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OBSERVATIONS ON BEHAVIOR IN CAPTIVE FULMARS

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The writer collected Pacific Fulmars (*Fulmarus glacialis rodgersii*) in the winter of 1946-1947 in connection with an investigation of the physiology of stomach oil production. Four specimens were secured alive. Since very little concerning the behavior of Pacific Fulmars, wild or captive, has been reported, it seemed worth while to record some of the behaviorisms observed in these birds.

METHODS OF CAPTURE

Two methods of luring fulmars to baits have been employed. The first, less successful than the second, involves the preliminary attracting of gulls, with the hope of exciting the interest of passing fulmars. The collector is lowered in a small skiff from a larger vessel about five miles off shore. As soon as he releases the falls, the ship's cook, by previous arrangement, dumps the previous day's refuse into the sea. That this maneuver immediately attracts gulls in considerable numbers goes without saying. The collector then sets out his baits, which consist of pieces of salt pork each fastened to at least three number 12 treble hooks, which, in turn, are secured to a length of light wash line floated with corks. If there are any fulmars in the vicinity, they are likely to be drawn to the scene by the activity of the gulls. If a fulmar does appear, it wastes no time, as a rule, on the garbage, but immediately investigates the baits, which seem to interest only the more daring, or perhaps, less experienced gulls. The chief disadvantages of this method are interference by gulls and the temporary nature of the lure, that is, the ship's garbage either sinks or is soon consumed.

The second method, which is to be preferred since it attracts petrels but does not excite the interest of gulls, is the salt pork grease method attributed by R. C. Murphy to R. H. Beck. If the sea is very calm, it proves quite reliable. The collector either rows out to sea from shore or is lowered from a larger vessel. In addition to the baited line referred to previously, he is equipped with a small gasoline stove and a considerable quantity of salt pork grease which he has prepared on shore. When he reaches a point far enough off shore to be assured of meeting fulmars (about two miles seems to be enough, although the birds are frequently seen on the seaward edge of the kelp beds), he lights the stove and melts some of the grease. When it is hot and crackling, he pours a little on the sea, and rows on. He sets his course so that when he has created a slick of pork grease a half mile long and a hundred yards wide, he may drift at one end of it. Whale blubber oil was tried, but the film formed by this material was too delicate and was broken up by the slightest breeze. He then sets out his baits and occasionally drops a little more hot grease over the side.

If a foraging fulmar, flying low over the surface of the ocean, crosses the slick, it is as good as in one of the sacks waiting in the bottom of the boat. It will promptly double

back and forth, coursing up drift along the slick not unlike a hound on a fresh trail, seeking the source of the fat. When it sees the baits, it will alight on the water, swim up and commence tearing at them without any preliminaries whatever. Such a slick will cause Black-vented Shearwaters to deviate from their courses, but birds of this species are interested neither in refuse nor in baits. The fulmars tear at the baits by grabbing them with the hooked tip of the maxilla and pulling back vigorously. This tendency—to tear their food, rather than to wolf it as do the gulls—results in the birds being hooked by the tip of the beak rather than by the tongue or pharynx. They will duck under for baits suspended under water, but the writer has not seen the fulmar dive.

On February 6, 1947, the writer captured three fulmars in a morning's "fishing." The first bird sighted the slick and came to the baits at 9:00 a.m. It started tearing at them immediately and was so adept at bait stealing that forty-five minutes elapsed before it was caught. Four times during this period the bird was enticed so close to the boat that attempts to snare it with a casting net were made, but each time it darted out from under the mesh. This threat to its freedom was not recognized as such and it was not in any way deterred from returning to the baits. About twenty minutes after its arrival, a second fulmar appeared. Each time the second bird approached the baits, the first fulmar drove it away, actively snapping at the wings and neck of the former. The victim emitted a throaty clucking noise, but the aggressor was silent. At about 9:45 a.m., the first fulmar was caught and placed in a sack, whereupon the second fell upon the baits as though famished and was caught about three minutes later.

Later in the morning, a third fulmar was seen resting quietly on the sea about fifty yards away. A quantity of grease was poured on the water, and as soon as the edge of the slick reached the bird, it swam up and commenced sampling the baits. A minute or two later it was in a sack in the boat.

