water in the wading pool instead of the sea water in the bucket. Later observations make it reasonable to believe that this occurred simply because there was much more surface available in the wading pool. These unhealthy birds became rapidly worse and, within a day, dropped to the ankles as the other had done. In the belief that the cold weather could be an important factor—for even the Black-foots were now

beginning to keep their feet pulled up into the feathers unless driven to stand—arrangements were made to move the birds to new quarters which could be heated.

Before this could be done, however, the second Laysan Albatross died. On April 28, one of the Black-footed Albatrosses was killed for anatomical study, and the Laysan, which had died over the previous night, was used likewise. The third Laysan was obviously within hours of death, and the fourth, which had just started to take a little food, was noticeably depressed. Accordingly, it was decided to inject into these birds large doses of NaCl to see whether dripping from the beak, which had not been observed up to this time in any of the albatrosses, could be induced and whether this would help the situation.

The Laysan Albatross which had fed a little received 10 ml. of 0.5 M NaCl solution intraperitoneally, and the other Laysan received 25 ml. of the same. Neither showed dripping from the beak after this, but the recovery in both was startling. Within 10 minutes after the injections, the birds were upright and walking about quite normally. Obviously, these birds had been heavily deficient in sodium. They had also been observed repeatedly drinking fresh water. Apparently, sodium deficiency caused the birds to drink, but discrimination between fresh and salt water was lacking. In nature, of course, mere drinking would bring about increased salt intake, because only sea water would be available.

The birds were now moved to new quarters, a circular sheet metal turkey pen (about 15 feet in diameter and 10 feet high) with five windows comprising about half the wall area. Two small electric glow-type heaters were suspended from the ceiling and could be turned on and off as needed. This allowed considerable manipulation of the temperature, except on sunny days, when the temperature inside mounted sharply. There was no provision for the birds to be outside. A layer of coarse, dry sawdust, about 6 to 8 inches deep, was put on the floor to absorb the liquid feces.

On the basis of the results with NaCl injections, all the birds were given gelatin capsules containing 0.8 gm. of NaCl imbedded in fish. The Laysans were force-fed to get the medication into them; the Black-foots ate regularly. Two NaCl capsules were required for each bird to induce dripping of fluid from the beak. The improvement in general health and activity in all the birds was striking.

This led to a study of the action of the nasal gland, using these five birds; the results have been published elsewhere (Frings, Anthony, and Schein, 1958). The nasal glands of these birds excrete NaCl and KCl in a solution containing 792–856 mEquiv/lit. Na^+ and 20–28 mEquiv/lit. K^+. The concentrations of these ions in the blood of non-excreting but sodium-sufficient birds is the same as that of actively excreting birds. The blood sodium and potassium levels are held by the glands to an absolute maximum.

The paired nasal glands discharge this salty liquid through small openings beneath the tube-nostril, whence the fluid flows along the grooves on the beak to drip off the end. When actively excreting, after a heavy salt load, these drops may fall at 2 to 4 second intervals, but more usually they fall at about 5 to 10 second intervals. The birds either allow the drops to drip off or shake them off. The tube-nostril would seem to be an adaptation of these marine birds which prevents fouling of the nostrils by the liquid excretion of the nasal glands.

It was now obvious that the activity of the nasal glands, which could be so easily observed by watching for dripping of liquid from the tip of the beak, could be used to test for sodium sufficiency. After this time, the birds were given salt either in gelatin capsules or in commercial salt tablets, such as are used for humans, by imbedding these in the fish on which they fed. The wading pool was filled with artificial sea water made by dissolving the necessary amount of rock salt in fresh water. No fresh water was avail-

able, except for a few times when large loads of salt were administered experimentally and this precaution seemed advisable. Even then, however, the birds were not observed drinking it. They were seen drinking the artificial sea water many times. Within a few days, the Laysan Albatrosses joined the Black-foots in feeding regularly from the hand, and no further difficulties were encountered in keeping these birds in excellent health and activity. In June, all were shipped by air to the laboratory at Salisbury Cove, Maine, where they were kept in an enclosed house (9 × 6 feet) and attached outdoor runway (9 × 16 feet). The floor of the house was covered with coarse sawdust; the runway was part of a lawn. The feeding regimen was continued as before, and true sea water, which all were seen to drink many times, was given in a small tub holding about four gallons.

