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MUSEUM OF ZOOLOGY

MISCELLANEOUS PUBLICATIONS NO. 25

THE MOOSE OF ISLE ROYALE

BY
ADOLPH MURIE

ANN ARBOR, MICHIGAN
UNIVERSITY OF MICHIGAN PRESS
July 7, 1934

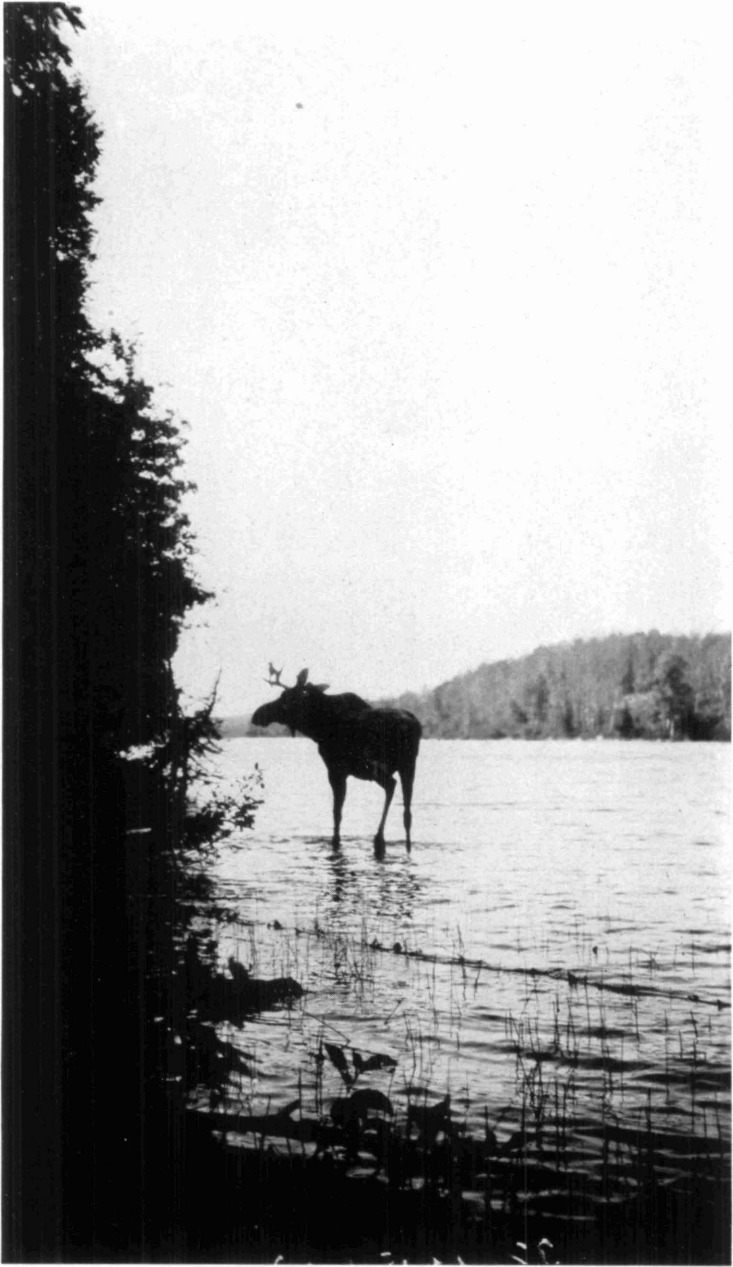
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FREDERICK M. GAIGE,
Director of the Museum of Zoology



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CONTENTS

| | PAGE |
|-------------------------------------|------|
| INTRODUCTION | 7 |
| PHYSIOGRAPHY OF ISLE ROYALE | 8 |
| VEGETATION OF ISLE ROYALE | 9 |
| HISTORY AND NUMBERS OF MOOSE | 9 |
| DESCRIPTION | 10 |
| DEVELOPMENT | 11 |
| SHEDDING | 12 |
| SENSES OF MOOSE | 13 |
| HOME RANGE | 16 |
| DAILY ACTIVITY | 16 |
| SOCIABILITY | 17 |
| INSECT PESTS | 18 |
| ACCIDENTS AND DISEASE | 18 |
| THE RUT | 20 |
| RUBBING OF ANTLERS | 20 |
| MATING | 21 |
| FIGHTING | 23 |
| BEHAVIOR | 24 |
| CALLING | 25 |
| CALVES | 26 |
| FEEDING HABITS | 29 |
| SUMMER FOOD | 30 |
| WINTER FOOD | 31 |
| ANNOTATED LIST OF FOOD PLANTS | 32 |
| Trees and Shrubs | 32 |
| Herbaceous Plants | 35 |
| STOMACH CONTENTS | 37 |
| SALT LICKS | 37 |
| DEPLETION OF RANGE | 39 |
| MANAGEMENT | 41 |
| SUMMARY | 43 |

THE MOOSE OF ISLE ROYALE

INTRODUCTION

In the spring of 1929 the Fifty-fifth Legislature of the State of Michigan passed an act directing the making of a survey of Isle Royale and made an appropriation of fifteen thousand dollars to cover the expense of the work. The University of Michigan was designated to conduct the project which was placed under the general direction of the Director of the Museum of Zoology. As the intent of the Legislature in passing this act seemed to be a broad and general survey of resources which would furnish data hitherto unknown in regard to the potential future uses of the island, the project was divided into four major parts: anthropology, botany, geology and geography, and zoology. The field work was organized under these general heads and the reports are classified in a similar way. While the funds available were inadequate for the comprehensive survey required, a very large amount of new data was assembled, and in the winter of 1931-32 some fifteen completed detailed reports with numerous maps, charts, and plates were submitted to the Governor. These reports were later deposited with the Isle Royale Commission, then with the Department of Conservation, and, finally, as no publication of the reports seemed possible, they were returned to the University with authorization by the Governor for publication in proper science journals and proceedings. The present paper on the moose is the first one of the reports of the survey to appear; several others are in process of publication.

I was assigned the study of the mammals of Isle Royale. Two papers were prepared as reports on the field investigations, the present one on the moose and a second one which it is hoped may appear later on the other mammals of the island. Emphasis has been given to the study of moose for several reasons. In the first place there is but little specific knowledge of the habits of the species, and since it was abundant on the island, opportunities for studies were excellent. Furthermore, the moose present something of a problem on the island. There is little opportunity for the animals to leave, and as there is apparently little check on their increase, it becomes obvious that sooner or later many plant species will be over-browsed to the extent that it will require years for a return to normal, and some extinction is possible. Because of the important relationship between the feeding of the moose and the preservation of the landscape, further emphasis was placed upon the food habits and the condition of the food plants.

On July 14, 1929, I arrived on Belle Isle, Isle Royale, accompanied by my assistant for the summer, Paul F. Hickie. The following day we set

up camp at Pickerel Cove, where we were located until August 5 when we moved to the head of McCargoe Cove. It proved to be a convenient location from which to work, for from it we had ready access to a large part of the eastern half of the island. The use of a boat equipped with an outboard motor facilitated travel. We camped at McCargoe Cove until we left the island on October 12.

I revisited the island on May 4, 1930, in company with Norman A. Wood, who was to study bird migration. From May 4 to May 16 I worked in the vicinity of Belle Isle, moving to McCargoe Cove on May 17 to camp with George Stanley, who was studying the old beach levels. On May 26, we left there in an outboard motor-boat and circumnavigated the island, returning June 7. Our camp sites on the trip were so chosen that I was able to cover most of the island by tramping inland from each stop. After completing the journey, I worked at McCargoe Cove until June 23, when I left the island.

I am indebted to Clair A. Brown, of the University Herbarium, for identification of plant material; to H. W. Schoening, of the Bureau of Animal Industry, United States Department of Agriculture, for kindness in examining pathologic conditions in some moose mandibles; to Olaus J. Murie, United States Biological Survey, for reading the manuscript, and to Paul F. Hickie, of the Museum of Zoology, for his help during the first field season. I am especially grateful to Frederick M. Gaige, Director of the Museum of Zoology, who had charge of all the work on the island, for his constant interest and help in the undertaking.

PHYSIOGRAPHY OF ISLE ROYALE

Isle Royale lies more or less parallel to the north shore of Lake Superior, thirteen miles from the Canadian side at its closest point. Its width varies from four to eight miles, and it is approximately forty-five miles long, with an area of about 220 square miles.

There are two main ridges which run parallel to the long axis of the island, that is, from northeast to southwest. The Greenstone Ridge has the highest elevation, reaching an altitude of over 550 feet; it lies about in the center and runs the entire length of the island. About a mile northwest of Greenstone Ridge is the far less prominent Minong Trap Ridge. Between these are a number of lesser ridges whose heights range from 100 to 300 feet. The ridges are formed of tilted volcanic rock with a steep and precipitous northwest face and a gently sloping southeast face.

Numerous lakes and bogs lie between the ridges, with the long axes parallel to them. There are more than thirty lakes, generally long and narrow, most of which are in the northeastern end of the island; they range in size from seven miles long by one mile wide (Siskowit Lake) to ponds a half mile long.

The imperfect drainage on the island favors the retention of swamp and lake habitats. There are no large streams; during the summer the watercourses become low, some of them drying up entirely.

The soil is stony, sandy, and shallow on the higher ground. On the ridges bed rock is exposed in many places, but in the bogs considerable soil has accumulated.

VEGETATION OF ISLE ROYALE

Mixed forests of birch and poplar, consisting of more or less uniform stands of various ages, cover a large part of the island. Extensive stands of balsam and white spruce grow on the lower ground. Balsam saplings, which are much more prevalent than white spruce, are sparingly distributed in much of the poplar and birch forest.

White cedar predominates in the bogs; black spruce and tamarack are not plentiful. A few red pine, jack pine, and red oak occur on the higher ridges. There are a few stands of large white pine, and their charred stubs are frequently found on the island. Stands of sugar maple grow on the higher ridges, especially on the southwest end of Greenstone Ridge, where there are magnificent forests of huge maples. Mountain maple occurs sparsely throughout the forest. Mountain ash is most abundant in the lower ground; it is widely distributed but nowhere is it very plentiful.

Pennsylvania cherry, juneberry, and huckleberry are to be found on the stony ridges. Two species of alder are abundant, *Alnus incana* on the lower ground, *Alnus crispa* on the dryer soil. *Cornus stolonifera* is common, growing in a variety of situations.

The undergrowth consists of *Diervilla lonicera*, *Aster macrophyllus*, *Rubus parviflora*, *Cornus canadensis*, and several ferns, as well as other herbs in lesser numbers. Formerly there was much ground hemlock, but as a result of heavy browsing by the moose, now only the bare branches remain. Around the lake margins *Myrica gale* is quite common, apparently taking the place of willow, which in most localities is rather rare.

Grasses and sedges grow in favorable spots. Several species of pondweed, rush, and horsetail are to be found in the lakes.

HISTORY AND NUMBERS OF MOOSE

J. Abner Sherman, of Dearborn, Michigan, states in a recent communication that when he visited Isle Royale in 1880 moose were very scarce. Sometime prior to 1880 he had visited the island and had seen four or five moose out on the ice. In former years moose apparently crossed over from the mainland at intervals, but hunting was probably at that time sufficient to prevent the moose from becoming numerous or gaining a foothold.