Of the many extraordinary characters which distinguish the petrels, their utter fearlessness is by no means the least. It is unquestionably a corollary of the adaptation to pelagic life. Mammalian predators probably affect them only during the breeding season and such enemies must be few, judging from the general inaccessibility of their nesting sites. The otic infection which kills hundreds of adults and offshore gales are probably the factors chiefly responsible for holding fulmar populations in check. Bent (1922) cites several references to the trust shown by both the Atlantic and Pacific races. So the fulmar brain probably contains no innate mechanism whereby its owner is apt to respond distrustfully with regard to human beings. The birds are apparently so constituted that, when suitable food is available, they are incapable of associating the manner in which it is presented—in this instance, on hooks—with possible hazard to themselves. Not so, of course, with the gulls. Usually, as soon as a gull perceives that bait is attached to a line, he drops it and moves away. If hooked, the gull seems immediately to associate its predicament with the human on the other end of the line. The fulmars pull back when drawn toward the boat, but with none of the obvious terror which motivates the wild thrashing of the gull. One may hoist a fulmar over the side with no more ado than in landing a smelt, but it takes some exertion to haul in a gull. The petrel seems unconcerned about anything except that somehow it has become entangled. The gull seems to be more aware of the actual state of events. Not until it was grasped by the head did any of the petrels seem to be concerned by the presence of the writer. None regurgitated oil at the time of capture. In the sacks, they constantly poked about, seemingly looking for a way out and occasionally they uttered a plaintive chirp, which, in reality, may have been a sneeze and not a true vocalization. Their activity in the darkness within the sacks is perhaps correlated with the fact that most petrels are normally as active in the dark as in daylight. Gulls are completely quiet, once confined in sacks.

MANNER OF CONFINEMENT

The four fulmars were kept in an outdoor, concrete tank, four feet by eight, with constantly changing sea water at a depth of five to ten inches. As a rule, the birds were separated by wooden partitions, a measure made necessary by the mutual antagonism displayed at feeding time. The tank was enclosed by a double cage of chicken wire which, because the petrels were unable to surmount the walls of the tank, served mainly to protect them from molestation. Each bird was provided with a wooden feeding tray and a wooden platform upon which to rest. Three of the birds showed no concern, at any time, about being confined. Not even when they were evidently hungry did they behave as though they had ever experienced any other environment. The fourth, which incidentally was the poorest feeder and the first to succumb, spent most of its waking hours

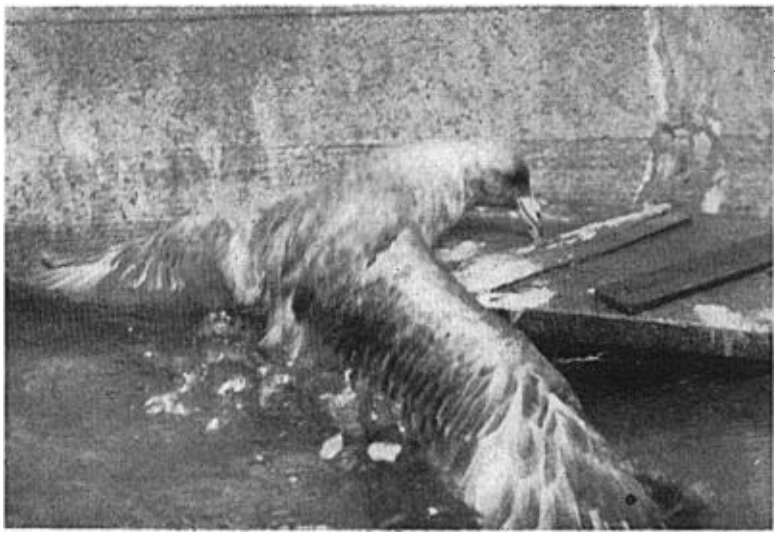

Fig. 1. Captive fulmar climbing on platform.

butting against the wall as though seeking a way out. When the partitions were removed, this bird attacked all of the others with savagery not entirely associated with greed for food. The only times at which the remaining birds showed fear were first, when the writer entered the tank to clean it, and second, whenever he made an unmistakeable move to grasp one of them. His presence at the entrance of the cage seemed usually to be viewed with quiet, alert interest rather than with fear.

