

~~12 4 78~~ 041

~~041~~ 91990/82

~~1 7 78~~ 186

~~041~~ 91990/82

~~F 043~~

~~041~~ 91990/82

A335

~~041~~ 91990/82

~~121 79~~ 057

~~041~~ 91990/82

~~MAY 4 78~~

~~041~~ 91990/82

B17

~~041~~ 91990/82

~~02 80~~ 012

~~041~~ 91990/82

~~02 80~~ 216

~~041~~ 91990/82

~~041~~ 91990/82

~~DEC 14~~ 350

~~041~~ 91990/82

~~02 80~~ 151

~~041~~ 91990/82

ABSTRACT

AN ECOLOGICAL STUDY OF THE COYOTE ON BEAVER ISLAND, LAKE MICHIGAN

by John Joseph Ozoga, Jr.

An ecological study of the coyote on Beaver Island, in northern Lake Michigan, was undertaken to evaluate the relationship of coyotes with other island wildlife, and to investigate the behavior and food habits of coyotes subjected to such partial isolation as provided by the island conditions.

Daily activities of coyotes in winter were studied by following their trails in the snow for 314 miles, and by interpreting animal sign along the trails. Fourteen coyotes were trapped, tagged, and released to obtain supplementary information on their movements. Two hundred and seventy-four coyote feces, representing all seasons, were collected and analyzed.

The winter hunting activities of coyotes were commonly nocturnal. A majority of the trailed coyotes traveled alone; no groups of three or more coyotes were noted to hunt cooperatively. Their movements followed nearly straightlined travel from one feeding area to another, but were not habitual in following a fixed pattern. Ranges of coyotes on the island overlapped. Trailed coyotes hunted for prey most frequently in mixed hardwood-conifer cover. Their beds were most often detected in dense coniferous vegetation. Northern parts of Beaver Island, which provide a habitat interspersed with open grassland, appeared to be favored by coyotes, rather than the densely vegetated southern parts.

One coyote which was tagged on the island was later killed in Lower Michigan, illustrating that coyotes possess the potential to disperse from the island.

The feeding habits of the island coyotes were found to change from a highly carnivorous winter and spring diet to consistent utilization of plant fruits and insect prey during the summer and autumn. White-tailed deer killed or crippled by deer hunters proved to be the coyote's primary winter food; only one of 19 deer carcasses found on the island was killed by coyotes. Snowshoe hares and muskrat remains were the most commonly detected mammalian item in coyote feces collected during the spring, summer, and autumn. Newborn deer fawn residues, frequently identified in coyote feces during June, could not be distinguished as carrion or fresh kills. Fruits of sarsaparilla were the most common item in feces collected during August. Ruffed grouse, gray squirrels, eastern chipmunks, and woodland deer mice were abundant on Beaver Island, but coyotes did not appear adept at capturing such prey. The fruits of apple, Rubus sp., strawberry, and sand cherry were readily eaten by coyotes.

Typed by
C. G. C. C. C.
C. G. C. C. C.
C. G. C. C. C.

ACKNOWLEDGMENTS

The field investigations covered in this report were conducted in cooperation with the Game Division of the Michigan Department of Conservation. The author is indebted to Mr. H. A. Ruhl, Chief of the Game Division, for making the study possible.

Many personnel from the Game Division have extended assistance in various ways. I am especially grateful to Dr. R. A. MacMullan and Raymond Schofield, for initiating the study. Ralph Blouch, Biologist-in-Charge, of the Houghton Lake Wildlife Experiment Station, directed my work and offered valuable advice and assistance. Doctors C. T. Black, L. D. Fay, and W. C. Youatt supplied laboratory space, equipment, and suggestions for the analysis of fecal materials. The following biologists contributed many services: Jerry Duvendeck, Herbert Johnson, Richard Moran, Robert Curtis, and Elsworth Harger. Mildred DeWitt generously provided her time for typing the manuscript.

I wish to express my sincere thanks to Dr. Leslie Gysel, and Dr. Rollin Baker, for guiding my program of study at Michigan State University, and editing the manuscript.

Finally, I am very grateful to my wife Janice, who frequently accompanied me in the field, and provided timely assistance and encouragement.

G-25559

17 July 1963

AN ECOLOGICAL STUDY OF THE COYOTE
ON BEAVER ISLAND, LAKE MICHIGAN

By

John Joseph Ozoga, Jr.

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1963

TABLE OF CONTENTS

	Page
Introduction	1
Study Area	2
Location	2
Physiography	2
Climate	3
Cultural History	4
Vegetation	6
Wildlife	9
Mammals	9
Upland game birds	10
Methods	11
Tracking or Trailing	11
Line Transects	12
Trapping and Tagging	13
Traps utilized	13
Trap preparation	13
Trap sites	14
Setting traps	14
Automatic tagging devices	14
Handling and tagging	14
Scat Collection and Analysis	15
Laboratory analysis	16
Field analysis	17
Past and Present Coyote Populations on Beaver Island	18
History	18
Numbers of Coyotes	21
Coyotes on Surrounding Islands	22
Daily Coyote Activities	24
Time of Travel	24
Manner of Hunting	25
Roving	25
Stalk and pounce	25
Chasing	27
Movement Patterns	27
Established Crossings	28
Use of Runways	28
Sociability	29
Movements in Relation to Vegetation	33
Interspersion of cover types	33
Upland hardwoods	33
Mixed aspen, white birch, and conifer	34
Cleared land	36
Swamp conifer	38
The Lake Michigan shore line	38
Other cover types	40

Bedding sites	40
Tracking Distances	43
Areas of Activity	44
Dispersal From the Island	46
Reaction to Humans	50
Reaction to Roads	51
Effects of Weather	51
X Coyote Food Habits	53
White-tailed Deer in Relation to Coyotes	64
The Deer Population	64
Importance in the Coyote Diet	66
Deer Carrion in the Coyote Diet	69
X Deer and Coyote Relations in Winter	71
Unsuccessful deer pursuits	71
Deer depredation by coyotes	76
Newborn Fawns in Relation to Coyotes	78
Other Mammals in Relation to Coyotes	82
Snowshoe Hare	82
Muskrat	85
Cattle	88
Gray Squirrel	89
Eastern Chipmunk	90
Woodland Deer Mice	91
Beaver	93
Raccoon	94
Woodchuck	95
Coyote	96
Masked Shrew	96
Red-backed Vole	97
Red Fox	97
Birds in Relation to Coyotes	101
Ruffed Grouse	101
Sharp-tailed Grouse	102
Duck	103
Song Birds	104
Other Birds	105
Miscellaneous Items in the Coyote Diet	106
Invertebrates	106
Grasshoppers	106
Beetles	106
Other Insects	107
Crayfish	107
Other invertebrates	107
Cold-blooded Vertebrates	107
Snakes	107
Turtle eggs	108
Fishes	108
Frogs	108

Vegetable Food	109
Sarsaparilla	109
Raspberry, blackberry, and dewberry	110
Apple	110
Strawberry	111
Sand Cherry	111
Beechnut	112
Grass and sedge	112
Other plants	112
Debris	113
Summary	114
Literature Cited	119

LIST OF TABLES

Table	Page
1. Record of the number of coyotes bountied on Beaver Island, 1947-1962	20
2. Number of coyote trails followed by month - 1961 . . .	30
3. Number of coyote trails encountered along 23.5 miles of line transects	30
4. Habitat availability on Beaver Island, and use by coyotes trailed for 227.7 miles	35
5. Frequency of food items located along 227.7 miles of coyote trails, in relation to cover types	37
6. Vegetative conditions where winter coyote beds were located on Beaver Island	42
7. Coyotes trapped, tagged, and released on Beaver Island	48
8. Tagged coyotes released on Beaver Island and recovered	49
9. Classification of food items found in 247 coyote scats from Beaver Island, 1960 and 1961	54
10. Frequency of food items identified in 27 undated coyote feces collected from Beaver Island on August 5, 1962	57
11. Frequency comparisons of the more important mammal and plant foods represented in the 1960 and 1961 summer coyote scats examined	63
12. Records of deer hunting seasons on Beaver Island . . .	65
13. Percent frequency and volume, by season, of adult deer in 247 coyote scats	67
14. Percent frequency and volume, by season, of newborn fawn deer in 247 coyote scats	67
15. Food items found along 86.6 miles of coyote trails on Beaver Island during January, March, and December, 1956-1958	74
16. Food items found along 227.7 miles of coyote trails on Beaver Island, during January, February, March, and December, 1961	75

Table	Page
17. Percent frequency of muskrat in coyote scats per month, in relation to monthly precipitation	87
18. Red foxes tagged on Beaver, Garden, and Hog Islands .	100

LIST OF FIGURES

Figure	Page
1. General cover type distribution on Beaver Island . . .	8
2. The observed frequency coyotes passed from one cover type to another. Based upon 227.7 miles of coyote trails	32
3. Intensive coyote utilization of the Lake Michigan shore, February 6, 1961	39
4. Clump of grass serving as coyote urination post on the Lake Michigan shore, February 6, 1961	39
5. Areas of coyote activity and sites where tracks of two coyotes missing toes were sighted	45
6. Seasonal variation of the major food groups in 247 coyote feces collected from Beaver Island, 1960 and 1961	60
7. Seasonal variation of the primary mammalian foods in 247 coyote feces collected from Beaver Island, 1960 and 1961	61
8. Seasonal variation of the primary plant foods in 247 coyote feces collected from Beaver Island, 1960 and 1961	62
9a. Large buck crippled and lost during the deer hunting season, serving as carrion to coyotes	68
9b. Right front leg of the above deer. Bones shattered by rifle bullet	68
10. Juvenile doe shot but not retrieved by hunters, serving as carrion for coyotes. Note manner in which carcass is consumed	70
11. Example of maximum utilization of deer carrion by coyotes	70
12. Juvenile female deer killed by coyotes on Beaver Island, March 2, 1961	77
13. General locale where coyote feces containing newborn fawn remains were collected, and where fawns were sighted, 1960-1962	79

Figure		Page
14.	General locale where coyote feces containing adult deer remains were collected, 1960-1962, and where deer carcasses were found along winter trails in 1961	79
15.	General locale where coyote feces containing snowshoe hare remains were collected, 1960-1962 . .	84
16.	General locale where coyote feces containing muskrat remains were collected, 1960-1962	84
17.	General locale where coyotes were captured or killed from 1958 through 1962	99
18.	General locale where red foxes were captured or killed from 1958 to 1962	99

INTRODUCTION

The effects of predation by coyotes (Canis latrans Say) on the whitetail deer (Odocoileus virginianus Zimmermann) of Beaver Island, Michigan, has been a controversial issue since the early 1950's. Since then, island residents have steadily supported the concept that Beaver Island maintains a large coyote population, and that predatory activities of these animals are responsible for reduction of deer numbers. Islanders contend that coyotes kill excessive numbers of deer during winter months, and prey heavily upon fawns throughout the summer. Furthermore, they assert that because the area is an island, conclusions drawn from studies of coyote-prey relations on the Michigan mainland are not applicable to island conditions.