Charles C. Adams,¹ reporting on his visit to Isle Royale in 1905, does not mention moose in his annotated list of mammals. It may, however, have been there, for Max Peet, a member of the party, observed some maples "which had been broken down, the branches, bark, and leaves stripped off, and the small branches eaten away." The feeding was attributed to caribou, but it is more probable that it was the work of moose, for this type of feeding agrees exactly with the feeding habits of the moose and is not characteristic of the caribou.

According to persons long familiar with Isle Royale, the last influx of moose occurred during the winter of 1912-1913. That winter was so cold that the water between the island and the mainland to the north froze over. The presence of moose on the island the following summer is correlated with conditions of the previous winter, and it is presumed that a few moose crossed over on the ice. Since 1913, the moose has increased in numbers until now it is very abundant.

Without an organized count of some sort it is practically impossible to know the moose population. From general observations I should estimate that in 1930 there were at least a thousand moose on Isle Royale, and I think that a count would give a figure far above the estimated minimum. As a rule, wild populations are greatly underestimated, so it would not be surprising if the actual number of moose in 1930 proved to be two or three thousand.

DESCRIPTION

A good description of the color of *Alces americana* in full pelage is given by Seton:

A fine bull moose shot near Kippewa, Que., by Mrs. E. T. Seton, September 25, 1905, in good condition, was black on fore legs, breast, shoulder, flanks, and hams, shading into rusty brown on withers, back, neck, and head; palest on nose and lips, and shading into white on the belly; the insides of ears also were whitish; the legs from the knee to the ground were of pale, warm gray or Caribou color. The appearance of this animal at a distance was that of a black beast, with brown head, and white stockings.²

The color fades toward spring, at which time the hairs become frayed and worn. The sexes are much alike, except that the brown face of the cow seems lighter than that of the bull. The calf, as described elsewhere (p. 11), is light brown without spots. The bell is present in both sexes and in the calf. It varies greatly in size and shape in different indi-

¹"Ecological Survey of Isle Royale, Lake Superior," *Rept. Board Geol. Surv. for 1908*, prepared under the direction of Charles C. Adams. Lansing, Michigan: Wynkoop Hallenbeck Crawford Co., 1909. Pp. i-xiv, 1-468, 63 figs.

²*Lives of Game Animals*, Garden City, N. Y.: Doubleday Doran and Co., 1929. III, pt. 1, 153.

viduals. It is especially long and broad in the males, usually simple and short in the females.

Measurements and weights of three bulls and two cows are given below. Under "dressed weight" the hide, head, metatarsals, metacarpals, stomach, and intestines are not included. In every case, lost blood was not included in the weight. Weight is given in pounds, other measurements in millimeters.

| Taken | Total Length | Tail | Hind Foot | Ear fr. Notch | Height at Shoulder | Dressed Weight | Total Weight |
|---------------|--------------|------|-----------|---------------|--------------------|----------------|--------------|
| Adult July 22 | | | | | | | |
| Cow 1929 | 2570 | | 790 | 265 | 1825 | 400 | 728 |
| Adult May 20 | | | | | | | |
| Cow 1930 | 2044 | 120 | 760 | | | | |
| Young Aug. 28 | | | | | | | |
| Bull 1929 | 2210 | 110 | 760 | 250 | 1690 | | 593 |
| Adult June 9 | | | | | | | |
| Bull 1930 | 2625 | | 806 | | 1825 | 544 | 848 |
| Adult June 18 | | | | | | | |
| Bull 1930 | 2475 | | 775 | 237 | 1900 | 523 | 847 |

DEVELOPMENT

Because of the small number of specimens on hand and the absence of certain age classes in the series available, no extensive discussion of development is possible. It seems desirable, however, to give the data obtained.

The youngest specimen is a fetus taken from a cow shot on May 20, 1930. The tips of the hoofs are soft and white. The incisors have broken through the gums, but the milk premolars have not yet erupted. The fetus is fully haired, and the eyes are open.

In a twin calf, collected on June 14, 1930, only the first two milk premolars in each jaw, besides the incisors, are functional. The short, fine hair is in whorls, and over most of the body is a dull, reddish brown at the tips and gray at the base. The breast and belly are grayish. The juvenile coat is shed after two or three months.

A male calf taken on August 10, 1929, has all milk premolars functional, although the last upper milk premolars have but recently emerged and are not quite grown into place. No wear can be seen on any of the teeth. The molars are just forming. The first molars, upper and lower, are emerging through the thin sheet of bone which covers them. The lower first molar seems a little more developed than the upper first molar. Only a few remnants of the juvenile coat are left, principally on the face, mane and legs. The new coat is dark, grayish brown, with a silvery cast

over the shoulders and neck. The face is brown, legs light brown, fore legs darker than hind legs. There is a small, whitish area in the inguinal region.

A calf taken on August 14, 1929, is similar to the one taken on August 10, except that less of the juvenile pelage remains. The milk premolars are all functional.

A yearling female, taken June 15, 1930, still retains most of the winter hair, which is much worn and frayed. The black tips of the hairs are worn away, giving the pelage a uniform grayish brown color. The new pelage is coming in under the old, over the entire body. The bell, hidden by the winter pelage, is covered with new, short, black hairs. The backs of the ears are bare except for a few short incoming hairs. The first milk incisor has been shed and replaced by the first permanent incisor. The rest of the milk incisors are still in place. The milk premolars are much worn and are being pushed out by the permanent premolars. The first upper molar is fully functional, the second upper molar only partially so. The first and second lower molars are functional. The third molar, upper and lower, has not yet appeared. The third lower molar is slightly more developed than the third upper molar.

We have no specimens of known age beyond the yearling stage. The following table gives measurements and weights of the calves and the yearling collected.

| | Taken | Sex | Total length | Tail | Hind foot | Height at shoulder | Live weight |
|----------|---------|-----|--------------|------|-----------|--------------------|-------------|
| Unborn | May 20 | | | | | | |
| Calf | 1930 | ♀ | 880 | 40 | 410 | 720 | 22 |
| Twin | June 14 | | | | | | |
| Calf | 1930 | ♂ | 1125 | 38 | 475 | 950 | 67 |
| Calf | Aug. 10 | | | | | | |
| | 1929 | ♂ | 1430 | 55 | 560 | 1055 | 153 |
| Calf | Aug. 14 | | | | | | |
| | 1929 | ♀ | 1545 | 90 | 605 | 1280 | 183 |
| Yearling | June 15 | | | | | | |
| | 1930 | ♀ | 1925 | 112 | 675 | 1375 | 280 |

SHEDDING

The much frayed and faded winter coat is shed during May and June. On May 5, 1930, large bunches of hair were abundant at the licks and along the trails, where the animals had accidentally rubbed against branches. During June the pelage has an especially ragged appearance. Bare spots, where the winter pelage is shed and the incoming hair is too short to be noticeable, occur on various parts of the body, most frequently

on the flanks and the ventral region and the posterior side of the ears. During July the new coat is thin and short. By September the pelage is again long and thick.

A pregnant cow, which was taken May 20, 1930, has shed very little of the winter coat except on the face and backs of the ears, which are almost bare.

A bull taken June 9, 1930, has lost most of the old pelage. A new short coat of brown hair has come in on the head, the ears are bare except for the short hair just appearing, and the belly and chest regions are nearly bare. The new coat over the body is sparse and short. Much of the hair is just appearing.

A cow shot July 22, 1929, has lost almost all of the old coat except a sprinkling of old hair on the flanks. The new coat is short and thin.

The pelage of a young bull taken August 28, 1929, is quite long and thick, but still is much shorter than the condition reached in the fall.

SENSES OF MOOSE

Impressions concerning the development of the special senses of the moose have been, for the most part, obtained from observations carried on in the field, generally under uncontrolled conditions and in the presence of many variables. It is for this reason that there has been much divergence of opinion among naturalists concerning the acuteness or dullness of some of the senses. It would be possible, by the selection of certain observations made on Isle Royale, to produce a fairly good case to show that the moose has a poor nose, or a good nose; has poor or good eyesight; is indifferent or alert to sound and scent of man; is watchful or unwary. So varied is the behavior that it is difficult to predict what any individual will do when influenced by any of his senses. From the literature it appears that inconsistencies are common in the behavior of the animal wherever it is found.

On Isle Royale, where the moose has come in frequent contact with man, usually without incurring any harm, it apparently has lost much of the wariness with which it is often credited. It is frequently indifferent to scent, sound, or sight of man. Numerous individuals were noted which were not at all vigilant.

On one occasion I watched a solitary bull at a salt lick. It seemed certain that he was scenting my presence, yet he did not appear to perceive me. I broke a stick to attract his attention. Peering in my direction, he sniffed and seemed to scent me at once. He continued sipping water, but he was restless and continually sniffed the air, and soon left the lick. The incident might indicate that the senses of an alert animal will function more keenly than those of one not on its guard.

The large ears of the moose serve well to gather in the softest sounds. Any one watching an alert or suspicious animal will at once see that it makes good use of its ears. They are turned toward the lightest noise, the better to gather in the sound. Animals feeding in shallow water, with the head submerged except for the ears, are often observed to focus them in various directions. If a noise is made when the moose is in this position, the head is at once jerked out of water, and the attention is directed toward the source of the noise.

Sounds, as a rule, do not seem greatly to disquiet the peace of mind of the animal. After being disturbed by a breaking twig or similar noise the moose quickly regains his composure if no further noises attract his attention. Most noises, however, especially those of a certain type, are viewed with suspicion. At salt licks, my attention was often attracted to the approach of moose by the erect ears of those animals at the lick. Sometimes I was certain that the approaching moose had not been scented, and the sounds it made were so faint that they were at first inaudible to me. On many occasions when approaching a lick I found the animals there looking in my direction, although I had taken the greatest care to walk quietly and to keep the wind in my favor.

The reactions of a moose to a sound probably depend on the state of mind of the animal. I once shot a calf at close range, which was feeding in a marsh but fifteen yards from its mother. At the sound of the shot from the high-power rifle the mother did not even raise her head, but continued feeding as though she had heard nothing. On two other occasions, harmless noises which must have been familiar to the animal seemed to startle it. Once a kingfisher rattling by over the tree tops caused a cow to look up. Another time, the calling of a blue jay attracted a moose's attention.

Most sounds seem only to direct the attention of the moose to the presence of possible enemies. The sound in itself, at least on Isle Royale, does not usually cause flight. The sense of smell and sometimes that of sight are used for the actual identification of the source of the noise, and dictate the reaction to it. In some instances moose were greatly alarmed and left in precipitous flight at the sound of the human voice. Once, when calling a bull, I suddenly talked in my natural voice. The sound caused him to reel and dash away through the alders. Several other experiments had the same result.

The eyesight of the moose is relatively poor and of but little use in detecting danger. I once spent seven or eight hours at a salt lick, hiding behind a tree but ten inches in diameter and only fifteen yards from the moose. Part of my body was in sight at all times, yet motions necessary in taking pictures passed unnoticed or obtained but momentary attention from the half dozen moose which were at the lick during most of my stay. At

the lakes I often stood in the water, in plain view of an animal feeding but a short distance from me, and was unnoticed until I moved. Even then, if I kept quiet, the moose were likely to continue feeding. When man is plainly seen moving close by, the moose generally dashes away. Often when suddenly frightened it will press the hind legs together and will urinate on them before running away; this behavior is probably due to action of the sympathetic nervous system.