USE OF THE PERCHING PLATFORMS

The writer was astonished at the alacrity with which the fulmars accepted and made use of the perching platforms. Out of deference to the weakness generally characteristic of procellariiform legs, the platforms were constructed to clear the water by not more than two inches and were equipped with cleats to provide purchase in climbing. At first, the use of the hooked bill and of the wings was indispensable to getting the initial toenail hold in climbing onto the platform. In the future the writer plans to equip the platforms with duck boards extending into the water. The fulmar swims to the edge of the platform, reaches forward and hooks the tip of the maxilla over one of the cleats, paddling vigorously, flaps its wings and finally gets a toenail or two hooked on the edge. Then, still pulling with its beak and using its pectoral appendages as arms rather than as

wings, it hoists itself up on the structure (fig. 1). After several weeks of captivity, the fulmar's legs grew strong enough to enable them to hop from the water onto the platform with no help from the bill and only a vigorous flap or two of the wings. When leaving the platform, the birds were obliged to scramble off, but were later able to jump into the water. The fulmars rested on the full length of the tarsi. Occasionally these were raised above the outwardly projecting side feathers as the bird rested on its broad, well-padded ventral surface. This sometimes gave rise to a ludicrous situation arising from the bird's holding itself down by the side feathers when it would attempt hurriedly to rise and get into the water. When the bird elevates itself to stretch or to cackle, it may lift its body on the phalanges alone, the tarsi being raised to an angle of more than forty-five degrees from the horizontal.

When the tank was drained for cleaning, the petrels would stand motionless with the tarsi almost vertical for fairly long periods. When the writer entered to scrub the floor of the tank, a wild panic would usually ensue, the fulmars madly scampering about, tripping and tumbling over one another in their efforts to avoid him. Only the first few steps, in such instances, would be taken on partially extended tarsi.

The eagerness with which the fulmars made use of the platforms is in agreement with the reports, cited by Bent, of the manner in which birds of the Atlantic race scramble onto floating ice when they have eaten so much that they cannot fly. Yet one would suppose that a bird which spends three quarters or more of the year at sea would prefer to rest on the water. It may be safely said that at no time did these petrels actually *rest* on the water in the tank, since they entered that medium only to avoid the observer, to feed, to exercise, or to engage in some other sort of overt behavior. They invariably slept on the platforms, although, in the wild state, they must perforce sleep on the ocean surface at times, at least. Very likely the Pacific birds ride on icebergs also. It would be very interesting to determine whether or not they rest on flotsam in the lower latitudes.

SWIMMING AND BATHING

The fulmar is an agile, if not particularly speedy, swimmer. The remarkable denseness of its ventral plumage which, in good condition, is extraordinarily water repellent and the boat-hull shape of its ventral contours serve to make it extremely buoyant. The upper two segments of the legs are used hardly at all in swimming, motion being restricted to the tarsus and webbed toes almost exclusively. When idling, the legs are fairly relaxed and the tarsi tend to extend laterally as they are waved gently back and forth. When turning and pivoting, they are also extended laterally. But when swimming more energetically, they are extended downward and quite a good deal of thrust is brought to bear in such swimming patterns as plunging in the bath, stretching and exercising the wings, in the peculiar sort of water treading associated with feeding to be described subsequently, and in taking off into flight.

The captive fulmars have demonstrated a remarkable fondness for bathing. One wonders just what sensory impressions evoke the bathing response. One of them was observed to bathe continuously for more than an hour on several occasions. This bird eventually drowned, partially as a result of what seemed to be its inability to satisfy an uncontrollable urge to bathe. The fulmar starts the bath by rearing up repeatedly on rapidly paddling feet, before ducking its head under for the first time. The head is raised immediately after the plunge, water being thrown over the back. The plunge is repeated rapidly, the breast being raised well off the water with the bill depressed before the head and neck go under. When the bird begins to become soaked, the wings are spread on the surface to aid in supporting the body and to give additional purchase in rearing for the next plunge. The birds become thoroughly sodden and bedraggled after

some minutes of this, so much so that a good deal of the natural buoyancy is lost. Much of the bird's body then sinks, the use of the spread wings becoming quite essential to prevent foundering. They often become so drenched that they are hardly able to crawl back onto the perching platforms. Two which eventually were found dead in the water evidently succumbed because of inability to regain the safety of the perching platform. That neither of them was malnourished was attested to by the fact that autopsy revealed richer subcutaneous and visceral fat deposits than the writer has seen in *any* bird. It is possible that because the birds received a diet containing a plethora of fat, their lipid metabolism was deranged in the direction of storage at the expense of normal utilization, with a resulting inability properly to anoint the plumage with preen gland wax. The preen glands were fat and one of the birds had produced copious quantities of stomach oil which differed markedly from that described in the literature (see below).