The birds were fed once daily with pieces of fish. These were frozen for ease in cutting and kept frozen until feeding time. They were then thawed, but cool. The birds were given one salt tablet each imbedded in a piece of fish every two or three days and, if not observed dripping after feeding for four or five days, were given an extra tablet and observed. Once the sodium balance was established, dripping from the beak occurred almost every day that salt tablets were fed. Once a week, multi-vitamin capsules were also fed in the fish. There were no evidences of vitamin deficiencies, but this seemed a reasonable precaution.

A number of species of fish were used for food, all about equally acceptable to the birds. At Pennsylvania State University, whiting (*Merluccius bilinearis*) was most usually used, in Maine, haddock (*Melanogrammus aeglefinus*) and hake (*Urophycis* sp.). Pollock (*Pollachius virens*), flounder (*Paralichthys oblongus*), ocean pout (*Macrozoarces americanus*), halibut (*Hippoglossus hippoglossus*), tuna (*Thunnus thynnus*), and herring (*Clupea harengus*) were also given.

The amounts of fish eaten varied widely from day to day, from as much as 5 to 6 pounds to 2 to 4 ounces for the five birds. Consumption of fish was reduced noticeably if the fish was warm instead of cold, if salt was sprinkled on it, or if an oily material, such as cod liver oil which was tried as a vitamin supplement, was poured on it. If the fish were allowed to thaw, then were refrozen and later rethawed and offered to the birds, intake dropped markedly. New foods were usually accepted very eagerly when first offered, but if continued daily, they were soon accepted like the usual items.

On the basis of reports of the eating of garbage, especially fatty materials, by Black-footed Albatrosses (Bent, 1922; Miller, 1936, 1940, 1942; Fisher, 1945; Yocom, 1947; Thompson, 1951), raw beef scraps and fat were offered, and these proved to be eminently acceptable. In fact, when the birds had stopped feeding on fish, apparently satisfied, they would take beef fat avidly. Veal, pork or turkey scraps and fat also were taken eagerly, even bread dipped in bacon fat or vegetables covered with fat or oleo. Ordinarily, after the birds reached Maine, they were given fish to eat first and then some raw beef fat. Under these conditions, the most usual daily consumption of food was about 2½ pounds of fish and 6 to 10 ounces of beef fat for the five albatrosses.

The birds were weighed three times during the four months we had them, and they remained essentially the same in weight. Two of the Black-footed Albatrosses, which we took from their behavior to be males, weighed 6 pounds each, the other, which we took to be a female, weighed 5½ pounds. The two Laysans weighed 5 pounds each. The sexes are indistinguishable externally, but the weights for the Black-foots gave support to the tentative diagnosis of sex based on aggressive behavior and appearance. Loomis (1918) reported that females average less in size than males in these species.

At first, there was some question about the possibility of overfeeding salt to the birds. This seemed, however, to be next to impossible. To enable us to collect specimens of the nasal drip, the birds were given up to 2.4 grams of pure NaCl in capsules in pieces of

fish. The birds already had normal sodium concentrations, and they were thus induced to drip rapidly for some hours but without obvious effects. Shortly after the birds reached Maine, they were given herrings which were heavily salted preparatory to being canned as sardines. They dripped from shortly after feeding, at about 5 p.m., until about midday the following day, but they seemed quite normal and fed regularly.

The dripping from the beak began in a remarkably short time after the birds had eaten pieces of fish in which salt capsules or tablets were imbedded, almost always within 10 to 15 minutes, and often in as little as 5 to 8 minutes. This may be a reflection of a surprising rapidity of digestion or it may mean that the salt capsules or tablets were squeezed out of the food in the crop. If the former is true, and it seems more likely to us, it may account for the fact that examinations of stomach contents of albatrosses have often revealed few identifiable fish remains (Matthews, 1929; Murphy, 1936), although Cottam and Knappen (1939) reported, for the Black-footed Albatross, appreciable proportions of fish in the stomach. Apparently, digestion of such objects as squid beaks and eye lenses is much slower. The reports of Nutting (1903), Fisher (1906), Dill (1916), and Chisholm (1937) that these are found near the nests of Laysan Albatrosses has led to the belief that squid is the major food of this species. For this reason squid was fed almost exclusively to captive individuals by other workers. On the basis of our results, it seems quite likely that the Laysan Albatrosses, like the Black-foots, might eat whatever they can find.