The sense of smell is highly developed. Messages brought through the air to the nose are accurately analyzed and interpreted. The behavior which follows is dependent, no doubt, on the instincts of the animal and its past experience. The Isle Royale animals generally turn away when man is scented, but unless the smell is very strong they are not greatly alarmed, and often seem unmindful of it. At one salt lick they often wandered all around the blind, hardly noticing my presence, although they undoubtedly had my scent. Since this particular lick was salted and therefore very attractive to the moose, and since it was frequented by tourists, the habitual moose pensioners no doubt had become accustomed to human scent and had lost somewhat their fear of it.

An experience I had during the fall would seem to indicate that the moose's fear of man is instinctive. Favored by a cross wind, I watched a family party consisting of a large bull, cow, and a calf as they fed in my direction. The calf, walking about ten yards ahead of the cow, suddenly got my scent when fifteen yards to one side of me. It stopped, wheeled, and galloped back to the cow, who was momentarily startled but continued feeding up to the spot where the calf had scented me. She also scented me but did not deviate from her original direction and walked slowly ahead as though feeling her way. After advancing in this manner for ten yards to a place where my scent escaped her, she walked steadily forward. The calf hung back a bit, but when it came to the spot where it had got my scent before, it hesitated momentarily, then galloped quickly forward to its mother. The old bull behaved much as the cow did, except that he stood for some time staring in my direction before going on beyond the "tainted" air. If the adults had reacted to the scent in the same way as did the calf, they would surely have turned and fled. Through experience they had lost much of their instinctive dread of man.

Other calves at salt licks have behaved quite differently from the above individual. One little fellow approached so near to where I was standing beside a tree that I could have touched it.

To summarize, in spite of apparent inconsistencies in behavior, I should say that hearing and smell are highly efficient in moose, and vision somewhat deficient.

HOME RANGE

The moose, according to all testimony, restricts his wanderings in winter to a very limited area, if food is plentiful. This may be due more to inertia than to the inability of the moose to travel at this season, for his long legs serve him well in deep snow.

Observations made during the summer of 1929 indicate that the moose at this season likewise tends to confine his movements to a small area. Data on home range were made possible because, due to characteristic forms of the antlers, some bulls were easily recognized. By recording each appearance of the recognizable bulls some information on home range was secured.

A twenty-one³ point bull was seen feeding at the head of McCargoe Cove each day from August 22 to August 31, except on August 25 and 26. On some days he was there both morning and evening. On August 24 at noon he was in the woods about one-half mile from the cove, so perhaps he did not wander far from it during the day.

A ten-point bull was observed at Sargent Lake in the same place on August 22, 27, and September 5. A bull and cow were seen together on a ridge, September 27, and the same bull was there with two cows on September 29 and October 1.⁴

A small seven-point bull appeared at a salt lick at McCargoe Cove on September 22, 23, 24, 25, 29, and 30. On several occasions he was found lying down during the day only 200 hundred yards from the lick. Although the attraction of the lick may have been a factor in restricting his wanderings, its influence must not be overestimated for there were other licks within a mile.

Possibly an individual drifts slowly from one place to another during the summer, but the entire range appears to be rather small. There may be some travel from a summer to a winter range, but it seems probable that many of the animals remain in the same general region the year round. Judging from the amount of winter browsing on the ridges I suspect that moose congregate to some extent on the higher ground where perhaps the snow is not so deep as on the lower ground. During the rut, bulls in search of cows probably travel more widely than they do at other seasons.

DAILY ACTIVITY

During the day, from about 7:00 A. M. until 4 or 5 P. M., the moose feeds and rests intermittently. During these hours a few moose may be seen feed-

³ By this phrase is meant that the total number of points on both antlers is twenty-one.

⁴ In Wyoming, O. J. Murie reports finding in August a large bull which remained for four days in a patch of willows 200 yards square; the fourth day he was disturbed when photographed. This was not an isolated patch of willows but was adjacent to large similar areas, which fact makes his aversion to travel more remarkable.

ing, but at any one time most of them are no doubt lying down. At some of the more frequented salt licks a few moose can be found at any time of the day, and this is true for a few of the lakes, such as Sargent and Ritchie, where the moose feed on the pondweeds. The moose does some feeding throughout the night, for individuals have been heard at all hours after nightfall.

Greatest activity, when all the moose are on the move, centers around daybreak and nightfall. At some of the licks under observation ten to twenty moose were assembled at dusk and early in the morning. An hour after daybreak most of the morning visitors dispersed to adjacent ridges to lie down to chew their cuds. The evening visitors remained active for several hours before lying down.

The moose rested in all sorts of situations. They were found resting at the edges of licks, on the ridges, in open stands of poplar, on a flat, or in a swale. Animals were often seen to lie down but a few paces from where they last fed.

SOCIABILITY

The moose is not a herd animal. During the summer as many as twenty moose were observed at one time at a salt lick, but individuals came and went irrespective of the movements of the others. In some of the lakes five or six animals often fed in close proximity to one another, but here also they behaved as individuals. Although bulls generally travel alone during the rut as well as in summer, two bulls were often found together. Cows were commonly found alone. During the winter moose are said to "yard up" in small groups, but even at this season, at least in other localities, lone individuals are not infrequent.

At a lick where a salt block had been placed only one animal fed at a time, except when a cow and calf were there together. When approached by another cow or young bull, the cow in possession of the salt lowered her ears and rushed at the intruder. On many occasions when the intruding cow refused to be intimidated, the animals faced each other with muzzles held high, reared up on their hind legs, and struck out several times with the front feet. This was in part sparring, for they simply pawed the air. After this manoeuvre one or the other retreated.⁵

If a bull approached a cow at the salt, he usually retreated when the cow threatened him with lowered ears. On one occasion, when several cows and young bulls (mostly one- and two-year-olds) were assembled near a salt block, one of the cows not occupied at the salt at the moment gave chase to a two-year-old bull, and followed him for about forty yards. At the same

⁵ Such sparring with the front feet is common among the elk of Wyoming, where large groups gather when hay is scattered for them.

time a two-year-old bull continued feeding at the salt for several minutes, even though a cow was manoeuvring near him with lowered ears. Later, because of the persistence of the cow, he apparently preferred to depart rather than be bothered.

INSECT PESTS

Flies annoy the moose considerably throughout the summer. A small fly, *Haematobia alcis*, was collected from an animal immediately after it was shot. Flies which appeared to be of this species were seen on a majority of the moose. It is interesting in this connection that this fly was first described in 1891, and since that time has been regarded as a "lost species," as it was not found again until these collections were made on Isle Royale in 1929.

On July 15, the first day that moose were observed in 1929, most of the moose carried raw spots, varying in diameter from one to two inches, on the hind legs from four to ten inches above the calcaneum, where the hair is short. Instead of one large spot, there were sometimes two or three small ones; all were usually black with flies. By September scabs were beginning to form on the spots. No raw areas were seen on moose in 1930 up to the time I left the island, a little after the middle of June, although there were many flies about the moose.

On June 20, a cow observed lying in the shade chewing her cud was much annoyed by flies. Her ears were working continuously, and her muzzle was used to chase the flies from her hind quarters. She finally walked down to the water and lay almost submerged in it. Becoming aware of me she returned to the shade, but in a short time again lay down in the water and leisurely chewed her cud.

On several occasions large horseflies kept hovering around an animal's muzzle, causing it to toss its head up and down in an effort to escape them. When swimming, the moose were generally followed by a swarm of flies.

It is often stated that moose go to the water to escape the flies. Except for the instance above mentioned, moose in the water were always feeding, which would seem to indicate that their primary reason for going there was to feed and not to escape insect pests.

ACCIDENTS AND DISEASE

The moose usually ventures unhesitatingly across bogs or into mud holes with apparently no fear of becoming mired. In some salt licks moose were often seen submerged in the mud so that only the shoulder hump showed. On one occasion, I watched a yearling struggling through mud which nearly covered his entire body. He was not at all concerned, although he progressed with great difficulty. At intervals he rested with his neck

stretched out on the soft mud. While still deeply mired, he sipped from the little pools of muddy water on the surface with not the least anxiety over his position.

The bones and carcasses found in bogs and licks are evidence that individuals occasionally lose their lives in such places. Possibly old or weakened animals find their strength insufficient to release themselves. One old bull with dwarfed, blunt antlers and stiffened joints had difficulty in extricating himself from soft mud which reached only a few inches above his ankles. This animal was very weak, for later when I followed close behind him with a camera, he fell down on his knees when turning on me. Such an animal could easily become mired where others would have no difficulty in getting out.

The circumstances of tragedy were plainly written in one place where I found the outstretched skeleton of a young bull. In crossing a quaking bog, his hind foot had been caught in a forked root and had been held fast.

I found two carcasses in June, 1930, one a cow, the other a young bull, in two different licks, one located among some alders, the other at the edge of an alder thicket. It seems likely that both animals had been caught by a submerged root, for neither was deeply mired. (The presence of a dead moose had caused the two licks to be deserted by other moose.)

Schofield, owner of the Belle Isle resort, reports extricating a cow which had become mired in a swampy place near Lake Eva, a year or two previous to 1929.

At Todd Harbor, I found the carcass of a bull which had been washed ashore. George Stanley reported finding the carcass of another bull in the water. Possibly these animals had been drowned.

Several lame animals were noted. On August 24, 1929, a lame cow was seen at McCargoe Cove. On September 21, 1929, a three-point-bull was limping badly. A large knob protruded from the knee of the left fore leg. On October 3, 1929, I came upon a huge bull lying among some thimbleberry bushes. He tried to run but due to a lame fore leg could go little faster than a walk. On May 28, 1930, a yearling was seen with a pronounced limp.

Epidermal growths of various sizes, some perhaps three inches in diameter, were seen on several moose, the larger warts suspended by a narrow neck of skin. The warts usually hung from the belly region, but in some animals they also occurred on the ears, flanks, and hams. One young bull was seen fairly covered with them. E. C. O'Roke, of the University of Michigan, after examining specimens of the growth, reports that they are purely epidermal and not directly injurious to the health of the animal.

Skeletal remains of twenty-four moose were found. Four animals had been mired, four had been killed by man, judging from the knife marks on

the bone and other evidence, and two had probably been drowned. Eleven of the specimens showed evidence that the animals had died from disease. Four of these were old bulls which had died in winter, two were young bulls which had died early in the summer, two were adult cows, and three were of unknown sex. I was unable to determine the season in which the two cows and the three of unknown sex died.

Evidence of disease consists in the porosity, enlargement, and necrosis of the bone of the mandibles and the region adjacent to the upper molars. Necrosis had exposed the roots of many of the molars. In one specimen there was much necrosis of the palate. O. J. Murie, who is studying the elk of Jackson Hole, Wyoming, showed me skulls of elk which had died from necrotic stomatitis and which had the same appearance as the diseased moose bones from Isle Royale. The Bureau of Animal Industry, United States Department of Agriculture, after examining two of the specimens which I sent, reports:

The lesions present in the bones were found to have an appearance very suggestive of the condition produced by the infection of necrotic stomatitis. In this affection there is often a mixed infection of the necrosis bacillus and pyogenic cocci. The organisms cause marked inflammatory and necrotic processes involving not only the soft tissues, but the adjacent bony structure. The latter may undergo extensive necrosis and become considerably enlarged and porotic.

