activity of the organisms—for example, of the marine bacteria—while they are nearly without effect upon the solubilities of the inorganic matters which are adapted to becoming food for the vegetation. It thus seems that the cause of the richness of cold waters and of the poverty of warm waters should be sought in the difference of development of the bacteria of putrefaction in the largest sense of the term, and in the influence of these bacteria on the proportion of nitrogenous compounds in the water.

Among these bacteria, the nitrifying bacteria exercise their function in arable soil only at a temperature above about 5° C. (41° F.). In all probability there are in the sea other sorts, nitrifiers and denitrifiers, able to accommodate themselves to other temperatures. Still, in the present state of our knowledge, we may assume that bacteria cease to act at the freezing point, or a little below that point. But if denitrifying bacteria can not perform their function in cold waters, it follows, almost necessarily, that polar seas must be richer in nutritive substances than tropical seas. In a large part of the polar seas the temperature of the whole liquid mass from surface to bottom remains even in summer, near 0°. North of a line extending from eastern Greenland to Norway, through Iceland and the Faroe Islands, the temperature at the bottom is generally below 0° C. South of this line the temperature of the deep waters of the Atlantic is certainly not much higher, because the cold water of the polar seas flows into the deep region toward the equator. But at 1,000 meters (547 fathoms) the temperature is already 4° to 5°, and for depths of less than 100 meters, as well as along the coasts, it is notably higher, so that the bacteria here find, precisely as in the productive layers of tropical seas throughout the whole year, conditions favorable to their life. In the temperate zones the destruction of nitrogenous compounds is too limited during the winter and it is only in summer that it becomes important. Finally, in the Mediterranean the conditions of life of bacteria are still more favorable than in the Tropics, because a bar across the Straits of Gibraltar prevents the cold water from entering. Hence, even at great depths (of about 1,000 meters), there is always a temperature of 12° to 16°, which explains the development of bacteria in the whole liquid column observed and the consequent striking quantitative poverty in plankton of the Mediterranean Sea.

If we can not dismiss absolutely the idea of a denitrification that can not be neglected in the ocean, it appears to me highly probable, according to the observations hitherto made, that this decomposition of the principal vegetable nutritive substances is preferentially accomplished in warm regions.

THE BREEDING OF THE ARCTIC FOX.[1]

By Henry de Varigny.

The taxonomic position of the arctic fox has been the subject of a good deal of discussion, which perhaps is not yet closed. It appears, however, that, for the naturalists, at least—the furriers thinking differently—there is no doubt about the matter; the arctic fox, being a perfectly characterized species, *Vulpes lagopus*, the *isatis* of F. Cuvier and Gmelin. On this point authorities agree, such as St. George Mivart, in his monograph on the *canidæ*, and our distinguished collaborator, Truessart, in his Catalogus Mammalium.

The arctic fox inhabits the Arctic zone, Spitzbergen, Greenland, northern Siberia, Nova Zembla, and the northern part of North America; in short, the extreme northern parts of both the Old World and the new.

The species is curious in several respects. Of all the *canidæ* it is probably the only one which, in certain regions at any rate, performs regular migrations, as Richardson's observations show that it does. The arctic fox is said to live in societies or communities of twenty or thirty families, in groups inhabiting the same number of holes or burrows in one neighborhood. In winter they go south, driven away by the cold and by the consequent scarcity of food, keeping usually near the coast. According to Parry, they begin to quit Melville Peninsula in November. In January very few remain behind. The southern limit of their migration varies. Along the coast they advance farther than they do in the interior, sometimes reaching north as far as the parallel of 65°, and they have been seen as far south as 59°, exceptionally even at 53°. Like other foxes, they are carnivorous. But what game can they find in winter? The birds of passage are gone. Not one is left. Yet the arctic fox does not hibernate. He retains all his activity throughout the long polar night, and to sustain this activity he must get food. Mr. Alfred Newton, who observed these foxes in Spitzbergen in 1863, asked himself whether they did not perchance lay up provisions during the fine season. But if so, where would these

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hidden stores be, which nobody had ever seen? One day Mr. Newton came across a heap of shells of fresh-water mussels, *Mya truncata*, in the moraine of a glacier, and it occurred to him that it might be the *kjökkenmödding* of some fox, the leavings of his winter meals. He thought that foxes might very likely store up in summer some provisions, mussels for instance, which they would use in winter.