This foundering or wallowing seemed not to diminish the bird's interest in continuing to bathe at all. It is possible that something about inadequately oiled plumage evoked sensory impressions undistinguishable to the birds from those which normally induce bathing in the wild. On the other hand, wild birds may bathe quite as vigorously without encountering the hazard of a thoroughly sodden plumage.

The preening which followed the bath was ordinarily performed on the perching platform. It differed in no noticeable respect from that seen in other birds. The birds were quite able to preen while sitting on the water, as may be supposed.

FEEDING

The diet of the captive fulmars was, for reasons dictated by the physiological experiments for which they were obtained, restricted to hog tissues. Hog lung, liver and heart were given *ad libitum*. The material was cut into small pieces and was placed on the wooden feeding trays. Usually the birds rested on the water while feeding, but if the perching platforms were placed near the trays, they would not always bother to enter the water. Choice morsels would be picked up from the dry concrete floor of the tank when it was drained for cleaning purposes. One bird almost invariably jumped from his perching platform into the water only to scramble out onto the feeding tray, consuming the meal while standing on the full length of the tarsi (fig. 2). If, in his haste, he assumed such a position that his toes only supported him on the tray, his precarious balance was partially supported on half-extended wings. These observations indicate that the fulmar, unlike certain other, more or less primitive sea birds, is capable of recognizing food out of the water. The fact that the feeding trays were used from the first day in captivity shows that this was not due to learning and suggests that when circumstances render it useful, the fulmar may at least clamber upon objects large enough to support it while feeding in the wild.

When the fulmar feeds from the water, it swims up to the tray, selects a morsel, backs away, and proceeds to manipulate it before swallowing it. The food may be shaken from side to side in the water, masticated, and, if it is dropped, retrieved by ducking the head under. The gape is then spread, the mouthful swallowed, and the bird returns to the tray for another morsel. After several have been swallowed, the birds invariably resort to the water treading maneuver alluded to earlier. In this, the legs are paddled vigorously and the entire ventral surface of the bird is raised clear of the water. The wings remain folded, as a rule. Quite a swirl of water passes under the bird as it "treads water." This may be repeated several times before the bird resumes feeding. The frequency with which the behaviorism occurs increases as the meal progresses, until the bird can eat no more. At least two explanations for this behavior pattern occur to the writer. It is possible, on the one hand, that it enables the bird to achieve easy and orderly pass-

age of bulky food particles into the proventriculus, which is a large organ extending throughout the length of the body cavity. Since the sternum is short, the greater portion of this part of the alimentary tract is separated from the exterior only by the thin abdominal wall and the ventral plumage. It is thought that the bird senses the entry of food into this structure and is so stimulated to perform this characteristic response. On the other hand, this performance may only be an homologue of the manner in which the fairly closely related whalebirds cause eddy currents to bring plankton toward their

Fig. 2. Captive fulmar feeding on platform.

open beaks while feeding. It was mentioned that a considerable swirl of water passes under the fulmar as it "treads water." It may be that, in the wild, fulmars also induce floating food particles to move in their direction in this manner, the mechanism being automatically evoked as an integral portion of the feeding response, whether or not the desired result is achieved.

Sea water is drunk in generous quantities before, during, and after the meal. The water is swallowed directly, without dependence on gravity as seen in most terrestrial birds. When the fulmar can eat no more, it will toy with food for some time before turning its interest to some other activity. A bath frequently follows feeding.

Bent stresses the fulmar's fondness for fatty food. The captive fulmars have rendered excellent substantiation to this report. Out of deference to this character, which seems to be based on a physiological requirement as yet to be worked out, the diet of the captives was always supplemented by small chunks of pure lard. A typical response to this supplement is as follows. As the writer placed chunks of liver, heart and lung on the tray which was, as the bird was well aware, within his reach, the petrel sat on its platform, clucking eagerly and showing great interest in the proceedings, but not

daring to come within reach. But when the three or four cubes of lard were dropped on the tray, all fear was forgotten, and the bird literally jumped off the platform, landing with a splash near the tray, to down the lard as fast as this could be done. He would then back away to await the writer's withdrawal before resuming feeding. Those portions of the food which were light colored were selected first. The dark red liver, far more nutritious, and, in fact, more fatty than either the lung or the heart, was left to be eaten last.