Ecological data pertaining to coyotes on Beaver Island, or for that matter concerning coyotes throughout Michigan, are sparse. I conducted periodic ecological investigations of coyotes on the island from July 15, 1960 through December 21, 1961. Eight months were spent in the field to better understand the relationships between coyotes and other island wildlife, and to gain additional information regarding coyote foods, movements, and daily habits. The objective of this thesis is to report these data.

STUDY AREA

Location

Beaver Island (often called Big Beaver) is situated in northern Lake Michigan; mean latitude for the island is $45^{\circ} 43'$ north, the mean longitude is $85^{\circ} 32'$ west. It is the largest of a group of islands commonly referred to as the Beaver Islands. Garden Island is the nearest to Beaver, less than 1-1/2 miles north northeast. Politically these islands are included in Charlevoix County, but Beaver Island is closest to Emmet County, approximately 19 miles east, and the shore line of Mackinac County, 15 miles north northwest.

Physiography

Beaver Island has a surface area of 58.4 square miles and is approximately 13 miles long, with its greatest width about 6.25 miles. Most of the island surface ranges from 40 to 80 feet above Lake Michigan. The maximum elevation is 200 feet. The interior of the island is primarily gently rolling, lacking the prominent bluffs of adjacent mainland areas. Shore line conditions vary considerably, being composed of glacial sand, shingled beaches, or marsh. A zone of sand dunes occur along the island's west side; "Mount Pisgah", a partially vegetated dune, is the highest point of the dune complex.

Sorensen (1961) describes the geology of the Beaver Island group as follows: "The entire region of the Beaver Islands is underlain by limestone, which has been slightly tilted and dips gently to the southeast. Outcropping at the surface and under water has caused the

formation of numerous shoals and reefs over much of the water surface of the area. The shore lines of the island are rough and broken, being everywhere characterized by numerous bays, channels, and inlets, and several offshore islands. The generally shallow water and the nature of the lake bottom, a heterogenous mixture of sand, pebbles, rocks, and huge boulders, necessitates extreme caution in handling even the smallest boats." Sorensen further states, that rock outcrops near lake level, mainly dolomites and limestones, contain fossils of the upper Silurian to middle Devonian.

There are eight lakes on the island, which are primarily shallow, with varying bottom types. Round Lake is shallow, and frequently dries up during the summer months. The north sides of Font Lake (also spelled Faunt) and Lake Geneserath have firm sandy bottoms, Fox Lake is firm bottomed, but with a leatherleaf (Chamedaphne calyculata) bog adjoining its southeast edge. Barney's Lake, Egg Lake, Green's Lake, and Miller's Marsh have generally soft abundantly vegetated bottoms.

The island's chief surface streams are the Jordan River, Cable Creek, and Iron Ore Creek. A number of intermittent streams also arise in the south central portion of the island, and flow to Lake Geneserath, or to Lake Michigan along the island's southeast shore. Beaver ponds are common on all the streams.

Climate

Climatic records for Beaver Island are available for a continuous period of 23 years, 1905 to 1928, whereupon annual daily weather recordings were discontinued. Recording of weather data resumed

in 1959. According to Darlington (1940), over the 23-year period the average yearly temperature was 42.8° F., the mean maximum 50.8° F., and the mean minimum 35° F. The greatest temperature extremes recorded on the island were 97° F. (in May) and -27° F. (in December). Darlington noted a 14 percent longer growing season on the island than in Emmet County, Michigan, at about the same latitude. May 14 was the mean date for the last killing frost, and October 13 for the first killing frost, thus, a growing season of 152 days. October received the maximum rainfall, while March had the minimum amount. The average annual precipitation recorded was 24.66 inches.

Cultural History

The first indisputable record of human inhabitants on Beaver Island comes from letters of Father Frederic Baraga (Cronyn and Kenny, 1958), who brought Christianity to island Indians in 1832.

James Jesse Strang, leader of a group of Mormons, brought his followers to Beaver Island in 1847. He founded the town of St. James in 1849, and in 1850 had himself crowned king of the island. The Mormons were responsible for clearing much land, and constructing roads to the island's south end. By 1854, the human population on Beaver Island totaled 2,608 residents (Cronyn and Kenny, 1958). Strang was assassinated by several of his followers in 1856. Shortly thereafter non-Mormon islanders and fishermen from Mackinac drove the leaderless Mormons from the island.

Irish immigrants came to Beaver Island in 1857, and in several years represented most of the island's population. In succeeding years

the fishing industry thrived; lake trout (Salvelinus namaycush) and whitefish (Coregonus sp.) comprised most of the catch. Fishing success declined rapidly with the spread of the sea lamprey (Petromyzon marinus) into Lake Michigan. Likewise, crop production dwindled on the island's infertile sandy soil. Since the mid-1800's the permanent population of Beaver Island has steadily diminished; from 1,095 island residents in 1910 (Cronyn and Kenny, 1958) the permanent population decreased to about 200 in 1961.

Today St. James is the island's only village, situated on crescent shaped St. James Harbor on the extreme northeast portion of the island. The mailboat "Beaver Islander", capable of carrying 10 automobiles and 150 passengers, conducts daily trips from Charlevoix to St. James, from April to January. Fast trips to Beaver Island can be made by airplane from Charlevoix, and is the sole winter transportation to and from mainland. Islanders claim there are about 75 miles of "good roads" on the island. All roads are gravel, with exception of one mile of asphalt through the village.

Income to the island in recent years has been dependent upon tourist trade. The permanent population of 200 residents swells four- or five-fold with tourists during much of the summer. Summer homes and cottages are scattered along the east side of the island and in the vicinity of Lake Geneserath. The deer season generally attracts several hundred deer hunters; fewer hunters participate in hunting of ruffed grouse.

Crop farming and commercial fishing, once the major island industries, currently contribute little to the economy of Beaver Island.

In the past several years 200 to 300 beef cattle have been brought to the island. Thus, much of the cleared land, previously abandoned to encroaching vegetation, has been converted to pasture land. Other cleared areas have been cropped for hay.

High transportation costs of forest products results in limited logging on the island. One sawmill on the island has been in operation in recent years, supplying some lumber used on the island and small amounts to mainland.

Vegetation

Darlington (1940) found the flora of Beaver Island to be closely related to that of Emmet and Charlevoix counties, in Lower Michigan. And like the Michigan mainland, the biotic communities have been modified by logging, fire, and agricultural use. He identified about 75 non-native plant species on the island.

The climax forest on Beaver Island is predominately beech (Fagus grandifolia) and sugar maple (Acer saccharum); associated species are basswood (Tilia americana), black cherry (Prunus serotina), and red oak (Quercus rubra). This type occurs most frequently on the mid-western and southwestern sectors of the island. Herbaceous flora of the woodland areas shows affinity to that of both the southern and northern peninsulas of Michigan mainland (Darlington, 1940).

Red pine (Pinus resinosa), white pine (Pinus strobus), and red oak occupy a narrow band of sandy soil west of St. James Harbor. These species occur with lesser dominance along the east side of the island. Balsam (Abies balsamifera), white spruce (Picea glauca),

white birch (Betula papyrifera), and aspen (Populus sp.) frequently occur as scattered representatives in these open stands.

Most cleared and all farmed land is on the northern half of Beaver Island. Very little land is presently farmed; more of the cleared land is in pasture, and still more is abandoned entirely. There are 10 or more unattended apple (Pyrus malus) orchards on the island. Sandy soil predominates on northern island areas, with numerous exposed sandy stretches. Low juniper (Juniperus communis var. depressa) and creeping juniper (Juniperus horizontalis) occur where such conditions prevail. Where the ground has been burned over, secondary successions have appeared. On such areas plant communities include blackberry (Rubus allegheniensis), red raspberry (Rubus ideaus), and low bush blueberry (Vaccinium pennsylvanicum). Herbaceous representatives on grassland areas (pastures, meadows, and stumpland) include bracken fern (Pteris aquilina), cinquefoil (Potentilla argenta), dwarf dandelion (Krigia virginica), spreading dogbane (Apocynum androsaemifolium), bristly sarsaparilla (Aralia hispida), puccoon (Lithospermum canescens), among others.

Northern bog communities are found bordering lakes and marshes. Tamarack (Larix laricina) and black ash (Fraxinus niger) are the common trees occupying such communities. Common bog shrubs include leather-leaf, labrador tea (Ledum groenlandicum), swamp birch (Betula pumila), and bog rosemary (Andromeda glaucophylla). A variety of herbaceous species are also present.