This hypothesis has been amply confirmed, at least in certain respects. It is evident that if the arctic fox made sufficient provisions, he would not have to migrate in winter. But, on the other hand, it is certain that he gathers enough to last him for some time. H. W. Feilden put this beyond doubt in 1875, during the Nares expedition. Having shot a fox, he noticed that little lemmings came out of their holes all about, and began nibbling leaves and blades of grass. But there were also quantities of dead lemmings, and these had died violent deaths, namely, from a fox's bite in the skull. Looking nearer, adds Feilden, he was surprised to find numerous accumulations of dead lemmings; in a corner, a little way off under a rock, he found a pile of more than 50 of them. Caches of 20 to 30 carcasses each were numerous; and the ground was pierced with many holes, each containing several carcasses of lemmings covered with a little earth. One hole he found to be stuffed with the greater part of a hare. Here is an interesting case of reciprocal action. For where the caches of lemmings were numerous the ground was, of course, richer in fertilizing matter, so that the vegetation was more abundant, and this relative exuberance of vegetation, of course, attracted more lemmings. Thus, the behavior of the foxes favored the multiplication of lemmings about their burrows; and they could not have contrived anything more ingenious if they had acted deliberately.

The arctic fox is not astute. In this respect he is markedly inferior to his cousin of the temperate zone. He can be caught in the same trap where he had been made prisoner only a few hours before. He does not fear man, with whom, it is true, he has but an imperfect acquaintance, which partially explains his freedom from timidity. On seeing a man, he retires to a little distance, stops, and scrutinizes the newcomer long before he finally takes his leave. He is easily domesticated, is not rancorous nor malicious, and is gentle and confiding. He is free from the odor of the fox. He is most cleanly, extremely careful of his person, and will not foul his lair.

Captain Lyon, who, in the eighteenth century, during two winters passed on Melville Peninsula, observed the arctic fox at close quarters, relates that when this fox is given anything to eat, his first impulse is to hide it as soon as he can, no matter how hungry he may be, even if he is alone and has no companions in captivity of whose probity he might

be disposed to entertain some doubt. In such cases he makes great use of snow; for nothing is easier than to heap it up over the hidden store, and then to press it down hard with his nose. A captive fox often used an ingenious stratagem when he had no snow at his command. He would take the whole of his chain into his mouth, and then carefully wind it up on the ground so as to hide his meat. When he went away, satisfied with having accomplished his object, he would, of course, unwind his chain, and expose the meat. Thereupon, he would go at it again, as before, with the utmost patience, recommencing five or six times in succession, until, at last, tired of this business, he would make up his mind to swallow his prey without having rendered it more appetizing by keeping it underground.

The Eskimos take the arctic fox in ingenious traps which, according to Captain Parry, consist of a sort of little round hut of stone, closed everywhere except on top, where there is a square orifice. This orifice is closed by whalebone fixed only at one end, and passing across the aperture. A little snow put on the whalebone makes the place look like solid ground; but when the fox, attracted by bait so placed that to get it he has to pass over the whalebone, puts his weight upon it, it gives way, and down he goes, too deep to get out, while the whalebone springs back into place, all ready for another fox; and two are often caught.

The arctic fox, like many other animals, has a fur which varies much, both in abundance and in color, at different seasons. This fur, which covers even the plantar side of his paws, especially in winter (thus at once protecting them against the polar cold and facilitating locomotion over ice), is white in winter and in summer has a grayish-brown color, giving a slightly bluish effect. This transformation of the hair does not appear with other members of the dog family. Nor does it invariably take place; for there are arctic foxes that remain "blue" all the year round, while others never cease to be white. This led F. Cuvier to distinguish two species, the one changing color and the other remaining white. But, in fact, the two sorts of individuals belong to the same species; indeed, young of the two kinds may occur in the same litter, according to Schreber. On the other hand, it seems that in Iceland all the foxes retain their blue livery all the year round, never donning the white.