From the very first, the petrels were able to select the more desirable lard from among the other morsels, probably primarily because of an innate tendency to choose light colored food, and secondarily because of association processes. Pieces of heart and liver which sank to the bottom at the shallow end of the tank were occasionally retrieved by ducking, but they accumulated in the deep end, where the bottom could be reached only by diving, a maneuver to which they never resorted.

The food was preserved in the freezing compartment of a refrigerator and was therefore very cold when fed. This did not deter the birds from consuming it rapidly, although the body temperature was often sufficiently lowered to cause violent shivering. Although wild petrels often feed with wings extended, the captives usually did so with wings folded.

The writer suspects that, with regular feeding times in captivity, the fulmars became accustomed to responding to food with greater regularity than is probably the case in the wild. Their occasional indifference to food when first caught prompts him to conclude that wild fulmars eat to the point of complete satiation when the opportunity presents itself and will then perhaps ignore food until the enormously distensable proventriculus is once again empty enough to evoke the sensation of hunger.

VOCAL BEHAVIOR

Bent quotes Stejneger as commenting on the "whinnying voice" of the "glupisch," and Captain Collins as reporting that the fulmar (Atlantic race) confines itself to a sort of chuckling sound, somewhat resembling a low grunt. He also quotes Morris who states "The noise that a large flock make is almost deafening, something between the cackle of a hen and the quack of a duck." Bent himself reports observing "a [Rodgers fulmar], presumably a female [that was] sitting on a ledge when a male flew up and alighted beside her; with his beak wide open and his head thrown back until it pointed straight upwards, he slowly waved his head from side to side uttering a soft, guttural, croaking note." This was interpreted as a courtship performance.

The statement is frequently made that the fulmar is a silent bird as a rule, and the writer's observations support this contention wherein it applies to lone individuals. But when others of its kind are about it can be very active vocally. All of the sounds the writer has heard these birds make seem to be derived from a basic croak, perhaps identical with that reported by Collins. This croak may be described as a short, guttural *uck*. When food was presented to the birds the croak was repeated rapidly with the bill almost if not quite closed, the sound becoming a sort of *buck! buck! buck!* When the birds were grasped the croak became a rasping *aaark! aaark!* given through open beak as the bird snapped and struggled in its effort to escape. When one bird was attacked by another, it would emit a *buck! buck!* somewhat similar to that used in anticipation of feeding. But the most elaborate derivative of the croak is what the writer terms "cackling" and which probably is identical with the cackling reported by Morris. When two birds approached one another, the complacent clucking of one would suddenly break into a strident *ăh, ăh, ăh, ăh, ăh, ăh, ăh, ăh, ŭh-ŭh-ŭh-ŭh-ŭh!* As this call was given, the beak was opened fairly wide, the head was raised and the bird's attention was di-

rected toward its companion. The outburst was either greeted by the other bird in kind, or with the more subdued *buck, buck* (fig. 3). Occasionally, particularly on windy days, the petrels were very active vocally and cackling duets were heard repeatedly. The significance of this behavior is as yet unknown. Sometimes, when the cackling had been indulged in for some time, one of the birds, if sufficiently "warmed up" would start "braying." This braying, unlike the ordinary cackling, seems to be produced by alternate inhalation and exhalation, just as in the quadruped with which braying is usually

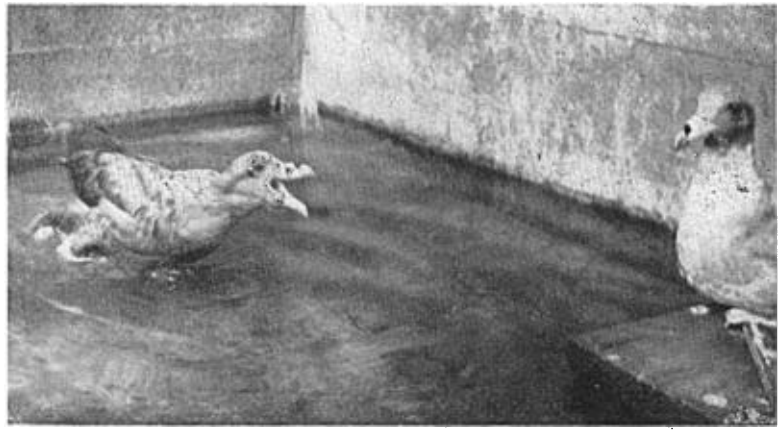

Fig. 3. Attitude characteristic of fulmars while cackling.

associated. Thus we have an *ăh, ăh, ăh, ăh, ăh, ăh, ăh, ăh, ăh, ŭh-ŭh-ŭh-ŭh-ŭh-ŭh-hongh-ŭh-hongh-ŭh-hongh-ŭh-hongh!* The expiratory honk is deep and resonant.

