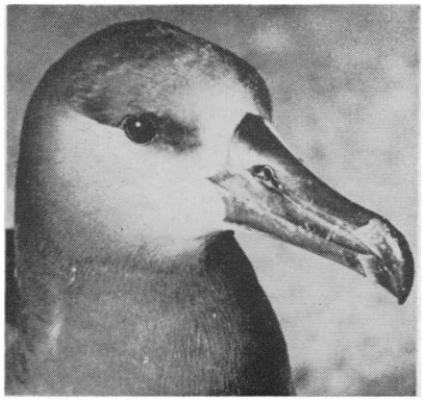
Salt Excretion by Nasal Gland of Laysan and Black-Footed Albatrosses

Abstract. Excretion of a liquid which dripped from the tip of the beak followed administration of salt loads. The Na^+ concentration in the liquid was 792 to 856 milliequivalents per liter, almost twice that in sea water. The nasal gland may thus enable these birds to meet their need for water by drinking sea water.

Recently, Schmidt-Nielsen and his coworkers have discovered that the nasal gland of two species of marine birds, the double-crested cormorant (*Phalacrocorax auritus*) and the Humboldt penguin (*Spheniscus humboldti*), excretes salt (*1, 2*). The nasal gland of birds, as these authors pointed out, has been known for a long time—in albatrosses, since 1834 (*3*)—but its function was unknown before this recent work. We have had an opportunity (*4*) to observe excretion of salt by this gland in two adult Laysan albatrosses (*Diomedea immutabilis*) and three adult black-footed albatrosses (*D. nigripes*). The two species are commonly called gooney birds. These were sent from Midway Island, where they breed. Since the sexes are indistinguishable externally, the sexes of these birds were unknown.



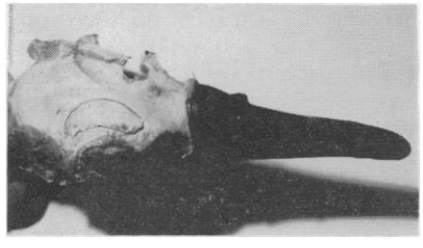


Fig. 1 (top). Head of black-footed albatross, showing tube-nostril, opening of nasal gland below nostril, and groove on beak along which nasal excretion flows to the tip. Fig. 2 (bottom). Skinned head of black-footed Albatross, showing nasal glands. The left gland has been removed to expose its bony socket. The right gland has had the capsule around it cut along the margin for differentiation in the photograph.

The birds were fed fish and given artificial sea water to drink. Voluntary drinking of this water by the birds was observed many times. A salt load was administered by feeding to each a piece of fish in which a gelatin capsule containing 0.8 g of NaCl was imbedded. Drops of the excretion appeared at the tips of the beaks of the birds, usually within 20 to 30 minutes, but occasionally in only 8 or 10 minutes. The differences may have been due to different rates of digestion of the fish. The fluid emerged from a small opening (Fig. 1) beneath the tube-nostril which is characteristic of albatrosses and other Procellariiformes. It flowed along the groove on the beak to the tip, from which it dripped or was shaken off. The drops fell at a rate of about 10 to 20 per minute during regular flow.

Samples of the nasal excretion were obtained from unrestrained birds by holding vials beneath the tips of the birds' beaks. This was tedious, for the animals often turned their heads to watch the vials, thus causing the drops to be missed. In an effort to speed up collection, the birds were restrained, but, in this case, dripping ceased within 30 to 60 seconds. Upon release of the birds, the dripping started again, within 1 to 2 minutes, usually at a greatly increased rate.

Determinations of sodium and potassium ion concentrations in the nasal excretion and blood plasma were made with a Beckman flame spectrophotometer. These data are given in Table 1. For the Laysan albatrosses, the mean value for sodium in the nasal excretion was 836 meq/lit.; for the black-footed albatrosses, 826 meq/lit. (the difference is not statistically significant). The values for the nasal excretion are like those reported by Schmidt-Nielsen and Sladen (*2*) for the penguin ($Na^+ = 726$ to 840 meq/lit.; $K^+ = 21$ to 29 meq/lit.) rather than like those for the cormorant ($Na^+ = 500$ to 600 meq/lit.; $K^+ = 5$ to 24 meq/lit.). There was no detectable change in the concentrations of these ions in the blood during excretion.

The nasal glands of these albatrosses thus act, like those of the other marine birds studied so far, to remove sodium and potassium ions from the blood. They are large and are situated in bony sockets above the eyes (Fig. 2), with ducts leading to the external openings. The similarity between the excretion in the penguin and the albatross is probably related to the fact that both are entirely marine in habitat and ingest sea water either voluntarily or accidentally. The action of this gland would enable the birds to use sea water as a source of water, in spite of its hypertonicity ($Na^+ = 420$ meq/lit.).

These albatrosses, which are large and docile, should make good subjects for studies of the action of this gland and its relationship to the water and ionic balance of marine birds. Hubert and Mable Frings have used the knowledge of the action of this gland to develop a method (*5*) for keeping these birds in captivity in apparently normal health.

Table 1. Amounts of sodium and potassium ions (meq) in the nasal excretion and blood plasma of albatrosses. Blood samples were drawn before feeding of NaCl and during excretion following feeding of NaCl. (σ_M, Standard error of the mean.)

No. of samples	Na^+ (meq/lit.) Range	Na^+ (meq/lit.) $M \pm \sigma_M$	K^+ (meq/lit.) Range	K^+ (meq/lit.) $M \pm \sigma_M$
	Nasal excretion			
7	792–856	829 ± 7.3	20 –28	24 ± 1.0
	Blood plasma before excretion			
4	162–171	167 ± 1.9	4.9– 7.0	5.7 ± 0.4
	Blood plasma during excretion			
5	159–170	164 ± 2.0	4.6– 6.0	5.4 ± 0.3

HUBERT FRINGS
ADAM ANTHONY
MARTIN W. SCHEIN
Departments of Zoology and Entomology and Poultry Husbandry, Pennsylvania State University, University Park

References and Notes

1. K. Schmidt-Nielsen, C. B. Jörgensen, H. Osaki, *Am. J. Physiol.* 193, 101 (1958).
2. K. Schmidt-Nielsen and W. J. L. Sladen, *Nature* 181, 1217 (1958).
3. G. Bennett, *Proc. Zool. Soc. London* 1834, 151 (1834).
4. These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and Pennsylvania State University (NR160-464). The birds were shipped by air through the cooperation of the Bureau of Aeronautics, Department of the Navy, and naval authorities on Midway Island, to whom we wish to express our appreciation. This is paper No. 2285 in the "Journal Series" of the Pennsylvania Agricultural Experiment Station.
5. A report on this method is in preparation.

31 July 1958

Correlation of Drug Penetration of Brain and Chemical Structure

Abstract. A study has been carried out on the permeability of the brain and a brain tumor to certain aromatic boronic acids with regard to their use in the neutron capture therapy of gliomas. The penetration of the brain by these compounds is discussed as a function of chemical substituent and benzene-aqueous partition coefficient.

The possibility of destroying differentially a group of neoplastic cells adjoining normal cells is presented by the nature of the reaction when boron-10 or lithium-6 captures a slow neutron (*1*). A large amount of energy liberated is shared between the two heavy fragments