Although the organism was not isolated in this case, it seems quite probable that the animals were affected by necrotic stomatitis. With a decrease in quality of winter food and an increase in the moose population, the disease will probably become an important check on the numbers. Its usefulness as a check, however, may come too late to save the landscape.

THE RUT

Early in September an unmistakable change of behavior was apparent among the bulls. The calling or grunting as they stalked along a lake shore or through the woods was a definite departure from their usual silence during the summer months. The mating instinct was gradually taking possession of them, and, as it increased, instincts relating to alertness, fear, etc., lost their acuteness. Sounds which would be noted with suspicion during most of the year were now eagerly investigated, for they indicated to the bulls either a cow or a rival, in either event important.

RUBBING OF ANTLERS

Eight or nine days before consorting, the bulls commenced to rub the velvet from their antlers. On September 5, 1929, two six-point-bulls were seen with rubbed antlers. One had one cleaned antler, while the other had

both cleaned except for a few strands of velvet hanging from one of them. On the same date the antlers of two large bulls and another six-point bull were still in velvet.⁶ The antlers of all the bulls seen on September 13 and thereafter, except those of a large bull noted on September 14 with some strands of velvet clinging, were free of velvet. The bulls cleaned their antlers during the period between September 5 and September 13. (See frontispiece of a young bull with a few shreds of velvet remaining on the antlers. The photograph was taken at Sargent Lake, September 5, 1929.)

On September 21, 1929, I watched a large bull as he rubbed his cleaned antlers against some alders. First one antler and then the other was rubbed, with an up and down motion of the head, in such fashion that the spaces between the several prongs were all rubbed. During the rut several bulls were seen rubbing their cleaned antlers against alders. On October 11, 1929, a large bull was observed rubbing his antlers on a five-inch balsam. The tree was girdled for several feet.

The rubbing against trees and thrashing of brush with the antlers seems to be associated with the mating instinct, for the performance continues throughout the rutting period, after the velvet has all been removed. Along the trails are many depressions, usually three or four inches deep, which have been made by the antlers or by pawing with the fore feet. This habit, as well as that of rubbing the antlers, possibly serves as an emotional outlet for the bulls.

The freshly cleaned antlers are white, often stained a little by the blood remaining in the velvet. The whiteness is soon lost except for the tips, due to the continued rubbing against various shrubs or trees of sapling size, which stain them a brownish color. Many of the saplings are girdled and killed by the process.

MATING

A bull was first seen consorting with a cow on August 23. At the head of McCargoe Cove shortly before dusk a large bull and a cow were feeding together in the water with noisy champing of jaws as they crushed the food. The bull dived for aquatic vegetation while the cow, grunting all the while, swam to and fro. She fed on the floating *Potamogeton* which other moose had loosened while feeding from the bottom. Presently the bull stopped eating, and with much blowing and grunting swam to the cow where he remained feeding from the surface. The cow swam toward him and then away from him; once she swam around him. I watched the performance for half an hour, but then it became too dark to see what was taking place.

On the morning of August 27, the same bull and presumably the same cow were again feeding on floating water plants in the cove. They left the

⁶ A young bull observed in the Jackson Hole region, Wyoming, on September 6, 1930, had removed most of the velvet from his antlers, which were stained with blood.

cove together. On the morning of August 28, the same bull, a cow, and an eight-point bull left the cove together. On August 30, the bull was seen leaving the water in a direction opposite to the one he had always taken previously. The cow gazed after him and as he neared the opposite shore followed him.

Possibly this companionship had nothing to do with the mating instinct, for it preceded any other consorting by more than two weeks. The cow seemed more attached to the bull than the bull to the cow, a relationship quite different from that which was evident later on.

No other bull was seen with a cow until September 13. On this date two different bulls were seen each with two cows. From September 13 until October 12, bulls were seen with cows almost every day. From September 24 to October 7, every cow observed was followed by a bull. Before September 24 and after October 7, lone cows were seen frequently. The height of the rut seemed to be reached towards the latter part of September. A few days preceding my departure on October 12, a waning of mating activities was evident in the behavior of the moose.

Observations made October 11 showed however, that rutting activities were still in progress. At the Lake Eva lick there were two cows, a large bull with a white blaze on the forehead, a ten-point, medium-sized bull, and a two-point bull. On separate occasions the two smaller bulls followed one of the cows, smelling her as she walked away. The large bull chased each of the smaller bulls while I watched. The old bull first took a few slow steps toward the larger of the two other bulls, and then rushed six or seven yards towards the retreating smaller bull. Several hours later the same group was at the lick. The large bull rubbed his antlers on a balsam for several minutes. While he was thus occupied, one of the cows approached him, smelled him, and called softly. He stopped rubbing, and followed the cow a few steps as she walked away. Another large bull appeared suddenly from behind a rise and watched us as we stood about ten yards from him. He was ten yards from the first large bull, which behaved as though he were unaware of the second bull. Although there were indications of mating, the passion was no doubt waning, otherwise the bull in possession would have been more disturbed at the presence of rivals.

Of the thirty-three bulls, different individuals so far as I could tell, seen with cows, eight of them were with two cows each, twenty-five with one cow each. The tendency is certainly toward monogamy. Since the moose is not a herd animal, it is to be expected perhaps that it will not be so during the rut. The bulls are probably not averse to having more than one cow, but they probably are not as a rule able to keep more than a single cow at any one time. There is little tendency for cows to herd together, so that if a bull should secure several cows and each cow had a different notion as to

where she was going, he would not be able to follow all of them. One of the bulls I saw seemed to be in this predicament. He was with two cows, one of which was feeding toward the top of a ridge, the other toward a marsh. The cows were about one hundred and twenty-five yards apart, with the bull between them. The bull seemed uncertain where to go, but when one of the cows disappeared into a growth of alders, he hurried after her. The other cow continued feeding up the slope without paying any attention to the pair which had left her. I was unable to learn if a bull deserted one cow after mating with it in order to join another.

During the period from September 13 to October 12, some sixty unmated bulls were seen, many of which were yearlings or two-year-olds. Only about ten of the bulls carried large antlers; most of these were seen during the early part of the rut, and possibly they secured mates before it was over.

The calf is accepted by the bull as part of the family. At no time did a bull show any antagonism toward a calf. On one occasion, a cow, calf, and bull all licked at a block of salt together. At another time, a calf was accidentally knocked over when a bull attempted to mount a cow. It always seemed that the bull was entirely oblivious of the presence of the calf.

FIGHTING

At salt licks, which were more less trysting places for the moose, I frequently saw the bull with the cow advance to meet rivals calling in the neighboring woods. The intruding bull always retreated or kept circling before the bull in possession. It seems that all the courage is lodged in the bull possessing the cow, for his threatening was sufficient to drive away other bulls. Younger bulls were tolerated to some extent, for they often remained within twenty or thirty yards of the lick undisturbed.

No actual fighting was seen. On September 30, two fairly large bulls moving along a hillside together sparred for a few moments, but appeared to be on friendly terms—they had nothing to fight over. On October 11, a yearling with one spike either undeveloped or broken off sparred with a five-point bull. They put their foreheads together three different times and pushed each other gently.

It seems that the younger bulls often indulge in fighting, possibly among themselves. Three different four-point bulls, seen between September 23 to 28, had one or the other antler broken off a few inches from the base. On September 26, a five-point bull passed me, followed in two or three minutes by a bull with two points on one antler and all of the other antler broken off. The second bull stopped near me on a rise and looked intently in the direction the first had taken. He was panting hard. Very likely the two had been fighting.

On September 29, a seven-point bull was observed with several tips broken off both antlers. He had been seen a few days before with unbroken antlers.

BEHAVIOR

During the rut the moose become unusually active as evening approaches. At an artificial lick at the head of McCargoe Cove, a number of moose assembled each evening. From camp we could usually hear the continual grunting of the bulls and now and then the long drawn out call of a cow. On September 28, 1929, there was an extraordinary amount of activity at the lick and in its vicinity. Shortly before dusk I hurried to the lick and climbed a poplar where I could watch the moose approach with little danger of being detected. Almost at once I heard loud grunting from the direction of a small creek flowing between banks grown up with alders. A bull was obviously approaching the lick. There was much crashing of branches and calling. The sounds of breaking branches and splashing water rapidly became louder. Presently a cow followed by a calf came hurrying out of the alders, crossed the wet sedgy ground, and eagerly drank the salty water at the lick. A large bull plodded along, calling, fifty yards in the rear. The cow at the lick answered the bull continuously with soft modulated calls, sometimes drawn out like the whining of a dog. The bull twice smelled the cow, but each time she hurried away from him.

Soon the loud calling of a second bull sounded from farther up the cove. This was answered from two other directions by a third and fourth bull. The calls of the intruding bulls were accompanied by breaking of branches and saplings.

From the sound it was apparent that the second bull was coming nearer. The bull at the lick was aware of this, for he moved slowly toward the approaching bull. His grunting became deeper. Occasionally he paused, either to demolish a clump of sedge with his antlers or to thrash alders in his path. When the bull at the lick had advanced in this way for about fifty yards, the second bull began to retreat, for his calling sounded more and more distant. In the meantime, the cow had gotten my scent several times. She barked each time as do elk when puzzled. The last time, she left the lick, followed by the calf and bull—the usual order in traveling at this time. The calling of the bulls at the head of the cove continued for several hours.

On October 4, a cow, which I had been watching as she fed in an open poplar wood, stopped her feeding and crossed over a ridge into a grassy swale. Here she began to run in a circle, dashing about like a frisking calf, cutting antics and "growling." As she disappeared in the woods I heard a bull coming up behind me toward her. Similar behavior was observed on

the part of several cows at salt licks. These cows ran in a small circle or from one side of the lick to the other, producing soft, muttering sounds, occasionally a prolonged call. Although Seton⁷ says that this strange behavior which has been related to him by several hunters, apparently has nothing to do with the rut, it has seemed as observed on Isle Royale to be closely related to sexual activity.

CALLING

During the rut, bulls were easily attracted either by imitating the prolonged call of the cow or by the breaking of branches. On a few occasions, bulls approached which had merely heard me walking. The time of day seemed to make no difference in the success I had in calling them.

Bulls which were near at hand were the only ones I tried to call, so I do not know whether or not any of them could be called from a distance. Probably lone bulls would respond from quite a distance, but I doubt that mated bulls could be attracted far, for they generally remain near the cow. Proof of this is that rival bulls were little noticed until they were close at hand, one or two hundred yards at the most.

Bulls were called on a number of occasions. On the morning of September 25, 1929, I came suddenly upon a large bull, two cows, and a calf. The bull no doubt had heard me walking, for he came in the usual manner, except that on the way he stopped to paw the earth. I climbed a birch unobserved, where I watched him as he passed a few yards from me. When he got my scent, he became tense, turned, and retreated at a fast walk. A half mile farther on I saw the same group resting in a swale. I was close upon them before the nearer cow got to her feet and galloped away, followed by the other cow and the calf, all very much frightened. The bull, now knowing the cause of the haste, was more deliberate in his departure. He must have lost the cows, for in a few minutes he reappeared, walking with long, swinging strides and calling anxiously. He heard me in the alders and came toward me, passing me but a few yards distant.