Areas of peaty soil, occupied by white cedar (Thuja occidentalis), are scattered over the island. Blocks of poorly drained peaty soil

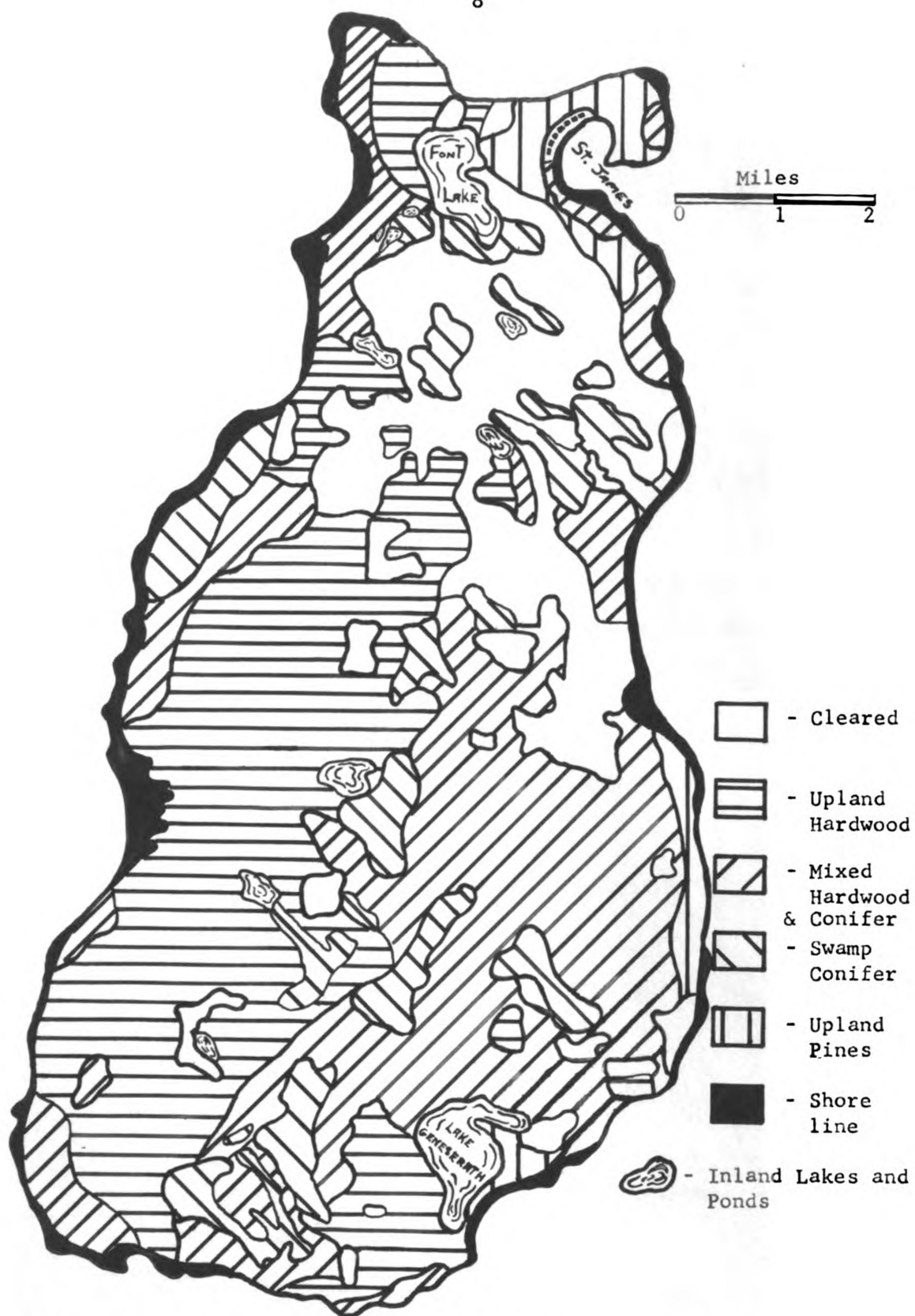


Figure 1. General cover type distribution on Beaver Island.

intermingle with larger areas of intermediate drainage in most of the island's south and southeast area. Aspen, white birch, white spruce, balsam fir, and white cedar occupy this area of intermediate drainage in various combinations.

Wildlife

Mammals. Following a study of animal life on eastern Lake Michigan islands, Hatt et al. (1948) wrote, "Few species of mammals have reached and established themselves on the islands without the help of man. The evidence indicates that but a quarter of the species represented on the nearby mainland can be included in our list of indigenous island mammals." He studied Beaver Island mammals in 1938, and concluded that the following mammals were present, or probably present then:

Raccoon (Procyon lotor) -- UR

*Otter (Lutra canadensis) -- AR

Red Fox (Vulpes fulva) -- CS

*Bobcat (Lynx rufus) -- UR

Eastern Chipmunk (Tamias striatus) -- SO

Gray Squirrel (Sciurus carolinensis) -- SO

Beaver (Castor canadensis) -- AR

Woodland Deermouse (Peromyscus maniculatus) -- SO

Muskrat (Ondatra zibethicus) -- AR

*Cottontail Rabbit (Sylvilagus floridanus) -- UR

Snowshoe Hare (Lepus americanus) -- SO

White-tailed Deer (Odocoileus virginianus) -- O

*mammals for which I observed no evidence	CS - clear sign of presence
UR - uncertain record	SO - specimen obtained
AR - acceptable report by others	O - observed

Robert Tuck, a student from Michigan State University working in cooperation with the Museum at East Lansing, conducted a small mammal survey on Beaver Island during July and August, 1960. He collected red-backed voles (Clethrionomys gapperi) and masked shrews (Sorex cinereus), not previously reported by Hatt et al. (1948).

In addition to mammals noted above, I observed or collected coyotes, shorttail weasel (Mustela erminea), woodchuck (Marmota monax), and house mice (Mus musculus).

Upland game birds. Ruffed grouse (Bonasa umbellus) are the most abundant upland game birds on Beaver Island. The present population originated from the release of 68 birds during the winter of 1948-49 (Ammann and Palmer, 1958).

Twenty-nine sharptail grouse (Pedioecetes phasianellus) were released on the island in 1940 (Ammann, 1957). By 1950, Ammann estimated the fall population to be 100 birds. Their numbers have decreased steadily since then, and at present only scattered individuals have been reported.

According to residents, ring-necked pheasants (Phasianus colchicus) were introduced in 1922, but disappeared completely by 1952.

Six juvenile turkeys (Meleagris gallopavo) were released on Beaver Island in August, 1961. Four of the birds survived the winter and brought forth two broods the following spring. Another 32 turkeys were released on the island in August, 1962.

METHODS

Movements of coyotes were studied primarily by following their tracks in the snow. Some coyotes were live-trapped, tagged, and released to obtain supplementary information regarding their activities. Tracks of coyotes were counted crossing line transects to assist in estimates of the number of coyotes on the island, and to help determine the areas and habitats most frequently traveled by coyotes. The food habits of coyotes were studied through observations of coyote feeding activities along their winter trails, and the analysis of coyote feces collected during all seasons. Interviews and correspondence with Beaver Island residents, and people familiar with the island, served to obtain additional information regarding wildlife on the island.

Tracking or Trailing

The tracking technique employed by Murie (1936), Stebler (1951), Erickson (1955), Arnold (1956), and Schofield (1960) in ecological studies of such species as red fox, coyote, timber wolf (Canis lupus), and bobcat was the primary method utilized in the winter study of coyotes on Beaver Island. The method consists of following mammal tracks left in the snow and interpreting activities and behavior of the animal tracked. Regarding the validity of this technique, Murie (1936) states, "...it is practically equivalent to observing an animal under natural conditions."

Upon encountering carnivore tracks in the snow, the first problem was that of proper identification. Red foxes and domestic dogs were the only species present which made tracks that might have been

confused with those of coyotes. Dogs were not numerous. Nearly all winter residents resided at the very northern part of the island, with dogs limited to this region. Red fox tracks, while definitely smaller than those of coyotes, were sometimes difficult to distinguish from tracks of small coyotes in fine loose snow. In such instances odor of the carnivore's urine was an effective diagnostic character, as Stebler (1939) also noted. The odor of fox urine resembles that of skunk musk and is much more intense than that of coyotes.

Efforts were made to trail coyotes after fresh snowfalls, when sign interpretation was considered most accurate. Generally, the first coyote track encountered was followed on foot, with or without snowshoes depending upon snow conditions, until the track was lost, the coyote was jumped or darkness prevented further tracking. The distance any particular coyote was trailed was measured by tallying paces with a pocket Veeder counter, then transforming the distance into miles. When paired coyotes were trailed the individual distance was doubled; thus, the logged distance was expressed in "coyote-miles". Special tracking forms were completed for each coyote or group of coyotes trailed.

Line Transects

Line transects were employed to a limited extent during the winter studies, to help determine in which areas carnivore and prey species tracks were most abundant, and with what frequency their tracks were encountered in various vegetative cover types. Kelker (1943), Quick (1953), and Dahlberg and Guettinger (1956) also used the technique. They counted mammal tracks encountering cruise lines to estimate the size

of mammal populations and fluctuations in their abundance. A total of 28 miles of compass lines, of varying lengths, were followed over Beaver Island. All fresh mammal tracks crossing the lines were tallied.

Trapping and Tagging

Coyotes and red foxes were live-trapped, tagged, and released on Beaver Island during the summer study periods, July through mid-September, 1960 and 1961. Trapping also assisted in determining where they concentrated their summer activities, and what sectors were favored for raising of their young. Capturing and recapturing foxes and coyotes provided further knowledge of their movements, along with a more confident estimation of their numbers.