Lone birds were never heard to make any sound except the rasping, snarling croak which accompanied their efforts to escape from one's hands. Thus all the other sounds may be ascribed to social responses. The clucking and cackling may be elicited by imitation. The cackling is certainly indicative of an emotional outburst, because while doing so the fulmars may raise themselves, extending the tarsus if perched, or paddling vigorously if sitting on the water, and fanning the air vigorously with the wings. Conclusions as to the significance of these sounds will have to be deferred pending study of the birds in the field.

OBSERVATIONS ON STOMACH OIL

A physiological character which distinguishes the Procellariiformes from other water fowl is the ability to produce in the proventriculus, which is a secretory stomach rather than a crop, a waxy oil which is regurgitated in response to noxious stimuli and when feeding the young. The ornithological literature is rich in references to this phenomenon. Murphy (1936) has presented a concise discussion of the problem, stating that "the function of the oil is not known, beyond the fact that it is discharged as if in defensive reaction, when the birds are approached." He goes on to comment upon the several hypotheses that have been hazarded as to its function. He discounts the supposition that it serves as food for the young on the basis that "the oil does not contain the quantity of protein that would be expected." Yet large quantities of this oil accumulate in the digestive tracts of young petrels, so much in fledgling Atlantic Fulmars that the natives of the Faeroe Islands are said to have used them as candles. When fledgling "mutton birds" are exploited for their oil by the natives of New Zealand, the carcasses are suspended by the head to keep the oil from running out. It must be borne in mind that

fledgling petrels and albatrosses, which are usually fed but once daily and which are abandoned by their parents before they are able to fly (three months or more in the Wandering Albatross), have a real problem in water metabolism. When an animal's physiological economy has so evolved that it must depend on the combustion of food for its water supply, an highly adaptive lipid metabolism usually appears. Witness the high fat content of egg yolk, the fat deposits in the camel's hump and in the tails of the Gila monster and the Australian fat-tailed lizard. The enormous fat deposits in female bears which lactate for months during hibernation without feeding are certainly the source of the water secreted in the milk. It is not altogether unlikely that the oil regurgitated by the petrels constitutes the fledgling's water supply. The proteins requisite for differentiation and growth could be supplied in the form of semidigested material regurgitated with the oil. The high hydrocarbon content of the oil would surely provide sufficient energy and water for growth, not to say survival only, when the fledgling has been abandoned on its nest or in its burrow. That there seems to be a relation between the reproductive process and the regurgitation of oil is supported by the fact that the oil has not, to the writer's knowledge, been observed in any of the larger petrels which occur during their respective non-breeding seasons in California waters. No trace of the oil has been found by the writer in healthy fulmars collected in December, January and February, but the captive fulmars commenced oil production in March. It would therefore seem that the possibility that the oil constitutes food for the young should not be ruled out without further study.

Murphy also feels that Hagerup's conclusion that the oil is merely an undifferentiated product derived from the bodies of minute crustaceans is not warranted, since the oil occurs in petrels which have not eaten crustacea and in young birds which have fasted for long periods. It is likely that Hagerup's conclusion was precipitous, but there is a possibility that the oil does arise as a relatively undifferentiated product of partial digestion of not only crustacea but also of other marine organisms, such as squid, which may have fed on crustacea before being consumed by the petrels. The writer has not yet failed to find squid bills either in the proventriculus or in the gizzard of any fulmar or shearwater he has examined. Moncrieff (1946) points out that ambergris, another lipoidal material of musky odor, found in the digestive tract of the sperm whale, an exclusive feeder on cephalopods, is a residue of incomplete digestion of these mollusks. The Merck Index, however, states that ambergris contains about 80 per cent cholesterol, wherein it differs markedly from petrel oil. However, it is possible that there is some relationship between feeding on squid, which seems to characterize most petrels, and the production of the proventricular oil. That there is considerable similarity in chemical composition between petrel oil and spermaceti may be a relevant point (Rosenheim and Webster, 1927).