At dusk on September 30, I saw a medium-sized bull at the far end of a sixty-yard opening. The bull had either seen me or heard me, for he was gazing in my direction. I gave the prolonged call of a cow, muffling the sound with my hands. He advanced a few yards at a time, while I called at intervals. He came within twenty feet of the tree I had climbed, and no doubt had my scent, for I was only a few feet from the ground, and the wind was blowing in his face. I called again softly and he came closer. After a couple of minutes he walked slowly away.

On September 26 a young bull, with two points on one antler, the other broken off at the fork, approached me through an alder thicket, attracted

⁷ *Life Histories of Northern Animals*. New York: Chas. Scribner's Sons, 1909, I, 178; or III (1), 153.

by the noise I made. When five yards from me he turned and moved away with great dignity.

On October 7, I saw a cow and calf among some alders. After I imitated the prolonged call of a cow a few times, a large bull emerged from the thicket, calling as he advanced. When he was ten or fifteen yards from me, I spoke in my natural voice. At once he jumped wildly away through the soft mud and alders.

An interesting incident occurred on October 3. Paul Hickie, while walking along an open ridge, heard a noise behind him. Turning, he saw a sixteen-point bull and a smaller bull coming over the ridge toward him, but thirty yards away. The bulls approached within fifteen feet of the stunted pine which Hickie had climbed. After three or four minutes the sound of breaking branches came from the woods and both hurried toward the noise. The new disturbance betokened the proximity of moose, possibly an unmated cow, hence worthy of examination. The eagerness to investigate sounds explains the ease with which moose may be called.

CALVES

Calves were not seen until the latter part of May and early June, and then only a few were noted. The behavior of some cows early in May, however, indicated that the calving time was at hand. On May 5, my first day in the woods in 1930, a large cow and a yearling, and a smaller cow were at one of the licks at Lake Eva. The large cow approached me with lowered ears, so I was forced to climb a tree to avoid frightening her. When about twenty feet from me she uttered a squealing, menacing sound, and walked slowly back again. Later this cow chased her yearling with lowered ears. A cow seen on May 9 barked several times and remained in the vicinity of the spot where I had first alarmed her. The behavior of both cows was unusual, due no doubt to emotion related to calving.

As the calving time approaches, the cow apparently feels an urge to be alone. She endeavors to rid herself of the yearling, which is still very much attached to her. On several occasions, besides the one described above, a cow was observed making short dashes at her yearling, forcing it to retreat hastily. Because of the disinclination of the yearlings to leave them the cows no doubt have some difficulty in securing seclusion, and at times fail to do so. Cows were observed trying to drive away their yearlings on May 5, 20, 22, and June 15, 1930, and July 17, 1929.

Lone yearlings, which had undoubtedly been deserted, were seen on the following dates: May 10, 16, 23, 24, 30, 31, June 14, 15 (two yearlings), and June 20 (two yearlings). The yearling observed on May 10 was running aimlessly through the woods calling, and at intervals stopping to listen. The lone yearling observed May 23 was also wandering through the woods

calling, probably looking for its mother. On May 31, I frightened seven or eight cows and five yearlings from a lick near Lake Desor. A few minutes after the moose had left, a yearling returned calling, evidently in search of its mother. Later, I heard a yearling a half mile from the lick, possibly the same individual.

Yearlings were observed with cows on apparently amicable relations on May 18 (two cows each with a yearling), May 19 (two cows each with a yearling), May 22, 23, 28 (two cows each with a yearling), June 2, 9, 12, 15 (four cows each with a yearling), and June 17. Very likely most of these cows had many times discouraged the presence of the yearlings, but had not yet succeeded in driving them away. By the middle of the summer the yearlings are practically all shifting for themselves.

The first calf was seen on May 28. About 4 p. m., while I watched a yearling, which was listlessly feeding and calling at intervals, a cow emerged from an alder thicket and rushed at the yearling with short, choppy jumps. She came with a threatening attitude rather than with any apparent intention of doing injury to the yearling, for she did not try to overtake it. The yearling hurried away and was soon out of sight. In a moment a weak looking calf came jumping out of the thicket. After being nuzzled a bit by the mother and nosing at some of the vegetation, the calf lay down; the cow commenced to feed on poplar leaves. At my approach she ran slowly off, followed by the calf.

A cow seen on May 27 was evidently in the act of parturition. When I saw her she had my scent, and left soon after, calling a few times before leaving. Where she had stood was a much trampled area four feet in diameter. In this area was a small amount of blood and mucous. A few yards away were two other areas where it appeared she had been lying. I searched the surroundings but did not find any calf.

Besides the one seen on May 27, calves were seen on June 6, 9, 12, 14 (twins), 17 (single calf and twins), and June 20. This appears to indicate that few are born before the first of June, but since few calves were seen even in June, some might have been born during May and escaped observation. The attitude of animosity which the cows exhibited toward their yearlings early in May seemed to indicate that the calving period was close at hand, but this behavior of the cow may precede the calving by a number of days. The height of the calving time is probably reached early in June and no doubt extends over a period of three or four weeks.

The gestation period for moose is about eight months. The cows are bred the latter part of September and the first part of October, and the calves are probably born, in the latter part of May and the first part of June.

From observations in the field during the summer it is difficult to arrive at definite figures concerning the proportion of cows which have calves. At this time the calves are often left in hiding, especially when the cow is feeding in the water or visiting a salt lick.⁸

Although figures obtained during the summer bearing on the calf crop are unreliable, those obtained during the rut are probably fairly accurate, so far as the sample of the population observed is concerned. The cow at this time is apparently always followed by her calf. The number of cows seen with yearlings in the spring is also useful in helping us arrive at the proportion of cows with calf the preceding year. In figures arrived at from spring observations on yearlings there is a possibility of error, because of a possible calf mortality during the winter, but ordinarily this should not be great.

Of the cows observed during the period from July 16 to September 11, 1929, twenty-eight were followed each by a calf, seventy-five were not. Some of these cows were undoubtedly counted more than once, but perhaps the same applies to the calves. Of the cows seen with bulls during the rut, from September 13 to October 12, all different individuals so far as I could tell, seventeen were followed each by a calf, twenty-five were not. Of the cows observed in the spring of 1930, from May 5 to June 20, thirty-eight were followed each by a yearling, forty-five were not. Seven lone yearlings were seen. Animals recorded were, for the most part, quite certainly different individuals.

The figures for the summer months, when compared with the other two sets of figures, show that calves are seldom seen at this time. About forty percent of the cows observed with bulls during the 1929 mating season were each followed by a calf, and almost forty-six per cent of the cows observed in the spring of 1930 were each followed by a yearling. If the seven lone yearlings observed at this time are considered, the last percentage becomes about fifty-three. The fall and spring records combined make the percentage of cows with calf about forty-nine. Since some of the barren cows were probably too young to breed, the actual percentage of cow moose, of breeding age, with calf would be well over fifty. Figures arrived at by the above method are, of course, subject to many errors.

Of interest is the fact that the above figures closely agree with those pertaining to the same question, given by Otto Schierbeck.⁹ In Nova Scotia, during an open season extending from December 1 to 10, 561 cows were killed. Questionnaires were sent to the hunters to obtain information as to

⁸ An incident at Bridger Lake, Wyoming, is interesting in this connection. On September 15, my brother and I followed into the woods a cow which had been feeding by the lake, and saw her join a calf a quarter of a mile from the lake.

⁹ "Is It Right to Protect the Female of the Species at the Cost of the Male," *The Canadian Field Naturalist*, January, 1929, XLIII, 6.

whether the cow was barren or with calf. In the 525 replies received, 273 cow moose were reported barren and 252 pregnant. Of course it is possible that some of the hunters failed to notice the fetus when it was actually present. As the figures stand, forty-eight per cent of the cows were with calf. Schierbeck attributes the large number of barren cows to a scarcity of bulls, a conclusion which is open to question and cannot be final until similar studies are made where conditions are known to be normal. The agreement of Schierbeck's figures with mine tends to show that normally only about fifty per cent of the cows, all ages above "yearlings"¹⁰ considered, produce offspring.

From my observations, it seems that the cows have, as a rule, but one calf each. Forty-four cows were seen, in 1929, followed by one calf each, and only one cow by twins. In 1930, thirty-seven cows were followed each by one yearling and one by twins. During the same period in 1930, six cows were observed each with a single calf and two with twins. Schierbeck states that only twenty-one, or eight per cent of the 252 pregnant cows carried twins. My figures indicate that a little less than five per cent of the cows had twins. It would therefore seem that twins are the exception and one offspring the rule.

FEEDING HABITS

Because of the abundance of moose and the consequent abundance of feeding signs, Isle Royale is a specially favorable region for study of the food habits of moose. Furthermore, since no other large herbivore occurs on the island, there is little likelihood of confusing the feeding signs of the moose with those of any other animal.

The data on food habits were secured by observing the animals feeding, by a survey of the plants which had been eaten, and by examining the stomach contents of the specimens collected. Data were gathered from the first part of May to the middle of October.

The moose is primarily a browser but not solely so, for sedges, grasses, and weeds are grazed extensively. The animal grazes not only on dry and swampy ground, but also, during the summer months, on the bottoms of the numerous lakes and coves of the island, which support aquatic vegetation.

In much of the summer browsing, only the leaves are eaten, although the stems of some plants, such as *Diervilla lonicera*, are also utilized. In browsing, a branch is grasped some distance proximally, and the leaves are stripped off as it passes through the mouth. Branches and twigs too high to be fed upon conveniently are firmly grasped in the mouth and pulled down until they break, when the leaves are quickly removed. Saplings

¹⁰ Animals one and one-half years old also designated as yearlings.

and tall shrubs are systematically broken down in order to secure the leaves and twigs otherwise out of reach. In breaking down a sapling the moose reaches high and pushes the trunk down with its muzzle, gaining leverage as the tree is bent by sliding the muzzle toward the tip until the break occurs. Sometimes a tree slips away, but a second attempt is at once made to bring it down. In place of pushing down on the sapling with the muzzle, the sapling is sometimes grasped in the mouth and pulled down. Some of the larger poplars which were broken over were two and one-half inches in diameter at the break, four or five feet from the ground.

In browsing, the moose frequently stretches to a height of about eight feet, but browsing signs twelve feet from the ground are common. Some of the higher browsing, however, is probably done in winter while the moose is standing on the snow.

The moose is not adapted to grazing, because of its long legs and short neck. The adults are barely able to graze on short vegetation on hard ground without bending the knees. The calves find it more difficult and often drop down on their knees to feed.¹¹ In wet ground where the moose feeds on rushes and sedges and *Equisetum*, the disadvantage of the long legs disappears, for in such situations the feet sink into the mud, bringing the mouth nearer the food.

In order to obtain much of the aquatic vegetation growing on the lake bottoms the moose must resort to diving. In deeper water the animal sometimes entirely disappears, although usually the shoulders protrude above the surface. Some individuals roll to one side when submerged, so that a foreleg can be seen moving slowly near the surface. The moose observed remained under the water on an average of from twenty to forty seconds, but one individual remained down a minute and a half on several successive submersions. The animals do not generally feed in water deeper than six feet. Some of the aquatic vegetation which is broken loose by the moose comes to the surface and drifts to the shore, where the moose obtain it along the water's edge.

SUMMER FOOD

All plants given in the annotated list, with the exception of the conifers, balsam, spruce, white cedar, and white pine, are included in the summer menu. The browse at this time consists principally of leaves, although twigs are eaten to some extent.