To see whether they would eat invertebrate food at all, if not force-fed, whole squid (*Loligo pealeii*) and pieces of the flesh of lobster (*Homarus americanus*) were offered. The former was taken eagerly, after some hesitation at first, the latter not at all. In nature, any ionic differential produced by eating quantities of squid could easily be rectified by drinking sea water.

It would thus seem that, as originally postulated, the activity of the nasal gland in these birds—and possibly other marine birds as well—is an important factor in maintaining them in captivity. There was plenty of evidence, in these birds, that excitement or "stress" caused dripping from the nasal gland. On arrival from Midway Island, the birds were found to have the beaks covered with crystals of what was almost certainly salt. When they were handled for experiments, dripping occurred afterward. Actually, one or two birds often dripped from the beak apparently just from excitement during feeding. Force-feeding, or even attempts to coerce the birds into feeding if they showed no interest or seemed to be satisfied, was avoided. Obviously fish was fully acceptable to these albatrosses as food, and the ionic problems created by this, when some stress was unavoidable in confinement, were undoubtedly less than those created by invertebrate foods. The birds drank sea water if this was available. In sodium deficiency, intake of water increased, but without apparent selection. Thus, if fresh water was present and there was no supplementary feeding of salt, the birds could deplete their blood sodium. Apparently, the nasal gland had to be fairly active for normal health, so supplemental feeding with NaCl tablets or capsules containing NaCl or dry sea salt was essential. Activity of the nasal gland, easily visible in the dripping from the beak, made a good test for sodium sufficiency. When this was maintained, and suitable quarters and attention were given, the birds seemed to remain healthy and active in captivity, at least for the four months we had them.

On August 20, 1958, the five albatrosses were shipped by air from Maine to the National Zoological Park in Washington, D.C., where Drs. Theodore Reed and Malcolm Davis are continuing with the methods described here.

NOTES ON BEHAVIOR

A few notes on the behavior of these birds in captivity might be of interest. Their docility and fearlessness, as in nature, were striking. They could be approached to within touching distance, with only beak-snapping to ward one off. With a little care, they could be gently handled. One surprise was the ease with which the Black-footed Albatrosses became tame. On Midway Island, they are considerably less docile than the Laysans (Hadden, 1941; Bailey, 1952, 1956). Reports of regurgitation by other species of albatrosses (Matthews, 1929, 1951; Murphy, 1936), and by young Laysan Albatrosses under some circumstances (Fisher, 1904), led us to expect this during handling, but it did not occur. There was no "fishy" odor at any time near their quarters; the liquid feces, which rapidly soaked into the dry sawdust or sandy soil, had only the odor of the birds themselves, which was not at all unpleasant.

The danger from the beak, at least in these captive birds, was little. Gloves were used in feeding at first, but these were later discarded. A number of times the birds were allowed to take our bare fingers into the beak, with no effects or only minor marks. The hook at the tip of the beak could certainly tear the flesh, if one pulled away when the birds seized his hand. If, however, one did not move, they seemed to be unable to press hard enough to do much damage. If one pressed his hand toward them, they usually released immediately.

The Black-footed Albatrosses learned readily to feed from the hand and came to the person offering food when he entered their pen. They had the habit of snapping at objects dangled in front of them, and, when they had seized something, they could be induced to pull on it and move it backward in the beak by pulling in the opposite direction. Once they had thus gained a good hold on a piece of fish, they were able to force the food into the mouth by opening the beak slightly and thrusting it forward, or they could toss the fish into the air and catch it in the mouth. The Laysan Albatrosses, on the other hand, were shy, and, if they seized an object at all, seemed unable to work it back from the tip of the beak. If one pulled on an object in their beaks, they released. Thus, in the early days of their captivity, they could not be induced to feed by the methods used with the Black-foots. If, however, a piece of food or one's finger were rubbed alongside the beak about a third of the way out from the mouth, they opened the beak and the food, or finger followed by food, could be slid in. With a slight thrust, the food could then be moved into the mouth. Once in the mouth, it was almost invariably swallowed. After this was discovered, feeding the Laysans became as easy as feeding the Black-foots. Actually, one could approximate force-feeding, once the birds were trained, by merely continuing to press food on them. If the birds were hungry enough or eager enough, as for beef fat or living fish, they would pick up the food from the floor or from a dish.