Traps utilized. Assorted sizes of steel-spring traps, in conjunction with various trap modifications, were used in attempts to capture foxes and coyotes in an uninjured manner. With the limited number of foxes and coyotes available on the island, utmost care was exercised to injure as few as possible. Consequently, a large percentage of the traps employed in the study were not capable of holding large animals, and coyotes often escaped from traps. The majority of the traps used in the study consisted of No. 2 Victor Fox Traps, No. 2 Victor Jump Traps, No. 2 Victor Long Springs, and No. 1-1/2 Victor Long Springs. Fewer numbers of the larger traps were set on the island.

Trap preparation. Traps, chains, and grapples were boiled for approximately one hour in a commercial trap dye, then were left soaking in the solution over night. The traps were then waxed. This process involved drawing the heated traps through a boiling solution of

wax and water, whereby, each trap obtained a film of wax. During and after waxing traps were handled with clean canvas or rubber coated gloves, and kept in a clean well-aired place. These procedures made traps free of foreign odor, and resistant to rust for several months.

Trap sites. Traps were placed where fox and coyote sign was evident. Trapping sites included grass clearings, sand ridges, sand blows, the Lake Michigan shore line, and old roads. Garlough (1945) and Nagel et al. (1955) provide detailed discussions on selecting proper trap locations. Their general suggestions were followed.

Setting traps. The "dirt-hole" set, described by Hawbaker (1944), was the basic type set employed during the summer trapping. It supposedly represents the efforts of an animal to bury scraps of food. The "scent-post" set, described by Hawbaker (1944), Nagel et al. (1955), and Garlough (1945) was used less frequently. Such sets are imitations of sites where foxes or coyotes frequently urinate. Commercial coyote or fox gland scent was applied at both type sets. Limited trapping was also carried out at fox dens. In such cases the traps were set in den entrances, without use of scent.

Automatic tagging device. Limited use was made of snare-like automatic tagging devices, similar to those devised by Romanov (1956), to mark coyotes without handling them. Such devices were set on trails which were frequently traveled by coyotes.

Handling and tagging. Trapped red foxes and coyotes were normally subdued with a "choker", an apparatus which was constructed similar to that employed by Erickson (1957) when he handled black bears. No anesthetics were used. Following rigorous treatment with the "choker"

coyotes invariably exhibited a fear response which rendered them immobile for a short time. Red foxes never exhibited such reactions. Numbered metal tags were attached to the ears of all trapped animals. A few were also provided with colored or numbered collars. Foxes and coyotes were normally retained in captivity for 15 to 30 minutes. With few exceptions, foxes and coyotes always were released where captured.

Scat Collection and Analysis

Direct observation, examination of stomachs, and the analysis of fecal passages provide methods for food habit studies of animals. Of these, direct observation, limited to interpretation of sign along coyote trails, could be accomplished on Beaver Island only during the winter months. Coyote stomachs were not readily available for analysis, since so few are killed each year. Examination of coyote feces was the primary technique which revealed the foods of coyotes on the island during the snow-free months.

The technique of scat analysis has been used widely in studies of coyote feeding habits. Adolph Murie's (1940) study of coyotes in the Yellowstone National Park entailed the analysis of 5,086 coyote feces. In Jackson Hole, Wyoming, Murie, O. J. (1935) determined the food habits of coyotes through the analysis of 714 coyote scats, supplemented with field observations. Fitch (1948), Fitch and Packard (1955), Korschegen (1957), Bond (1939), Sooter (1946), Tiemeier (1955), among other, have utilized this technique in studying coyote food habits in various parts of the country. In Michigan, Stebler (1951) examined 99 coyote scats from the Upper Peninsula; Dearborn (1932) analyzed 78 coyote scats taken from Lower and Upper Michigan.

Coyote scats were collected while operating trap lines during the summer studies, and along trails of coyotes followed in the winter. Special effort was made to differentiate between fox and coyote scats. On Beaver Island, foxes were the only wild carnivores which deposited feces comparable to those of the coyote in size and shape. Since red foxes were not abundant during the study, there was little chance for mis-identification of feces. Those scats not properly identified were discarded. Collected scats were wrapped in cheesecloth, dried, stored in paper sacks, and labeled as to date, location (to 40 acres), and other pertinent information. Spring (April-June) scats could be only approximately dated, since all scat materials for this period were collected in June and July.

Laboratory analysis. A total of 247 coyote scats were analyzed at the Rose Lake Wildlife Experiment Station laboratory near East Lansing, Michigan. Identification of food items was facilitated by use of a binocular dissecting microscope. A compound microscope was used to identify hair, with reference to a collection of hair slides at the laboratory. Reference was also made to mammal skeletal collections, supplied by the Michigan State University Museum, and to seed collections.

Analytical procedures followed closely those described by Mosby (1960). All scat material was examined in a dry state, with careful segregation of constituent materials. Percentage calculations were then made both for frequency and volume of each food item, in the same manner used by Korschegen (1957) and Fitch and Packard (1955). Volume of the food items was obtained by inserting the material into graduated cylinders partially filled with water, consequently displacing a unit volume.

Field analysis. Twenty-seven scats, collected in August, 1962, were analyzed in the field without aid of laboratory equipment. This entailed breaking apart fecal passages and recording only the frequency of food items visually identified.

PAST AND PRESENT COYOTE POPULATIONS ON BEAVER ISLAND

History

Dice (1927) suggests that coyotes originally occurred in the prairie lands of southwestern Michigan, indicating that coyotes have been present in Michigan since Pleistocene time. Since clearing and settlement by European man this carnivore has spread throughout Michigan.

Earliest state records of coyotes come from southern Lower Michigan. Wood (1922) reported the species in Washtenaw County in 1881; Wood and Dice (1923) reported its presence in Berrian County in 1900. Goldman (1930) suggests that coyotes entered Upper Michigan about 1906. Because coyotes first became numerous in Upper Michigan, then in northern Lower Michigan, while occurring only sporadically in southern Michigan, Stebler (1951) postulates that the species invaded the Upper Peninsula from Wisconsin, spread eastward, and then across the straits of Mackinac into northern Lower Michigan.

Hatt et al. (1948) did not report coyotes on Beaver Island during their visit in 1938. He classified coyotes as "Prairie or second-growth inhabitants," which "...have not had adequate opportunity to cross, or sufficient population pressure to induce them to cross, the barriers of water or ice." The first reliable observation of coyotes on Beaver Island was by Karl Kuebler (in litt., 4 March 1962), retired conservation officer. He identified coyote tracks on the snow-covered ice at Fox Lake in December, 1943. Archie LaFreniere (in litt., 6 March 1962), life-long resident of Beaver Island, reported seeing tracks which he thought were made by a coyote in the Hanigan area, during late fall of

1942. According to LaFreniere the first coyote killed on the island was shot by Andrew Wuerfel of Three Rivers, Michigan in November, 1944. Correspondence with Mr. Wuerfel (in litt., 20 May 1962) confirmed the kill. He indicated that the coyote he killed was an exceptionally large male, weighing 42 pounds, and that it was shot approximately 6 miles south of St. James. From this limited information it seems likely that the first coyotes probably arrived on the island in 1940 or 1941.

Introduction of coyotes onto Beaver Island by man was possible, but unlikely. Coyotes apparently established themselves on the island by traveling across the ice of Lake Michigan. Beaver Island is isolated by broad expanses of water during much of the year, but bridges of ice extend from the north end of the island to both Upper and Lower Michigan through much of the winter. Generally, by late January ice thick enough to support a coyote's weight is formed between Beaver, Garden, and Hog Islands. By mid-February, ice beyond the islands to mainland is well formed. On February 7, 1961, several islanders made an automobile trip across Lake Michigan from St. James to Naubinway, in the Upper Peninsula. Whether coyotes came to Beaver Island from the Upper or Lower Peninsula of Michigan, or both, is uncertain.

The Michigan Department of Conservation have compiled records for the number of coyotes killed and bountied on Beaver Island since 1947 (Table 1). Assuming that these records provide a reasonably accurate index to coyote abundance, it appears that island coyotes reached their greatest numbers between 1951 and 1954. Ninety-one of the total 143 coyotes bountied on the island during the last 16 years were taken

Table 1. Record of the number of coyotes bountied on Beaver Island, 1947-1962

Year	Shot by Deer Hunters	Shot by Coyote Hunters	Trapped	Misc. Kills	Total Kill
1947	0	1	0	0	1
1948	"few"	0	0	0	1 /
1949	"few"	0	0	0	1 /
1950	0	0	"few"	0	1 /
1951	3	0	7	0	10
1952	4	12	11	0	27
1953	4	16	16	0	36
1954	2	5	16	0	23
1955	0	2	0	0	2
1956	0	0	0	0	0
1957	0	0	0	0	0
1958	0	0	1	0	1
1959	0	0	14	0	14
1960	6	0	2	0	8
1961	1	8	0	3	12
1962	2	4	0	0	6
Totals	24	48	68	3	143 /

during this four-year period. At that time islanders participated in frequent coyote and fox hunts. The majority of the trapped coyotes were taken by Karl Kuebler. Arthur Stoel of Charlevoix, Michigan, also trapped a considerable number of coyotes on the island in the early 1950's.

Several island residents report that they conducted an extensive coyote poisoning campaign during the winter of 1954-55, using strychnine in deer flesh baits. In following years the number of coyotes taken by hunting and trapping dropped sharply, and seemed to reflect a direct decrease in coyote numbers on the island. Whether or not the decline can be entirely attributed to the poisoning is not known.