The following plants, due to their abundance and palatability, probably make up the bulk of the summer food: poplar, birch, hazel, dogwood, alder, mountain ash, pin cherry, hard maple, bush honeysuckle, sedges, large-

¹¹ A calf observed in the Upper Yellowstone region of Wyoming frequently went down on its knees to eat mushrooms, but its mother did not resort to such manoeuvres.

leaved asters, and pondweeds. Ground hemlock and water lilies are also favorite summer foods, but at the present time are nearly gone. The stomach content of a cow killed May 20, 1930, however, was composed almost entirely of ground hemlock. Willow is eaten where found, but it is not plentiful. Moose are fond of mushrooms, but on only one occasion were they found in the stomachs examined.¹² This may be explained by the scarcity of the plant during my stay.

From May to October the utilization of certain plants varies considerably. In May and early June the bark of mountain ash, poplar, and pin cherry is fed upon extensively; none was found eaten during the summer, but late in September the bark of a fallen poplar and a mountain ash was eaten. Thimbleberry is eaten much more during the latter part of May, just as the buds are bursting, than it is later in the summer. Fern, aster, sedge, and grass are more sought after early in the summer when tender sprouts are numerous. Jewelweed, on the other hand, was not eaten until August, when the plant was in bloom. The feeding on the water vegetation did not begin until the latter part of June and was more or less discontinued early in September.

WINTER FOOD

Although I was unable to visit the island in winter to study conditions, some of the food habits for this season are manifest from signs observable during the summer.

Many plants which are fed upon in summer are not available during the winter. Most herbs die down in the fall, and the grasses, sedges, and some of the smaller shrubs are not easily secured as they are covered with snow. The deciduous forms have lost their leaves, so that only the stems and bark are available. Alder, whose leaves are relished in summer, are but sparingly eaten in winter, for the moose apparently cares little for the twigs of this form.¹³

Because of the restricted food supply in winter, the moose at this season turns to foods which are hardly tasted in summer. Balsam becomes one of the important sources of food, as shown by its heavily browsed condition. White pine and white spruce are sparingly eaten. White cedar is in places eaten extensively, but again some cedars growing among heavily browsed balsams were untouched. It is evidently not highly relished. Nearly all the taller deciduous shrubs and the trees which are browsed in summer are also eaten in winter.

¹² Near Bridger Lake, Wyoming, on September 13, 1930, a cow and calf were observed feeding on mushrooms for half an hour. At least five varieties were eaten.

¹³ O. J. Murie has found the same to be true in the Upper Yellowstone region of Wyoming. He states that where he has found fir and alder growing together, the moose have browsed heavily on fir and but sparingly on alder.

To what extent bark is eaten in winter I am unable to say. Certainly most of the feeding on it is done during May and early June. On May 9 a bull was seen stripping the bark from a poplar, grasping it about six feet from the ground and loosening it to a height of nine feet. The stomach of a bull collected June 9 contained much poplar bark. The browsing of bark in spring is from preference, for other food is plentiful at this time, but that eaten in winter may possibly be an indication of shortage of food for it may not be so palatable at this season. The popular supposition that bark is eaten only as a starvation ration can no longer be held.

ANNOTATED LIST OF FOOD PLANTS

TREES AND SHRUBS

White Pine (*Pinus Strobus*). A scattered growth occurs on some of the ridges, for the most part old trees. On Greenstone Ridge, where balsam and various shrubs had been heavily browsed, a few small pines had been utilized practically one hundred per cent, that is, all the available browse within reach of the moose had been eaten. Since pine was hardly touched in most places, the considerable use of it on Greenstone Ridge was undoubtedly due to shortage of food rather than to its palatability.

White Spruce (*Picea canadensis*). Quite common but not nearly so plentiful as balsam. Very sparingly browsed on some of the ridges, but generally untouched. On Greenstone Ridge some windfalls and a few growing trees had been heavily browsed, perhaps for the same reason that pine was browsed on this ridge.

Balsam Fir (*Abies balsamea*). Balsam is the most abundant and widespread conifer on the island. Some of it occurs in mature stands, while throughout much of the poplar and birch forest there is a scattered growth of saplings. Because of its palatability and abundance, it is a highly important winter food. I found no indications of it being browsed during the summer. Excessive browsing has sadly diminished the food supply originally furnished by the balsam. On the large trees the moose feed upon the lower branches; nearly all the branches of the saplings are eaten, the tops often being broken over. Twigs a half inch in diameter are sometimes consumed. In a few cases the bark was eaten.

Arbor Vitae (*Thuja occidentalis*). Large trees occurring in the bog areas furnish but little browse, for the lower branches are usually dead. Small trees are plentiful in a few areas but over most of the island are rather scarce. In a few places arbor vitae was heavily browsed, some of it had been merely tasted, but most of it had hardly been touched, even in places where the balsams growing beside it were almost completely

utilized. In an area very much overbrowsed, long strips of bark had been eaten from forty or more trees about seven inches in diameter. This barking may have been resorted to because of the scarcity of food. *Arbor vitae* is a winter food, but apparently not highly relished by moose.

Juniper (*Juniperus communis* var. *depressa*, and *J. horizontalis*). A few were scattered on the ridges and rocky places. Very sparingly browsed.

Ground Hemlock (*Taxus canadensis*). This form is very abundant in the spruce and balsam forests. Practically everywhere, as a result of browsing, the branches are dead except for a few leaves near the roots. It cannot longer be considered a source of food on the island. On one occasion a cow was observed as she fed on a few scattered twigs yet remaining on the plant. Ground hemlock was found in several of the stomachs examined. It is a highly palatable food during the summer, and undoubtedly is relished also in winter when available.

Poplar (*Populus tremuloides*). Poplar occurs over large areas, in stands of various sizes, depending on the age of the burn in which it has sprung. Great numbers of young trees have been broken down and stripped of their leaves and twigs. On May 28 a cow broke over two poplars about two inches in diameter and stripped off the leaves while I watched; I found an abundance of fresh work of the kind during this period. Chiefly leaves but also some twigs are eaten in summer. In September more of the twigs are eaten than during the rest of the summer. A large poplar was cut down by beaver September 11, and in two or three days it was stripped of the leaves and twigs to the diameter of half an inch by moose. A poplar felled October 2 had the smaller twigs and much of the bark removed two days later. During May and early June much bark was eaten and fresh signs of barking were abundant. Moose were observed feeding on bark May 9, 19, and 22. A large amount of bark was found in the stomach of a bull killed June 9. In some areas, fully nine-tenths of the poplars have been barked, in other areas relatively few trees are touched. The barked trees are usually the older ones and are rarely completely girdled.

Birch (*Betula alba* var. *papyrifera*). Besides paper birch, which is almost as plentiful as poplar, a small amount of yellow and black birch occurs on the island. Like poplar, the stands of birch are of different ages. Principally leaves are eaten in summer, but the shoots growing at the bases of large trees are closely browsed. Large numbers of the smaller trees have been broken over and are now dead or retain but a few leaves.

Willow (*Salix* spp.). Several species occur. In a few areas, willow is quite abundant, but over most of the island it is rather sparsely distributed. Here as elsewhere the moose is fond of willow and has browsed upon it heavily. Willows occurring on the dry slopes are generally dead.

Beaked Hazel (*Corylus rostrata*). This palatable shrub is fairly abundant on the higher slopes. On several occasions I watched moose feed on it for long periods, generally consuming only the leaves. In places this shrub had been eaten down to what was apparently the snow line.

Mountain Alder (*Alnus crispa*). Common in the upland forest. The leaves are eaten in large quantities during the summer, and in some places a few of the tips had evidently been consumed during the winter. Mainly a summer food.

Speckled Alder (*Alnus incana*). Very plentiful in the lower ground and around streams and coves. The leaves are freely eaten during the summer, but apparently this alder is hardly touched during the winter.

Red Oak (*Quercus borealis*). A few oaks were seen on Greenstone Ridge. They had been heavily browsed. Evidently this species is highly relished.

Mountain Ash (*Pyrus americana*). Sparingly distributed throughout the forest. It is one of the most palatable foods. The branches within reach of moose have generally been stripped of leaves and twigs, and the trunk in most cases has been barked.

Juneberry (*Amelanchier* sps.). Sparingly distributed, generally found on the ridges and rock openings. Wherever noted, juneberry was heavily browsed, and much of it is dead.

Pin Cherry (*Prunus pennsylvanica*). Characteristic of xerophytic slopes, but not abundant in most places. The major part of the shrubs has been killed by overbrowsing. At Todd Harbor, where the species is plentiful, the tops of nearly all the bushes have been broken over.

Hard Maple (*Acer saccharum*). This species is very abundant on Greenstone Ridge on the southwestern end of the island. Saplings were all heavily browsed.

Mountain Maple (*Acer spicatum*). Generally distributed but nowhere abundant. Leaves and twigs within reach of the moose are generally browsed.

Dogwood (*Cornus stolonifera*, *C. circinata*). *C. stolonifera* is widely distributed and plentiful, but *C. circinata* is rather rare. Scarcely a dogwood was found which was not heavily browsed. Much of it is dead or badly stunted, and the tops over wide areas are broken down. It is a favorite summer food, and is apparently also relished in winter.

Bristly Gooseberry (*Ribes setosum*). Rare. Found browsed in several places.

Thimbleberry (*Rubus parviflorus*). A very common and widely distributed shrub. In many places it forms a dense ground cover. I watched a bull, on May 19, eating a number of the stems which at the time carried bursting buds. The plant at this stage is more eagerly sought than

later, when the leaves have uncurled and attained their growth. During the summer small patches of this shrub were noticeably browsed, but over most areas there was no sign of browsing. Several times moose were observed nipping off a few leaves in passing. Apparently it is frequently tasted but not eaten in large quantities, except in May before the leaves have developed. Probably not available in winter.

Cinquefoil (*Potentilla* sps.). Rare. A few bushes found browsed, August 1.

Prickly Rose (*Rosa acicularis*). Nowhere abundant. Generally heavily browsed.

Staghorn Sumac (*Rhus hirta*). Sparingly distributed on rocks and ridges. Wherever it was observed, it was closely browsed.

Huckleberry (*Vaccinium* sps.). Abundant in rocky places. Browsed in many cases.

Red-berried Elder (*Sambucus racemosa*). Sparingly distributed. Generally browsed.

Few-flowered Cranberry (*Viburnum pauciflorum*). Quite common in moist woods. Generally browsed.

Honeysuckle (*Lonicera* sps.). Some of the species in this genus are fairly common in the woods. All the honeysuckles noted were heavily browsed.

Bush Honeysuckle (*Diervilla Lonicera*). A very abundant shrub, occurring in a variety of situations. In many places it forms the principal ground cover. The shrub is so short (one to two feet tall) that it is probably deeply covered with snow in winter, hence not available as winter food. In summer, it is one of the important foods. By fall, the tops are cropped from a majority of the plants.

HERBACEOUS PLANTS

Virginia Grape Fern (*Botrychium virginianum*). Sparingly distributed. A few specimens found which had been grazed.

Royal Fern (*Osmunda regalis*). A half dozen plants found had been grazed.

Wood Fern (*Dryopteris spinulosa*). Quite common. Often eaten.

Lady Fern (*Asplenium filix-femina*). Found eaten.