Many persons feel that the name "gooney birds" for these albatrosses accurately reflects a lack of intelligence on their part. This belief in their stupidity seems to be based on observations of their awkward gait, mischances in landing from flight, and extreme docility. Actually, none of these has any real relationship to intelligence or adaptability. We are convinced, after observing these birds closely, that they are among the more intelligent and adaptable of birds. Pallesen (1940), describing the behavior of a captive Galapagos Albatross (*Diomedea irrorata*), also noted the ease with which the bird could be trained.

These albatrosses adjusted remarkably well to captivity, in spite of the vast changes in habits and climatic conditions involved. They rapidly learned to associate the gloves with food. Two of the Black-footed Albatrosses came immediately to a person with the gloves within two days after they arrived from Midway Island. A pair of gauntlets,

similar in appearance to the gloves, was used in handling the birds for experiments. After only one series of captures, they distinguished between the gloves and gauntlets, clustering around anyone who wore the gloves and avoiding anyone who put on the gauntlets. Within two weeks, they gathered near the doorway for feeding only at mid-afternoon, the daily feeding time. Furthermore, if we arrived in our automobile, in which we usually drove to their pen, they hurried to the windows and started scrapping for position. If, on the other hand, we came in some other automobile, they paid no attention until we had stepped from it with their feeding dish. Many other examples could be cited.

The three Black-footed Albatrosses, as is their wont in nature (Hadden, 1941; Bailey, 1952, 1956), were more aggressive among themselves than the Laysans and set up a dominance order based on some fighting. After the first few bouts, this never achieved more than ritualized fighting, and at no time did they injure each other. The aggressive behavior took place almost entirely before feeding, when they could see someone coming with food. The two Laysan Albatrosses did not show any aggressive behavior, and, in general, were more shy than the Black-foots, but they did resist aggression by the Black-foots by beak-snapping and fencing.

At Pennsylvania State University, the birds were given a large wading tank in the belief that they would swim or bathe in this. There was no evidence, however, that this happened. One of the Black-footed Albatrosses was wet occasionally in the mornings, but whether voluntarily or accidentally was not determined. They became progressively less tidy and were finally forced into the water a few times and bathed.

When they arrived in Maine, however, we could not find a wading tank, and sea water was provided in a small tub for drinking only. Before this situation could be changed, a rain storm came, and it immediately became obvious that these birds could bathe in rain. All spread their wings and flapped in the falling droplets, snapping at them all the while. They ran their beaks through their feathers, using a scissors-like action, and generally cleaned and preened. Interestingly enough, they even used the wet grass to scrub their heads by rolling them in it from side to side rapidly and vigorously.

This discovery led us to give them a lawn sprinkler for bathing. This was turned on for about an hour every three or four days, or once a day when the temperature was high. The reaction was the same every time—active bathing, flapping the wings and jumping up and down, some screaming, and snapping at the falling droplets. With this arrangement, the birds soon became sleek and shiny.

The sprinkler also helped with the problem created by heat. Our early worries about cold seem to have been poorly grounded. When the birds were normal with respect to salt intake, they seemed to suffer very little from temperatures as low as 38°F. The Black-footed Albatrosses, however, did show signs of discomfort when the temperature was above 75°F. Instead of sitting with the feet drawn into the feathers, as they usually did, they spread their feet and wings wide. Furthermore, they sought shade, and it was necessary to provide some cover in the outdoor cage for them, as well as to turn on the sprinkler. When the temperatures were above 75°F. at feeding time, the appetites of the Black-foots were severely reduced. On the other hand, the Laysans seemed to have a higher temperature preference than the Black-foots. They sat in the direct sunlight in temperatures up to 85°F., and their appetites were unaffected by high temperatures. They were much less eager to get into the cold water from the sprinkler. In Maine, as soon as the temperature fell below about 55°F., they went into the house. In the turkey pen in Pennsylvania, they sat in the direct beam of the glow heaters, when they were turned on.