Coyotes were not taken in large numbers again until 1959, when Jeremy Jones of Roscommon, Michigan, trapped 45 red foxes and 14 coyotes on the island. During 1960 and 1961, the number of coyotes bountied by hunters increased, and seemed to suggest an increase in coyote numbers. However, the increase may only have been the result of increased coyote hunting effort, since the 1960 deer season attracted more deer hunters than ever before (Table 12); 475 deer hunters on Beaver Island in 1960 shot six coyotes. Likewise, intense coyote hunting with hounds accounted for eight coyotes in 1961.

Numbers of Coyotes

While no census of coyotes has been made for the island, it seems advantageous to submit some population estimates, and notes concerning coyote abundance. There is little doubt that high coyote numbers occurred on the island between 1951 and 1954. With a kill of 36 coyotes in 1953, the autumn coyote population probably numbered at least 45 or 50 animals. Coyotes did not appear so abundant during the

1960 and 1961 island study. According to observations which I made, as the result of trapping and hunting coyotes on the island, from the frequency with which coyote scats were found, and from the amount of coyote tracks noted in winter, I estimated that the coyote population ranged from a low of 15 to 20 coyotes in the winter to a high population of 25 to 30 in the autumn. During the summer months I searched intensively for litters of young coyotes, and located two areas where separate coyote litters were active each summer. In 1959, Jeremy Jones covered the island thoroughly while trapping foxes and coyotes in August and September. Jones (in litt., 9 November 1961) estimated that the 1959 autumn coyote population consisted of 30 animals. He further stated, "I am quite certain that there were only two litters of coyotes raised on the island the summer of '59." Jones trapped 14 coyotes, of which only four were juveniles which seemed to support his conclusion. Roy Chambers (in litt., 3 February 1962) hunted coyotes on Beaver Island in December, 1961, and estimated that about 25 coyotes inhabited the island at that time. In general, islanders disagree with the above estimates. They contend that the annual autumn coyote population normally consists of 40 to 50 animals.

Coyotes on Surrounding Islands

Because of their small size, other islands in the Beaver Island group probably do not support many coyotes, although red foxes are common on most. I observed few coyote tracks on Garden Island (area of 7.8 square miles), and none on Hog Island (area of 3.9 square miles) in August, 1961. Biologists from the Houghton Lake Wildlife Experiment

Station report that coyote tracks are common on Garden in the winter, and that some evidence of coyotes has been found on High Island during spring and fall visits. It seems possible that coyotes visit these islands by traveling across the ice in the winter, and may become stranded as ice leaves in the spring.

DAILY COYOTE ACTIVITIES

Information pertaining to the winter activities of coyotes on Beaver Island was obtained by trailing coyotes for 227.7 miles (217.7 miles from January through March, 1961, and 10 miles in December, 1961). In addition, game biologists from the Houghton Lake Wildlife Experiment Station logged 86.6 "coyote-miles" on the island from 1956 to 1959. Detailed observations of coyote behavior were recorded only along trails in 1961; notations on coyote food habits were available from the earlier tracking.

Field study during the summers of 1960 and 1961 provided further opportunity to study coyote activity, and resulted in the tagging and release of 10 coyotes and 20 red foxes. In addition, four coyotes had been tagged on the island in 1956 and 1957. Four tagged coyotes have been killed and returned at this writing.

Time of Travel

Trailed coyotes ordinarily started their nightly hunting activities at dusk and curtailed their travel by dawn. One coyote was disturbed while it fed at a deer carcass at 10:30 AM, but on 22 other occasions trailed coyotes were jumped from their beds between 10:00 AM and 5:00 PM.

Coyotes seemingly foraged more during daylight hours of the summer months, since they were more frequently sighted and heard in the daytime.

Manner of Hunting

Coyote hunting habits in the winter, determined through interpretation of coyote sign left in the snow, were observed to follow the techniques described by Stebler (1951). He determined the primary hunting techniques employed by coyotes in winter to be "roving", "stalk and pounce", and "chasing". The manner of hunting used was found to depend on the type of prey being hunted.

Roving. This method is employed by coyotes specifically in hunting snowshoe hares. It consists of continual circling and back and forth movements in apparent attempts to locate, flush, and capture hares. While I frequently observed signs of this hunting action, it was limited to areas of coniferous cover where snowshoe hare evidence was plentiful. This habit was especially evident on two island sectors; one, the narrow band of mixed aspen conifer growth along Lake Michigan from Green Bay north to Boner's Bluff, the other patches of swamp conifer on the northeast part of the island. Coyote tracks followed in either area were invariably lost among other coyote tracks, as the paths of different animals entwined.

Stalk and pounce. The stalk and pounce system of hunting is meticulously described by Murie (1940). Coyotes were observed by Skinner (1927) to hunt for mice in a similar manner.

On the island, coyotes utilized this technique primarily to capture woodland deer mice and masked shrews. However, the practice probably serves as means to capture most small mammals. Stebler (1951) also denotes the stalk and pounce as being employed by coyotes to capture roosting ruffed grouse in winter. Sixteen mice and two masked

shrews were killed by coyotes that I trailed on Beaver Island, using this method of hunting. Attempts were considered successful when the mouse carcass, blood, or fur were discovered at the site. However, small mammals are frequently ingested whole (Sperry, 1941), leaving little evidence of the kill. Thus, greater success may actually have been attained.

Chasing. Stebler (1951) denotes chasing as the coyote hunting technique for capturing deer, but states that stalking is probably involved until the deer is jumped. During the Beaver Island winter tracking study coyotes were never observed to actually stalk deer. They showed no signs of selecting areas of deer concentration as favored hunting grounds. When they traveled deer yards they generally passed directly through without devoting any noticeable effort to locate deer. On three occasions trailed coyotes appeared to come upon deer entirely by accident, and then gave chase when the surprised deer fled. Origins of three other observed chases were unknown.

Movement Patterns

Winter coyote movements most always involved near straight-lined travel from one feeding station to another. These sites consisted primarily of deer carcasses, areas of abundant snowshoe hare evidence, and apple orchards. Deer carcasses were by far the most important food factor affecting the coyote's winter movements. Coyotes did not follow the same travel patterns throughout the winter, or revisit feeding areas in the same sequence. At times their movements followed near circuitous routes, traveling from feeding station to feeding station during the circuit. On other occasions coyotes were found to travel 2 or 3 miles in one direction only to turn back and recover the same area. Complex circling movements were rarely noted, except at designated feeding stations or areas where coyotes hunted snowshoe hares.

Established Crossings

Despite the fact that coyotes were not habitual in following fixed patterns of movement, they frequently crossed at regular points when traveling between hunting or feeding places. Crossings were most frequently observed on northern portions of the island, generally in conifer cover near the Lake Michigan shore. Frequently used crossings were also noted during the summer months in open sand areas, usually adjacent to protective cover.

Island residents often took advantage of the coyote habit of repeatedly crossing at select points, by watching such crossings while coursing coyotes with dogs. Single coyotes were shot by Karl Kuebler at such a site on January 27 and 28, 1961. Another coyote was killed by Archie LaFreniere under similar circumstances on December 18, 1961. According to Kuebler and LaFreniere, knowledge of such coyote crossings has proven useful in past coyote hunts, accounting for a number of coyote kills.

Use of Runways

In January, when a foot of soft snow covered the ground coyotes traveled deer trails and established their own runways. Runways formed by coyotes could generally be found radiating from deer carcasses, but after several hundred feet the tracks dispersed and the characteristics of distinct runways were soon lost. Likewise, where coyotes frequently hunted snowshoe hares short runways were established. Coyotes also established runways when making straightline trips through pure upland hardwood cover, where prey was scarce. However, hard thick crusted snow facilitated coyote travel in February and March, and coyotes rarely traveled runways.

Sociability

Of the 60 coyote trails that I followed on Beaver Island during the winter, the majority were made by single coyotes, only 31.7 percent were made by paired coyotes (Table 2). The pairing habit seemed to increase from January to March. Seton (1929) and Stebler (1951) state that coyote pairs, rather than lone traveling animals, are the general rule during the winter. Stebler found that coyote pairs made 53 percent of the coyote trails which he encountered in the Upper Peninsula of Michigan.

I attempted to determine the percentage of coyotes which were paired on the island in March by examining coyote tracks that intercepted line transects crossing the island (Table 3). Only 22.2 percent of 72 coyote trails encountered along 23.5 miles of transects were of paired coyotes. However, this figure is certainly erroneous. On March 13th line transects traversed an area where coyotes were intensively hunting for snowshoe hares. Tracks of coyotes criss-crossed the area, and designation of paired and single tracks was extremely difficult. On March 10th transects traversed only upland hardwoods, which coyote pairs rarely traveled. The transect completed on March 12th probably provided the most accurate estimate of the percentages of coyotes which traveled alone and paired, since the line bisected the island, and crossed all cover types.