Even in his winter costume the arctic fox is never completely white, the nose and the end of the tail generally remaining black. Moreover, many foxes become rather gray than white during the dark season. Many are only relatively blue. This coloration presents numerous differences of [chromatic] intensity.

Seeing that the pelt of an arctic fox will sell for $20 or more, provided it be "blue," and for nothing at all if it be white, it is not to be wondered at that some ingenious spirits have been led to practice the

breeding of these animals. The narrative of the Harriman expedition, recently returned from Alaska, informs us that the Alaska Commercial Company is doing this in several islands of the region it exploits, and in particular in the neighborhood of Kadiak, where the experiment has succeeded to perfection and where the company has established "blue-fox farms," which are in a flourishing condition.

These farms are, in fact, as simple as possible. The breeding simply consists in feeding the foxes during the winter, in protecting them from their natural enemies, and in only capturing and killing them under prescribed conditions. In order to be able to protect its wards, the company places them where they can not get away. It captures a number of them on the mainland and puts some couples on certain islands where there were none before and whence they can not escape. It provides for their needs by establishing stations on these islands where special employees go to carry the animals food, consisting mainly of fish, fresh or dried, or else put up in oil. No salt fish is given to them, because it is believed that that would mar the beauty of the fur. This food is left every day of the year in certain places, which the foxes get to know, so that they resort there.

Very ingeniously, the company causes the food to be always placed in traps, which, however, are not set too close. The animals thus acquire the habit of entering traps and do so without distrust. Thus, when it is desired to capture any, the traps are set and do their work with certainty. Food is given to the foxes all the year round, as much as they seem to need, judging by the haste with which they eat what they get. They get most in May, June, and July, because it is then that they litter, and the females consequently need a great deal of food.

When the fur is in fine condition the foxes are trapped in the manner above explained. The females are spared in order to favor multiplication, being set at liberty after having been marked with scissors in the caudal brush. Those males whose fur is suitable are killed; a few of the very finest are, however, set free to improve the breed.

It is to be remarked that the foxes do not live exclusively on the food furnished them. They eat, besides, what they find, which varies their fare, for they prowl about the shore and pick up any dead fish which the sea may throw up; they follow the bears and eat what they leave, and they hunt the rodents, so that in some of the farm islands mice have been quite exterminated. The best parts of the fish are not given to the foxes. They are fed on salmon mainly—the heads, and, in short, whatever is not dried or preserved for man.

It seems that not all the foxes are equally sensible of good and bad treatment from men. In most of the islands there are individuals who will not come to take the food that man distributes, but, avoiding the traps, live entirely on what they can find for themselves.

The foxes on the farms are numerous enough to be remarked as one

goes about. Besides, they are curious and not timid. On an island of Prince William Straits there is a farm where 50 or 60 adults are fed on salmon and halibut. It is useless to offer them cod; they will not touch it. They are there accustomed to seek their food in a little house, which acts as a trap during the short period when their fur is the finest—that is to say, from December 20 to about January 10.

The arctic fox is abundant in the Pribylov Islands, or, rather, it was formerly so, and at present efforts are making to restore the abundance. On the island of St. George an American Government agent, Mr. Judge, has devoted several years to this question and has ascertained interesting facts. It is a rocky island, heaved up into a chaos, where birds flock in great numbers to breed, and is particularly suitable to the fox, if only his subsistence is insured for the winters, for otherwise he will not remain, but will embark on the first ice sheet which in spring comes near enough, and that will be the last of him, whether he reaches some distant shore or not. In summer he will remain quietly, for, in the first place, he can not do otherwise, and then birds are plenty, and eggs too, as well as young seals whose mothers have been killed and who have been left to starve. The pelagic hunting of the fur seal has been rather advantageous to the foxes because of the number of small seals which have perished and furnished food. There are some 2,000 foxes on the island of St. George. They fed upon lemmings (*Lemmus nigripes*) until the latter became well-nigh extinct. In winter they get their living on the shore, and, curiously enough, live largely on sea urchins, of a species of *Strongylocentrotus*, which are found on the rocks that are left uncovered at low tide. They also eat grass in winter, and worms, which they scratch out of the sand. They also swallow sea squirts and carcasses of fish. But, on the whole, their living is precarious at that season.