These two species of albatrosses are of economic importance because of their habit

of soaring in front of airplanes on Midway Island, thus creating hazards to man and machines. Consequently, any method which could be found to discourage their flying or to repel them might have practical value. Some tests were, therefore, made with suggested "repellents" to see whether any of these would be effective.

As others had noted (Aldrich, 1958; Kenyon *et al.*, 1958), mere loud sounds had little effect on the birds. Pure tones at high intensities, noise bursts, and such natural sounds as loud thunder, all of which are without apparent biological significance to the birds, were ignored. Mere racket was obviously of little concern to them.

It has been suggested that the fear of snakes which some birds have might exist in these birds also. We presented to the albatrosses, at various times and under many circumstances, a number of garter snakes (*Thamnophis* sp.) and a hog-nosed snake (*Heterodon platyrhinos*). At no time did the birds even notice them. The hog-nosed snake struck at the birds as they went by, but they paid absolutely no attention to it. A number of times persons who had dogs or cats brought these near the birds' cage. Except for occasional beak-snaps at the intruders, no more attention was paid to these.

Two chemicals which have been suggested as repellents for pest birds are naphthalene and para-dichlorobenzene. Crystals of these were exposed in pans near the birds at various times under a number of different conditions. Except for interest shown by the birds in anything which resembled their feeding dish, causing them to come and inspect the crystals in the pans, these were ignored.

The birds showed definite rhythmic behavior patterns in captivity, which we were able to follow in Maine, where they were under potentially continuous surveillance. They moved little or not at all at night, although they did not sleep all night. They were active at dawn and for about three hours thereafter, depending upon the weather. When it was rainy or dark, they were active somewhat longer than when it was sunny. From about midmorning until midafternoon, they mostly rested or slept, although there was usually one individual moving about at any time. When it was hot, the sprinkler was turned on at about noon, and they then became very active in bathing and preening. The birds were fed between 5 and 6 p.m. and were usually quite active just before this. After feeding they sat quietly until nearly dark, when they moved about a little, then took their places for the night. In general each had its own preferred spot and, unless disturbed, returned to it each night. If undisturbed, they usually faced toward some object, such as the water container, and thus did not usually soil each other with feces. The two Laysan Albatrosses and one of the Black-footed Albatrosses rested and slept mostly inside the house. The other two Black-foots were rarely inside. When it rained all day, this pattern was disrupted, and the birds generally stayed out in the rain most of the time.

In general, we believe that these albatrosses would be excellent subjects for studies on the behavior and physiology of marine birds. They are large, easy to handle, and extremely docile. They can be easily trained and have predictable patterns of movement. If care is taken to assure that the salt balance is maintained, through regular feeding of salt and observation for dripping from the beak, and if suitable quarters are provided, they seem to be easy to keep in captivity for appreciable periods of time.

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SUMMARY

A study was made of the physiology of the nasal glands and the general behavior of three Black-footed and two Laysan albatrosses which were kept in captivity in Pennsylvania and Maine, after being shipped from Midway Island. Successful maintenance of these birds in captivity requires the provision of sufficient salt. Loss of NaCl by the action of the nasal glands can be reduced by avoidance of stressful situations, such as force-feeding. The bad effects of depression of the sodium level of the blood can be reduced by avoiding the feeding of invertebrate materials, such as squid, which are high in calcium and magnesium, and by feeding only vertebrate foods, mainly fish. Intake of NaCl can be facilitated by providing only sea water for drinking and by feeding salt tablets or capsules imbedded in the food. Normal sodium concentration of the blood can be assayed by feeding NaCl and observing for activity of the nasal glands, as shown by dripping of saline solution from the tip of the beak. If the birds are thus maintained in normal ionic balance, they readily adapt to captivity and train easily to hand feeding. They probably bathe in rain, and this can be satisfactorily simulated by the use of a garden sprinkler. This can also be used as a means for cooling the birds on hot days. They have regular diurnal cycles of behavior, being mostly inactive at night and at midday on sunny days.

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