Lone traveling coyotes were observed to merge hunting activities and continue as a foraging unit only once during the winter study. On January 22nd, I had trailed a single coyote for 3.7 miles when I came upon an area littered with coyote tracks. The snow was spattered with

Table 2. Number of coyote trails followed by month - 1961

Period	Number Coyote Trails Followed	Trails Made by Single Coyotes		Trails Made by Paired Coyotes	
		No.	Percent	No.	Percent
Jan. 9-31	23	18	78.3	5	21.7
Feb. 1-28	20	14	70.0	6	30.0
Mar. 1-15	<u>17</u>	<u>9</u>	<u>52.9</u>	<u>8</u>	<u>47.1</u>
Totals	60	41	68.3	19	31.7

Table 3. Number of coyote trails encountered along 23.5 miles of line transects

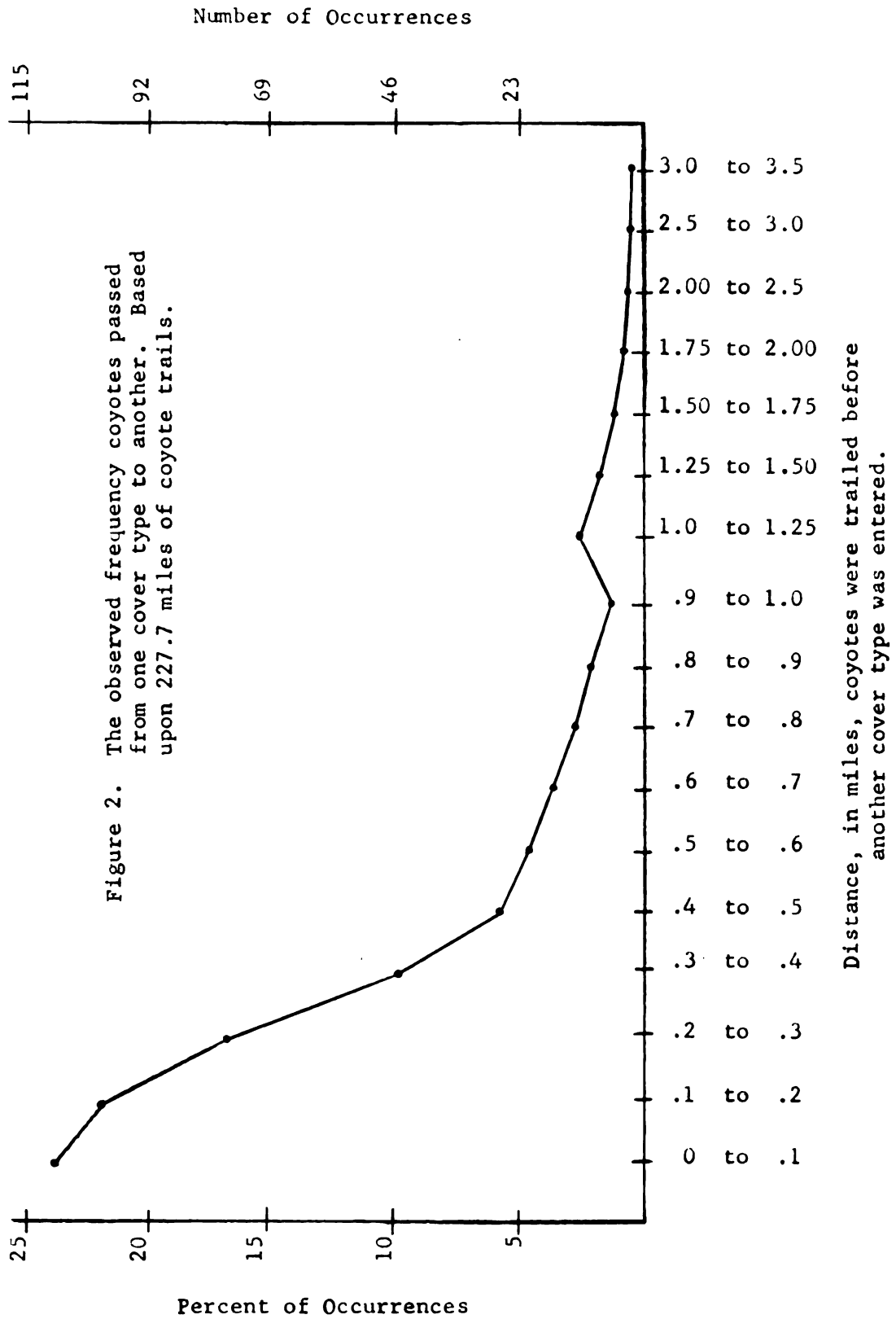
Date	Length of Transect in Miles	Trails Made by Single Coyotes		Trails Made by Paired Coyotes	
		No.	Percent	No.	Percent
3-10-61	3.50	6	100.0	0	0.0
3-10-61	3.75	6	100.0	0	0.0
3-12-61	9.00	14	60.9	9	39.1
3-13-61	6.00	22	78.6	6	21.4
3-13-61	<u>1.25</u>	<u>8</u>	<u>88.9</u>	<u>1</u>	<u>11.4</u>
Totals	23.50	56	77.8	16	22.2

blood, and tufts of coyote fur were scattered about where the trailed individual met with another coyote. Beyond the point of conflict the coyotes apparently combined forces and hunted cooperatively.

Paired coyotes generally traveled parallel to one another, rarely more than 10 or 20 yards apart, and commonly within sight of each other. When snow conditions were a hinderance to travel, they frequently moved in single file. Regardless of which member of a hunting pair discovered a food item both individuals tended to visit the food site. Under no circumstances were paired coyotes observed to sever relations.

The practice of coyotes traveling and hunting in groups of three to five animals, or more, reported common by Murie (1940) and Stebler (1951), was not observed on Beaver Island in the winter. Only once did I note where more than two coyotes traveled concertedly. On March 12th I trailed a group of three coyotes on the south central portion of the island, for approximately three-quarters of a mile. Throughout this distance there was an excessive amount of antagonism. The group finally separated into a single and a pair. I continued to trail the pair, and in another mile jumped them from beds on a hemlock ridge.

Coyotes frequently followed tracks of other coyotes. They not only followed these tracks on excessively used runways or shorelines, but also through areas where travel was not restricted by topography, vegetation, or snow conditions. When following another's tracks, they most often followed the animal's progressive movements, not the backtrack. A pair of coyotes I trailed on March 5th encountered a single coyote track, several hours old, on a beaver pond. Both coyotes followed the track closely for 2.2 miles. Tracks of another coyote followed the pair for 1.3 miles further along their trail.



Movements in Relation to Vegetation

Interspersion of cover types. Due to their general straight-line travel, coyotes seldom traveled continuously for great distances in any one cover type (Figure 2). They exhibited a tendency to travel cover type edges, weaving in and out of the adjacent types. Maximum continuous distances in any one type were attained along the Lake Michigan shore. Extensive areas of upland hardwoods, and mixed aspen, white birch, and conifer vegetation are present on the island, but coyotes infrequently traveled continuously for more than a mile in such cover.

Northern portions of Beaver Island present a well interspersed habitat, with numerous cleared areas. Southern island sectors are less interspersed and lacking in cleared land. Tracks and feces of coyotes were most commonly observed on northern parts of the island. The majority of the coyotes that were shot and trapped on the island in recent years were also taken from these northern areas (Figure 17). However, freezing of the numerous beaver ponds, and the lakes in winter provides additional openness and diversity to the usually dense southern vegetation, possibly increasing the use of this vicinity by coyotes in winter.

Upland hardwoods. Stands of upland hardwoods, dominated by mature beech and sugar maple associations, occupy about 32 percent of the island area. About 19 percent of the winter coyote trails I followed were in this vegetational type. Most of these trails consisted of near straightline travel from feeding areas between Green's Lake and Lake Geneserath to sand dunes at Green Bay. Other coyote activity in upland hardwood cover centered around the carcasses of three deer which had been killed the previous deer hunting season. However, two of the carcasses

were situated near conifer cover often traveled by coyotes, which seemingly affected the amount of coyote activity at the carrion. These carrion depots were consumed to scattered skeletal structures and hair. The third deer, centrally located in pure hardwood cover south of Green Bay, was only half eaten by foxes and coyotes (Figure 10). Single coyotes seemed to cross upland hardwood stands more often than paired coyotes while traveling from one feeding area to another.

Representatives of nearly all winter coyote foods were found along coyote trails through beech-maple associations (Table 5), despite the fact that coyotes did not travel for great distances in upland hardwood types. Most of these items were found at the margins of hardwood cover, in carrion form.

Mixed aspen, white birch, and conifer. According to winter observations coyotes hunted for prey more frequently in mixed hardwood and conifer vegetation than in any other cover. This cover type occupies about 29 percent of the island, and dominates the southeast quarter. The composition and density of trees within the type is variable. Aspen and white birch generally occur as mature trees, only occasionally in near pure stands. White spruce and balsam fir occur as understory species, but on occasion form dense clumps with only a scattering of hardwood species. Numerous beaver ponds occur along intermittent streams which dissect much of this cover type.

Of the 227.7 miles of coyote trails followed, 39.3 percent were in this type. Remains of most winter coyote foods occurred often along these trails (Table 5). Deer carcasses were frequently visited by coyotes, and with few exceptions, the remains were stripped of flesh by intensive coyote feeding (Figure 11).

Table 4. Habitat availability on Beaver Island, and use by coyotes trailed for 227.7 miles

Cover Type	Percent Island Area in Type	COYOTE TRAILS IN TYPE		
		Percent Total Trails	Percent Single Trails	Percent Paired Trails
Upland hardwoods	32.0	19.3	21.2	17.4
Mixed aspen, birch, conifer	29.1	39.3	28.7	49.9
Cleared land	16.6	13.2	16.1	10.4
Swamp conifer <i>Swamp forest</i>	9.0	10.1	8.9	11.4
Lake Michigan shore	4.5	6.5	12.6	0.4
Inland lakes	3.3	1.3	1.4	1.2
Upland pine, aspen, birch	2.9	4.3	3.9	4.7
Marsh and leatherleaf	1.2	2.4	2.4	2.4
Aspen, birch	0.7	2.6	3.4	1.6
Hardwood swamp	<u>0.3</u>	<u>1.0</u>	<u>1.4</u>	<u>0.6</u>
Total	98.0	100.0	100.0	100.0

Nearly 50 percent of the paired coyote trails I followed, compared to 28.7 percent of the single coyote trails, were in mixed hardwood-conifer cover. Paired coyotes seemed reluctant to leave such cover.