Brake (*Pteridium aquilinum*). Abundant in dry, open places. Much of this fern was browsed. Generally the leaves are stripped from the main stem, except in the spring before they have unfolded, at which time the stem is also eaten.

Swamp Horsetail (*Equisetum fluviatile*). In many localities an important moose food. Found sparingly on Isle Royale. Usually grazed. A branching species of horsetail growing on the shore was not touched.

Pondweed. In several of the lakes, especially in Lake Richie, Lake Feldtmann, and Sargent Lake, moose feed extensively on the pondweeds; they are apparently absent from most of the lakes. Very probably moose have cleaned them out of some of the lakes now lacking them.

Blue-joint Grass (*Calamagrostis canadensis*). Quite common in wet places. At McCargoe Cove, some of the tender sprouts had been eaten.

Bluegrass (*Poa pratensis*). Eaten sparingly at the head of McCargoe Cove.

Sedge (*Carex* sps.). Quite plentiful in the wet places, and fed upon extensively. The young shoots are preferred, but larger plants are also eaten. At the head of McCargoe Cove, where sedge is the principal ground cover in the low area, five or six moose were to be seen feeding on it each evening in the early part of August, 1929. In 1930, the sedges there as well as in other localities observed, were closely cropped by the middle of May.

Rush (*Juncus* sps.). At Sargent Lake, rushes occurred in the shallow water. Wherever observed, they had been cropped to a few inches from the water. On August 17, I watched a young bull feed on rushes for a half hour.

Large Yellow Pond-Lily (*Nymphae advena*). This plant, formerly quite common, is now very rare. The moose has undoubtedly destroyed it.

Sweet-scented White Pond-lily (*Castalia odorata*). Formerly abundant, now exceedingly scarce. Its almost complete disappearance is a result of heavy grazing by the moose.

Marsh Marigold (*Caltha palustris*). Found sparingly in wet places. Usually grazed.

Purple Rue (*Thalictrum purpurascens*). Found eaten, in one instance.

Red Clover (*Trifolium pratense*). Red clover was evidently brought to the island during the early mining days. It is very common between McCargoe Cove and Todd Harbor, and some was noted on the south side of the island at Long Point. Clover although not eaten in large quantities is freely tasted.

Round-leaved Violet (*Viola renifolia* var. *Braenerdii*). Occurs in moist woods, found eaten on several occasions.

Fireweed (*Epilobium angustifolium*). Noted eaten in a few places.

Cow Parsnip (*Heracleum lanatum*). Very scattered in occurrence. It is but sparingly eaten.

Water-Hemlock (*Cicuta bulbifera*). Occasional in bog margins. Found eaten July 19 and August 25, 1929.

Jewelweed (*Impatiens biflora*). Found in thick stands on several beaver dams. It was heavily grazed in August after the flowers had bloomed.

Swamp Buttercup (*Ranunculus septentrionalis*). A few plants found eaten by moose July 25. Very few of this species were noted.

Turtlehead (*Chelone glabra*). Found eaten August 19.

Large-leaved Aster (*Aster macrophyllus*). Very abundant in open forests and clearings. In May, before the leaves have uncurled, the moose begins to graze on this aster, and it is eaten throughout the summer. On May 17, a bull fed on it near camp for about fifteen minutes until I frightened him. Every aster over several square yards was grazed.

STOMACH CONTENTS

In the study of the food habits of large herbivores, stomach contents often serve as a check on field observations. Although some of the material in the stomach is too finely ground for identification, much of it can be identified. The stomach content of old animals with worn teeth can be usually readily determined, because of the incomplete mastication of the food before it is swallowed. Where the food is finely chewed, even an attempt at percentages is futile. Of the following stomach content analyses, about half of the contents was saved as a sample.

Cow, taken at Lake Eva, July 22, 1929. Mainly browse, some of which is identified as poplar and alder. There were two pin cherry seeds, a small amount of sedge, perhaps one per cent, a slight amount of grass, and one small mushroom.

Cow, taken at McCargoe Cove, May 20, 1931. Almost entirely ground hemlock (yew) and a small amount of sedge.

Young bull, taken at McCargoe Cove, August 28, 1929. Seventy per cent *Diervilla lonicera*, twenty per cent sedge, traces of poplar, maple, horsetail, pin cherry, and sedges. A few *Potamogeton*.

Bull, taken at Brady Cove, June 9, 1930. (Most of contents finely chewed, hence difficult to identify). Much poplar bark, some pieces six inches long, traces of ground hemlock, a few leaves of *Aster macrophyllus*, thimbleberry, and hazel.

Yearling, taken at Lake Eva, June 15, 1930. (Contents well digested, difficult to determine). A large amount of poplar leaves and pin cherry leaves.

Calf, taken at McCargoe Cove, August 10, 1929. Ninety-five per cent browse, mainly poplar, alder, and willow, two per cent sedge, traces of grass and ground hemlock.

SALT LICKS

The many salt licks on the island are commonly found along streams or in low, swampy areas where soluble salts have evidently been washed down and deposited in the lower ground. The licks are usually muddy

and full of standing water. Some are really mud wallows, so that the bodies of animals become almost submerged. In places the banks and the roots of trees have been undermined by the moose eating the mud. Numerous well worn trails lead to the licks.

Some samples taken from a few of the licks were analyzed by B. A. Soule of the Department of Chemistry, University of Michigan. Three salts were found to be present, besides the sodium chloride which had been deposited at some of the licks by man. The content was chiefly calcium sulphate and ferric sulphate, with a small amount of magnesium sulphate.

The results of the analyses of five samples, one of dirt, the others of water, are as follows:

| Location | Approximate proportion of salt in aqueous extract | Analysis |
|---|---|---|
| 1. Lick, east end of Lake Sargent | .25% | Chiefly calcium sulphate and ferric sulphate, small amount of magnesium sulphate. Trace of sodium chloride. |
| 2. Lick, on Sargent Trail, near the Lake | .10% | Same as No. 1, though less iron and chloride. |
| 3. Lake Eva Lick | .13% | Approximately same as No. 2, sodium chloride higher. |
| 4. Lick, southeast of head of McCargoe Cove | .16% | Similar to No. 2. |
| 5. Lake Eva mud sample | .20% | Same as samples No. 2, 3, 4, but much sodium chloride. |

(Test No. 5 was made on aqueous extract from 160 grams of the soil.)

The number of moose found at the licks is rather surprising. As many as twenty were observed at a salt lick at one time. Possibly the mineral content of the plants on the ridges is low, due to a heavy leaching of the soil, forcing the moose to get the necessary salts at the licks. A few individuals, usually cows, were to be found at some of the licks at all times of the day, but they are most frequented early in the morning and in the evening. More cows were seen at the licks than bulls. Individuals remain at the licks for long periods of time. On one occasion two cows were occupied at a salt block alternately for about three hours. While one cow was at the salt, the other was drinking at a pool of water a few yards away.

At the natural licks, the moose generally sip the water. They are seldom seen eating mud, although there was evidence that much mud had been eaten. During the period that I observed moose, May 4 to October 12, the licks were constantly frequented, and I am told that certain of them are used by moose even in winter.

DEPLETION OF RANGE

So far as the moose is concerned the overbrowsing of winter foods is most serious, for at this season the food supply is generally greatly restricted, but from the standpoint of conservation in general, summer overbrowsing may be as serious as winter overbrowsing. On Isle Royale all of the important winter foods as well as several species eaten only in summer are overbrowsed. The destruction of certain summer foods such as some of the lake plants probably has more serious effects on the plant and animal interrelationship than the destruction of winter foods. For instance, a reduction of water plants may have a rather direct deleterious effect on the fish fauna.

I have but little information on the original distribution of the pondweeds on the island. Many of the lakes where conditions seem to be favorable to the growth of pondweeds are now destitute of them, and only a few of the lakes now contain a sufficient amount to attract the moose. In Sargent Lake, where moose feed in the water quite extensively, the pondweeds are becoming scarce, for on three occasions when I examined the lake bottom where I had observed moose feeding in the shallow water, I had difficulty in finding any plants.

Water lilies were formerly abundant in at least some of the lakes. Adams,¹⁴ in 1905, reported white pond lilies (*Castalia odorata*) very abundant in Summer Lake, and yellow pond lilies (*Nymphae americana*) occurring in several bogs. William S. Cooper,¹⁵ in 1910, noted yellow pond lilies as common in lakes and bogs, sheltered bays, and delta streams, and the white water lily occurring in bogs, lakes, and delta streams. Today water lilies are practically gone; only an occasional plant is seen. No doubt the lakes were formerly a source of much summer food which has now become greatly depleted.

Ground hemlock (yew), an evergreen shrub attaining a height of four or five feet, is another important source of food which has been practically exhausted. Adams, in 1905, and Cooper, in 1910, found it growing in profusion. Adams stated that "it is everywhere abundant in the upland forest." Today nothing remains of this spreading shrub except the dead branches and a few leaves near the roots. The fact that this shrub is eaten the year round hastened its destruction. Ground hemlock at one time furnished a large amount of food for the moose. Its disappearance has resulted in concentration on the remaining species utilized in winter.

Balsam fir is one of the most important sources of food during the winter. It is widely distributed over the island, occurring either as mature

¹⁴ *Op. cit.*, p. 8.

¹⁵ "A Catalogue of the Flora of Isle Royale, Lake Superior," *Sixteenth Ann. Rept. Mich. Acad. Sci.*, 1914, 121.

stands or as small trees scattered throughout much of the poplar and birch forest. Its utilization is not so complete on the east end as it is on the western two-thirds of the island. At Chippewa Harbor, on some of the steep slopes of Greenstone Ridge, and along Lane Cove there are areas where it is not very heavily browsed. From Chickenbone Lake westward I did not note a single balsam unbrowsed; most of it was heavily browsed, the branches closely trimmed and the tops broken off. Undoubtedly well over fifty per cent of the original supply of balsam has been utilized.

Stands of poplar and birch of various ages cover much of the island. The larger trees offer little in the way of food, for the lower branches have usually been killed by shading. Thousands of the smaller trees have been broken over by the moose. Many are dead, others have but a few twigs bearing leaves. Both species are greatly overbrowsed, as is also the mountain ash.

Most of the shrubs (except for the alders) have been heavily utilized. Those on the ridges have suffered most. In winter, shrubs on the ridges are more available, for in many lowland situations they are protected from browsing by a deep covering of snow.

Other factors bearing on the abundance of vegetation must be considered in connection with its utilization by moose. The beaver destroys some vegetation but in a relatively small degree compared to the destruction effected by the moose. Large trees felled by the beaver are fed upon by moose so that between the two species there is a more complete utilization of the down timber resulting from the beaver's logging operations than is usual. The food thus supplied to the moose tends, to a slight extent, to decrease the use of other plants. On the whole the beaver plays a rather minor part in the destruction of vegetation on the island.

More important, perhaps, may be the snowshoe hare population. This animal, particularly when it reaches the peak of its abundance, might become a more serious menace to vegetation. A number of shrubs have been killed through girdling by hares. At present the hare is very scarce and so has little effect on the vegetation, but should it become numerous again, it would make serious inroads on some of the shrubs. On the Yukon Flats in Alaska I have seen tracts of willow several acres in extent razed to the snow surface by hares, only the stubble remaining. Should such a condition arise on Isle Royale, the overgrazed condition would be further aggravated. The presence of coyotes, foxes, and other natural enemies may do great service in keeping the hares in check or at least retard abnormal increase.