Attempts have been made, perhaps not persevering enough, to introduce rodents allied to the rabbit. The acclimatization of the spermophile found at Unalaska has also been proposed. Preserved food has been tried, such as linseed-meal biscuits. The foxes did not like it, though they take it eagerly when it is flavored with seal oil. Mr. Judge gave the foxes carcasses of seals, and these not being enough, he finally used entire bodies, salted or frozen, digging "silos," where the provisions were stored till they were needed. The foxes appreciated this kindness only too much, for one day 60 or 70 of them got into the silo, tore up and pulled out the seals, and feasted so that several of them died of surfeit. Since the foxes do not like salt meat, the seals are soaked in fresh water before being given to them. The seals are given to the foxes when the time of their capture approaches by every evening leaving some bodies, not more than ten, at the place where the traps are to be placed. At the proper time the traps are set. The

females are set free, after having been marked, and some of them have been taken so often that their brushes have been quite spoiled. White females are, however, always killed in order to get rid of any tendency to the production of a breed that should turn white in winter and to establish a stable blue breed. The traps are large enough to take 40 foxes at once in each.

The practical problem of fox farms involves a psychological problem. In order to obtain the best results it is desirable that the foxes should practice polygamy. Now, they are naturally monogamous, but endeavors are made to induce them to become polygamous by reducing the number of males. The success of these efforts is still doubtful, but there are some encouraging indications. For example, the destruction of many males has had no appreciable effect upon the births. It may be noted that the collection of all the foxes into one place to feed makes promiscuous gatherings, which, it is hoped, may affect their moral nature.

According to the observations at St. George Island, the foxes have no predilection for any particular spot. They go about and only remain in one neighborhood as long as they are satisfied with the food. It is therefore easy to make them all come regularly to one place, and this is done. Their food is left near the village, and for the most part they remain thereabouts. It is easy to get sight both of the adults and the young, both of which are very curious about man and much given to observing him and his ways.

On this island, as elsewhere, it is stated that the arctic fox is much less astute than his European cousin. He allows himself to be taken in the same trap several times in succession, sometimes at intervals of ten minutes. Yet it will not fail to be remarked that neither this circumstance nor the fox's not avoiding places where man may be scented can seriously be regarded as a mark of low intelligence, seeing that the foxes who are so often trapped and let go again are thereby taught to regard the ambush as a joke. His experience assures him there is nothing to be feared. Those who are killed never return to tell the tale; and the arrangements are such that the others have no reason to suspect that any tragedy has taken place, for they are killed on a boat offshore, so that no blood may be spilled on the ground. Perhaps this is needless caution, for foxes are not very susceptible to extreme concern about deaths in their tribe, and they even resort to cannibalism whenever hunger presses them to it. So that the smell of blood or sight of remains of their kindred could hardly be very terrible to them; nor are their intellects so penetrating that they would be likely to draw inferences in regard to their own possible fate.

Observations at St. George Island show that the fur is in its perfection when the animal is in its first and second year.

The experience of farming is thus far encouraging. If success crowns the efforts that are making to break down the deplorable monogamy of the foxes, all will go well.

Some figures relative to the captures made in the season of 1898–99 may here be given. The "season," be it remembered, lasts but a few days, during which the animals' fur is in the exact state desired by the furriers and the public. During that season, then, 334 blue male foxes were taken and killed, 34 blue males were killed otherwise, 18 white foxes of both sexes were taken and killed, 110 blue males and 389 blue females were taken and set free.