Trailed coyotes visited three prospective coyote dens in mixed hardwood-conifer vegetation, and on two occasions entered and pulled dried leaves from the burrows. Two other dens which had been used by coyotes in past years were also located in this cover type. Only one such den was found in other vegetative conditions.

Beaver ponds appeared especially attractive to coyotes in winter. Coyotes rarely encountered these ponds without venturing onto the ice and inspecting the beaver lodge; coyote scats and urinations were commonly sighted on top of beaver dwellings. Coyotes which I trailed encountered beaver ponds 33 times, and traveled a total distance of 6.5 miles on the ponds. Remains of three muskrats were the only food items sighted along these trails.

Cleared land. The northern portion of Beaver Island manifests nearly all of the cleared island acreage, which occupies about 16.6 percent of its land surface. Winter coyote trails were followed for approximately 30 miles over cleared land, 13.3 percent of the total registered "coyote-miles". Lone traveling coyotes typically spent more time than paired on the open land (Table 4). Paired coyotes frequently encountered clearings, but traveled only briefly along the edges of the large pasture areas.

Certain coyotes which concentrated their winter activities on the north end of the island apparently hunted and traveled cleared land intensively. On January 21st, I trailed a coyote for 5.3 miles on this

Table 5. Frequency of food items located along 227.7 miles of coyote trail, in relation to cover types.

Food Item	COVER TYPE						Totals
	Upland Hdwd.	Mixed Aspen Birch Conif.	Clear Land	Swamp Conif.	Lake Mich. Shore	Other Types	
Deer carcasses	3	7	-	1	-	-	11
Deer entrails	1	9	2	1	-	2	15
Fragments of deer	5	9	1	-	1	-	16
Snowshoe hares	2	5	-	3	-	1	11
Mice and shrews	4	1	11	1	-	2	19
Gray squirrels	3	-	-	-	-	-	3
Muskrats	-	4	-	1	-	-	5
Ruffed grouse	2	6	-	1	-	-	9
Waterfowl	1	1	-	-	7	1	10
Chipmunks	-	4	-	-	-	1	5
Unidentified animals	-	2	-	-	-	-	2
Coldbloods	2	4	2	-	1	2	11
Apples	<u>3</u>	<u>-</u>	<u>23</u>	<u>-</u>	<u>1</u>	<u>-</u>	<u>27</u>
Totals	26	52	39	8	10	9	144

northern area, the animal traveled for 3.9 miles on cleared land. I trailed another coyote diagonally across the island for 5.3 miles on January 27th. It traveled 2.7 miles over the open grassland.

Coyote food materials obtained from cleared lands in winter consisted principally of mice and frozen apples (Table 5.)

Swamp conifer. White cedar, spruce, and balsam fir swamp vegetation occupies 9 percent of the island area. Such cover predominates on the south central part of Beaver Island. However, coyotes normally spent more time in search of snowshoe hares in northern swamps. Coyotes traveled less in the swamps at the south end of the island where deer yarded. Coyotes occasionally hunted swamp conifer cover intensively for snowshoe hares, but had little success despite an abundance of hare sign.

Lake Michigan shore line. Sand dunes bordering Lake Michigan, stretches of beach, and the frozen lake edges encircling the island are classified under this general heading. Such marginal conditions, excluding the frozen lake edge, represent 4.5 percent of the island surface area. While 6.5 percent of the coyote trails which I followed were along the Lake Michigan shore, differential use between single coyotes and pairs was striking. Trailed lone coyotes encountered shore line areas 30 times and traveled a combined distance of 14.3 miles on these areas, or an average of .44 miles per encounter. Paired coyote trails were followed along the shore line only three times, for a total distance of .2 miles.

On February 25th, I followed tracks of a coyote on the shore of Lake Michigan, in the Green Bay area, for a continuous 3.5 miles before it entered coniferous cover. I followed single coyotes along the shore in the same vicinity for 2 miles on February 7th, and 1.6 miles on February 27th.



Figure 3. Intensive coyote utilization of the Lake Michigan shore, February 6, 1961.

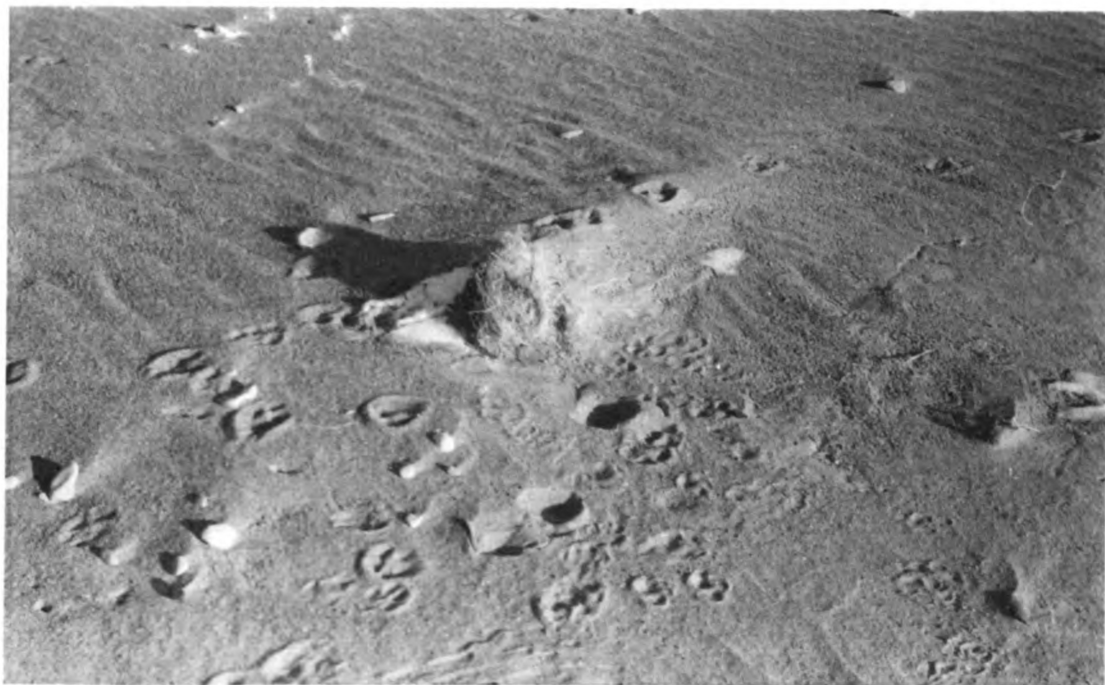


Figure 4. Clump of grass serving as coyote urination post on Lake Michigan shore, February 6, 1961.

Coyotes apparently utilized the wind-swept shore because of the minimal resistance to travel. Such areas, nearly snow-free, seemed to serve as travelways for coyotes between select feeding grounds, and occasionally between feeding areas and bedding sites. Trailed coyotes obtained insignificant amounts of food from the shore line (Table 5.). Waterfowl remains were frequently sighted, but seldom fed upon by coyotes.

Other cover types. Inland lake, upland pine, marsh, pure aspen-birch, and swamp hardwood areas individually occupy but a small part of the island. Due to the limited acreage of these types and relatively short distances that coyotes were trailed over each, it is difficult to evaluate their use by coyotes.

In winter, coyotes seemingly utilized inland lakes as travelways because of limited snow depths on the ice. Their trails were followed across Green's Lake and Lake Geneserath, but coyote tracks were observed on all the inland lakes at one time or another.

Coyotes frequently hunted in upland pine cover, as judged from the amount of coyote evidence observed in such vegetation. Snowshoe hare and gray squirrel tracks were generally abundant in pine stands, and provided a potential source of food for coyotes.

Marshes and leatherleaf bogs which bordered conifer cover generally exhibited impressive amounts of snowshoe hare sign. Coyotes probably traveled these borders in search of hares.

Bedding sites. Forty-two coyote beds were located along the winter coyote trails (Table 6). Of these, 25 were fresh beds of trailed and jumped animals, and 17 were incidental and several days old. Small

knolls or other points of vantage were often selected as bedding sites. However, the combination of a slightly elevated site and dense conifer cover was the most common. Mounds caused by up-rooted trees were frequently utilized as coyote bedding sites in upland hardwood cover. Only two coyote beds were found beneath the protective cover of windfalls.

When coyotes traveled together they were found to bed in close proximity. On two occasions, February 2nd and March 5th, beds of paired coyotes were located side by side, forming what appeared to be one bed. Generally, beds were 4 to 10 feet apart.

Coyotes sometimes bedded near deer carcasses. The bed of a lone coyote was located 100 yards from the carcass of a young doe in upland hardwoods on January 30th. Five additional older beds were situated within a 50 yard radius of the same deer. After trailing a pair of coyotes for 6.5 miles, on March 5th, their beds were finally located near the remains of a buck.

Coyotes jumped from daytime beds often expressed the habit of pausing on ridges or other elevated sites before continuing their flight. When frightened, they generally directed their path of retreat into the wind, toward dense protective vegetation, or took advantage of both conditions whenever possible. Paired animals jumped from their beds always fled together.

Table 6. Vegetative conditions where winter coyote beds were located on Beaver Island

Cover Types	Total Number Beds	Number Single Beds	Number Paired Beds
Conifer swamp	17	5	12
Upland hardwoods	9	7	2
Mixed aspen, paper birch, conifer	9	7	2
Cleared land	2	2	0
Vegetated sand dunes	2	0	2
Marsh	2	0	2
Upland pine	<u>1</u>	<u>1</u>	<u>0</u>
Totals	42	22	20

Tracking Distances

By tracking coyotes during the winter, attempts were made to determine the distance they traveled in a single night. The ideal method would have been to follow the trails of the animal until it was jumped, then backtrack the trail until the animal's bed of the previous day was reached; however, no such circuits were successfully completed. Coyotes were trailed and jumped from their daytime beds on 23 occasions, but backtracking failed to reveal their beds of the previous day. The average tracking distance from where trailing first began to where the coyote bedded down was 3.7 miles (minimum 1.3 miles, maximum 8.2 miles). The average straight-line measurement from the point where trailing first began to the beds was 2.1 miles (minimum .8 miles, maximum 3.5 miles).