Another factor affecting the vegetation is the presence of spruce budworm (*Cacoecia juniperæ*) in the balsams. In places, large tracts of balsam are suffering from this pest.

MANAGEMENT

To prevent further devastation of vegetation on Isle Royale it would seem highly advisable that control methods be initiated to reduce the moose population to the carrying capacity of the island. Because of its overbrowsed condition its present carrying capacity is less than it would be under intelligent supervision. It is plain that even though all the moose were to be suddenly removed, a period of some years would elapse before the vegetation could return to normal, so that for some time it would be necessary to reduce and hold the herd below the level at which it could afterward be carried. For the immediate present the numbers should be reduced enough to prevent further overbrowsing and to permit a recovery of the vegetation now overbrowsed. If the population is not reduced, the rate at which the vegetation is destroyed will rapidly increase, and, in the near future, the moose will begin to be eliminated by disease and starvation.

Complete utilization of a range composed of a varied vegetation is generally not possible without harmful effects to some species. Plant species are not uniform in palatability nor are they uniform in abundance. Therefore the palatable, less abundant species may be almost extirpated before a few abundant species making up the bulk of the food supply are at all damaged. Those species eaten the year around are apt to suffer before seasonal foods, other factors being equal. Thus it is evident that depletion of range may set in long before the bulk of the food supply has begun to be utilized.

If certain palatable plants which it is desirable to preserve in the landscape are early over-utilized it may be necessary to restrict the moose population even though the bulk of the food supply is not in any danger. It seems probable that water lilies and perhaps ground hemlock are species early affected. If so, and if the preservation of these species of plants is desirable, then the moose population must be held below the number which would harm these "indicator" forms. The carrying capacity of the island, so determined that no food species are overbrowsed, will probably be less than it would be if some of the more palatable species are sacrificed. Perhaps all plants cannot be preserved if a reasonable number of moose are permitted to roam the woods. Finer adjustments between the moose and vegetation must be worked out in the future when the vegetation approaches the normal state. The number of moose the island will permanently support without injuring the landscape can be arrived at only by close observation and careful investigation carried on over a period of years. The fact must be kept in mind that the interrelationships of nature are complicated and that few, if any, plant habitats should be sacrificed.

The elimination of a certain portion of the moose population of Isle Royale, in order to conserve the landscape, admittedly presents a difficult

problem. The first solution that presents itself is to permit hunting. Some supervised method of hunting could be used to eliminate a certain proportion of the animals. This may appear simple, but there are serious objections to the method.

Today, when we are faced by the fact that there are far too many guns in the field for the available game, it becomes important to foster the highest type of sportsmanship. It must be admitted that a true sportsman probably would not relish the thought of going to Isle Royale and shooting down a moose which presents only a large easy target, without the attendant thrills or difficulties of stalking. If the island becomes a national park as has been predicted, hunting, of course, should not be permitted.

Another possible solution which seems quite feasible would be for the state to kill a certain number of Isle Royale moose and place the meat on the market, the main object being to lessen the number of moose in the simplest way possible. The advantage of this method is that the extent of the reduction could be definitely controlled. This method is used in Yellowstone National Park in reducing the number of black bears and in keeping the buffalo herd under control.

A third method sometimes used to reduce populations is to transport the live animals elsewhere. It would probably be impractical to remove the entire surplus of moose by this method but if funds were available a few could be transported to another region for restocking purposes.

Were it known if and to what extent our larger predators such as the bear, cougar, or timber wolf prey on moose, a possible solution to the overpopulation on the island would be to introduce an effective predator. The usefulness of predators in this connection is being recognized in the Kaibab Forest. Here the cougar is now tolerated in order that it may assist in reducing the number of deer in this badly overcrowded area. Since one of these predators might possibly do good work in keeping the moose herd in check, and since there are few places where large carnivores are tolerated, it would seem desirable to introduce one or more of these predators on the island. Aside from the possible utility of the predator as a check on the moose population, such an introduction of a native species would add materially to the animal interests of the island.

Some have thought the coyote on the island to be preying extensively on moose, especially on the calves, and that this species is keeping the moose in check. There is no good evidence showing the extent if any it preys on moose, and the fact remains that the moose has not been held in check by the coyote.

On the other hand it is well known that snowshoe hares are in many places one of the principal items in the coyote diet. In a situation like

that on Isle Royale, where the preservation of forage becomes the chief consideration, most valuable service may be performed by the coyote. Any other species on Isle Royale which preys on hares participates with the coyote in the good service of conserving a certain amount of browse. Such predators, therefore, serve a useful purpose in this case.

The reduction of the number of moose should increase the charm of the island, even for those persons interested almost entirely in moose. There is a satisfaction in knowing that a lake before us is not partially depleted of its flora and fauna, but rather that it is full of a variety of life. For the greatest enjoyment of the moose, it is not particularly desirable to have them so plentiful that we involuntarily compare the gatherings of them to a prosperous barnyard. In northern Minnesota I was more thrilled by a week-old moose track found in some wet, grassy swale than I was by seeing twenty moose at a salt lick on Isle Royale,—the congregation of them left less to the imagination. Conversing with visitors to Isle Royale on the subject of moose, I often have received the impression that they mused over the statistics involved until a moose ceased to be an animal but simply a numeral. Great disappointment was sometimes expressed if only three or four moose were seen at a salt lick. I felt that instead of observing the moose and perhaps having its wild spirit arouse a dormant kindred spirit in them, they merely counted the animals. I mention this only to illustrate how quality of enjoyment may decrease when the animals become commonplace.

Moose management should fit into a larger program of wild life management, for the moose is a part of the wild life picture. The land should not be teeming only with moose but teeming with all of nature. The aim of wild life management should be to give consideration to all life so as to have nature present in good proportions. To this end principles rather than expediency should be emphasized in administration.

SUMMARY

The moose on Isle Royale has increased and become numerous since its last invasion of the island during the winter of 1912-1913. There were probably well over a thousand animals on the island in 1930.

Weights and measurements of adults collected are listed.

A description of the development of the younger animals is given.

The moose sheds most of his winter coat during May and June.

The senses of hearing and smell appear to be well developed; vision seems somewhat deficient.

Observations on home range show that moose may confine their wanderings to a small area, at least for a week or two.

The moose is most active in the early morning hours and in the evening. During the summer the moose is more or less solitary in habits.

Flies pester the moose considerably. Their bites cause raw spots on the hind legs above the calcanea. So far as my observations go, moose seldom enter the water solely to avoid the flies.

Of interest and importance was the finding of skeletons of which the skulls showed conditions indicating that death was due to necrotic stomatitis.

The velvet is rubbed from the antlers during the first part of September. In 1929 practically all of the antlers were cleaned between September 5 and September 13.

Mating takes place from the middle of September to about the middle of October.

Usually the bull consorts with but one cow at a time but occasionally with two cows.

The bulls, especially the younger ones, apparently engage in combat during the rut for their antlers are often broken. A large bull, when in company with a cow, seems to possess all the courage; competitors usually retreat before his advances.

During the rut bulls respond readily to an imitation of the prolonged call of the cow or even to the sound of breaking branches.

Most of the calves are probably born between the middle of May and the middle of June.

A single calf is the rule, but occasionally there are twins.

In summer the calves are often left lying somewhere while the cow feeds.

Almost fifty per cent of the cows observed during the fall were followed each by a calf, and about the same proportion of cows in the spring were followed each by a yearling.

A description of the food habits together with an annotated list of food plants is given.

Behavior of moose at salt licks is described, and contents of some salt licks are listed.

Overbrowsing on the island is general. In order to preserve the landscape it is recommended that a drastic reduction of the moose population be made. In the management of the moose all forms of life on the island must be given consideration. Several methods for reducing the number of moose are suggested.

PLATE I

- FIG. 1. A yearling rubbing his antler on his thigh. A number of bulls were seen scratching their tender antlers in this manner. Photograph taken at a lick near Lake Eva, June 20, 1930.
- FIG. 2. A cow at a lick at the head of McCargoe Cove. The yearling in the background remained at a distance probably because the cow had often discouraged it from following her. Photograph taken May 22, 1930.



FIG. 1



FIG. 2

PLATE II

FIG. 1. Salt lick near Lake Eva. By eating the mud the moose have undermined the roots of some of the trees. Photograph taken May 16, 1930.

FIG. 2. An area where many poplars were recently barked. Photograph taken near Linklater Lake, May 24, 1930.



FIG. 1



FIG. 2

PLATE III

Mountain Ash (*Pyrus americana*) barked by moose. The bark does not come off in long strips as in the poplar. Photograph taken near Lake Eva, May 5, 1930.



PLATE IV

A balsam heavily browsed, part of the bark eaten. Many are in this condition.
Photograph taken near Patterson Lake, May 9, 1930.



PLATE V

- FIG. 1. Bull moose feeding on pondweeds. Photograph taken at Sargent Lake, September, 1, 1929.
- FIG. 2. Pin Cherry (*Prunus pennsylvanica*) broken over by moose. Photograph taken near Todd Cove, May 30, 1930.



FIG. 1



FIG. 2

PLATE VI

FIG. 1. Birches heavily browsed by moose. A few of the trees have grown out of reach and are now too large to be broken over. Photograph taken on Greenstone Ridge, May 27, 1930.

FIG 2. Mandibles of moose showing necrosis of the bone. The upper specimen was from a skeleton of a cow found on the Desor Trail on the southwest end of the island in June, 1930. The lower specimen was found on Fish Island in September, 1929, sex unknown.



FIG. 1

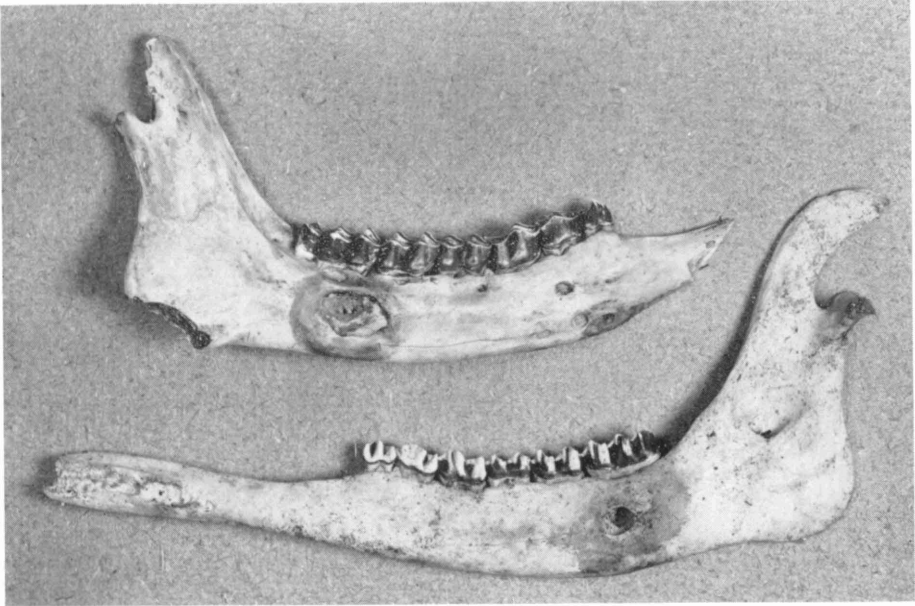


FIG. 2