The proposal of Rosenheim and Webster, who analyzed oil taken from a fledgling Atlantic Fulmar, that it represents an accumulation of preen gland oil (which has a similar composition) hardly seems tenable in view of the absence of stomach oil in non-breeding birds. However, there is no reason to suppose that the stomach oil, when available, does not supplement the product of the preen gland, for indeed, the feathers of freshly collected petrels and, in fact, those of very old petrel skins, invariably smell of the odor attributed to the oil. When petrels are producing stomach oil, it may be present in such abundance that it will bubble and spatter at the nostrils concurrent with respiration (Murphy, Bent).

The fact that petrel oil has a relatively high melting point (it is in fact a wax, rather than an oil) makes dubious the validity of the hypothesis of Green (1887) that the material may be used "to calm the troubled surface of the sea about the birds during

severe storms" (quotation from Murphy). For this purpose, an oil which remains fluid at low temperatures is needed.

Rosenheim and Webster showed that the ruby red color of the unsaponifiable matter of fulmar oil is due to carotenes. It was with the view of testing the possible secretory origin of the oil and its pigment that the diet of the captive fulmars was restricted to hog tissues, which contain no carotenoid pigments whatever. Only one brief experiment was performed and that on a single bird. This individual, after it began to regurgitate oil in March, could be relied upon to produce from five to twenty milliliters of oil, when sufficiently provoked, at any time after that. The technique of obtaining the sample is simple. One enters the enclosure with a large beaker in one hand, and after cornering the bird, annoys it with his free hand, by snatching at its tail and allowing it to snap at his fingers. Presently the bird begins to gasp and wheeze. The beaker is placed in front of or over its head, and in a few seconds the sample is violently ejected. If the bird is taken into the hands, there is less likelihood of securing a sample. The regurgitation seems quite involuntary and in no sense may be construed as being directed with reference to the source of annoyance. The occasional appearance of a lump of partially digested food shows that when only oil appears, it does not follow that no solid food is contained in the proventriculus. This ability to regurgitate liquid and retain solids is an extraordinary adaptation.

After several control samples of oil, which on superficial examination resembled nothing so much as rancid pork grease, were secured, the bird was subjected to a course of injections of a 1:9 mixture of alpha- and beta-carotene suspended with the aid of Tween 80 (Atlas Powder Co.) in a minimal volume of 0.9% aqueous sodium chloride. The suspension was injected on alternate days, subcutaneously in the region of the right breast, each dose containing about 2 milligrams of pigment. At the time of each injection and for a period of two weeks after the last (a total equivalent to 12 milligrams having been given), oil samples were secured. No detectable trace of carotenoid pigment was found in any of these samples. On autopsy, prodigious deposits of subcutaneous and visceral fat were found, and the only tissue containing any carotene was the subcutaneous fat overlying the right breast and axilla. The fact that the bird failed to assimilate the injected pigment may have been linked with the almost pathological deposition of depot fat. The unusually fatty diet to which it was subjected may have swung its fat metabolism so far to the storage side that it was incapable of normal utilization. However, the fact that the oil which was regurgitated by this bird more closely resembled pork grease than the petrel oil described by Rosenheim and Webster may lend support to the hypothesis that the proventricular oil is a digestive by-product rather than a secretion.

SUMMARY

Fulmars were caught on hook and line after being lured to baits by the commotion caused by gulls feeding on garbage or by a hot pork grease slick. The petrels took the baits without hesitancy and could hardly be frightened away from them. Consistent with this tameness, while they were still free, was the calm with which they accepted captivity. For birds which spend most of their lives at sea, the fulmars showed a remarkable preference for resting on solid platforms, onto which, at first, they could climb only with great difficulty.

An unusual penchant for bathing was possibly due to abnormal plumage condition resulting from a diet restricted to hog tissues. In feeding, the fulmars showed preference for light-colored food, particularly fat. The birds fed either from the water or while perched on feeding trays. A curious paddling performance associated with feeding was noted.

Four types of vocalization were observed, three of them obviously social in function. No production of stomach oil was observed during the winter months either by wild birds or by the captives, but the oil produced by the latter after the middle of March more closely resembled rancid pork grease than the oil described in the literature. The several hypotheses concerning the origin and function of the stomach oil are discussed.

ACKNOWLEDGMENTS

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