Arnold (1956), Schofield (1960), and Erickson (1955) calculated the average daily cruising distance for red foxes and bobcats by doubling the measured distance from the point where tracks were first encountered to where the animals were finally located; the assumption being that on the average this distance represented half the animal's nightly movements. Also, they assumed that the average straight-line distance from the start to finish of such trailing would approximate the radius of a circle which would encompass the area traversed by the animal in a single night. This technique did not appear applicable for use on the coyotes of Beaver Island. Consequently, accurate measurement of the distance and range that coyotes traveled in a single night could not be made.

Areas of Activity

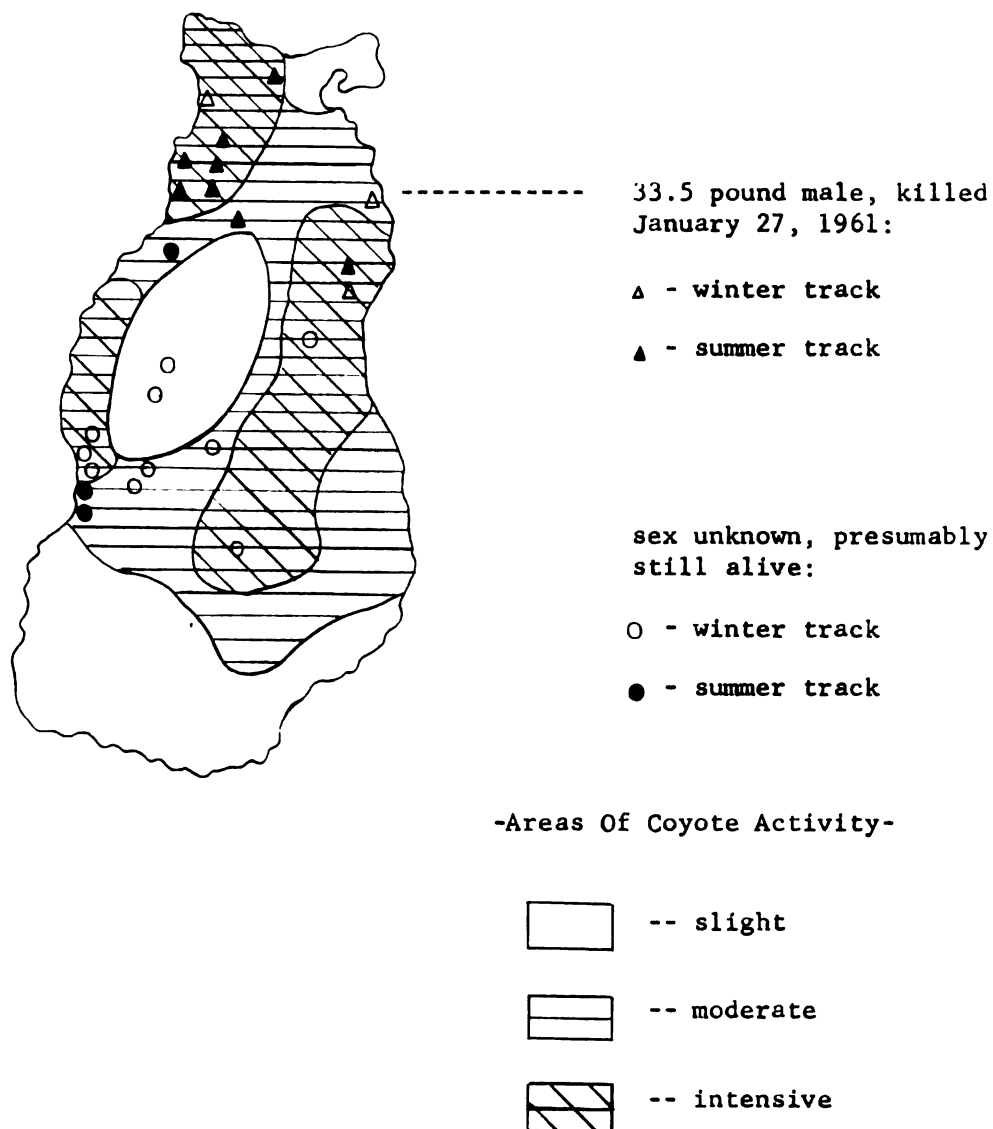
Ranges of coyotes on Beaver Island were noted to overlap. From all indications certain preferred areas were shared by a number of coyotes (Figure 5.)

Two coyotes on Beaver Island provided special opportunity to study range activity. Each of the animals were missing three toes from front feet, and their tracks were readily distinguishable. Tracks of these handicapped coyotes were identified on 24 occasions and mapped (Figure 5). Based on these records, the two coyotes seemed to maintain distinct areas of activity. One animal, a male weighing 33.5 pounds when killed on January 27, 1961, apparently favored the northern cleared portion of the island. The other handicapped animal concentrated its activity in the densely wooded central and western part of the island. From these track notations, minimal areas of activity of the two coyotes could be estimated at 20 to 25 square miles. No seasonal difference was noted in the amount of area they traveled over.

In northern Michigan, Stebler (1951) determined the winter range of a coyote pair to be 17 square miles. Ranges of neighboring coyotes did not overlay that of the study group. Seton (1929) indicates that 36 square miles is sufficient hunting area for a coyote pair in the summer, while in the "north" an area twice as large is required during the winter. He adds that ranges of coyote pairs tend to overlap.

Island residents report having sighted and chased foxes and coyotes from Beaver to Garden Island, and vice versa during the winter. Reportedly, on one occasion a coyote making this inter-island journey in daylight was run down and killed by ice fishermen in an automobile. It seems possible that some coyotes and foxes do extend their winter ranges to include other nearby islands.

Figure 5. Areas of coyote activity and sites where tracks of two coyotes missing toes were sighted.



Dispersal From the Island

Robinson (1951) studied the migratory habits of coyotes in Yellowstone National Park. Over a 5-year period 419 coyotes were tagged and released. The mean and median movement of 178 recoveries were 9.4 and 4.0 miles respectively. In Wyoming, Garlough (1940) found the mean movement of 89 recovered tagged coyotes to be 25.4 miles, the median movement was 16 miles. In comparing the two studies, Robinson and Grand (1958) attribute the difference in movement distance to the fact that 78 of 89 of Garlough's recoveries were juveniles originally taken from dens, while in the Yellowstone one-third of the recovered coyotes were adults when tagged. Thus, it appears that the distance of 25.4 miles would more closely approximate the mean distance which young coyotes disperse from natal dens. If so, the distance from Beaver Island to the Upper Peninsula (15 miles) and to the Lower Peninsula (19 miles) of Michigan occur below this mean. However, it is not known how adept coyotes are at traversing such extensive areas of ice as those between the islands and mainland.

Only two of the six juvenile coyotes which I tagged on the island have been killed to date (Table 8). Both were males, trapped, tagged, and released on August 11, 1960. One was retrapped and accidentally killed on August 23, 1960, one mile south of the original tagging site. The other, weighing 13 pounds when tagged, was killed in Lower Michigan on March 18, 1961, by Frank O'Neil in Emmet County, near Carp Lake (Section 21, Township 38 North, Range 4 West), a straight-line distance of 35 miles from Beaver Island. O'Neil (in litt., 23 March, 1961)

reported the animal to weigh 28 pounds, and stated it was in "top condition". This coyote probably traveled on the ice from Beaver to Garden Island, then to Hog Island and across Lake Michigan to Waugoshance Point in Lower Michigan.

There is a slight possibility that some coyotes are actually driven from the island in winter by intensive coyote hunting with hounds. According to Skinner (1927), if coyotes are severely hunted, "they may leave their accustomed ranges altogether".

Table 7. Coyotes trapped, tagged, and released on Beaver Island.

Tag No.	Date Tagged	Age	Sex	Weight (lbs.)	LOCATION WHERE RELEASED		
					Section	Town (north)	Range (west)
36508 - 9	9-12-56	Ad.	M	27	11	38	10
36510 - 11	9-16-56	Ad.	M	30 $\frac{1}{2}$	16	38	10
36417 - 18	9-7-57	Ad.	F	25	26	38	10
36423 - 25	9-26-57	Ad.	F	25	26	38	10
48501 - 03	7-31-60	Juv.	F	10	4	38	10
48509 - 11	8-11-60	Juv.	M	13	32	39	10
48512 - 13	8-11-60	Juv.	M	14	32	39	10
48518 - 19	8-29-60	Ad.	F	19	25	38	11
48552 - 58	7-8-61	Juv.	M	9	32	39	10
48553 -	7-9-61	Juv.	M	9	32	39	10
48559 - 60	9-4-61	Ad.	F	26	10	38	10
48565 - 66	9-7-61	Juv.	F	12	22	38	10
*48532 -	1-29-61	-	-	-	25	38	11
*48505 -	9-5-61	-	-	-	26	38	10

*Tagged with automatic tagging device.

Table 8. Tagged coyotes released on Beaver Island and recovered.

Tag No.	Weight When Recovered (lbs.)	Distance Traveled (in miles) from Release	Direction of Movement	Length of Time Since Trapping
36510 - 11 Ad. ♂	35	2	South	6 yrs., 2 mo.
48509 - 11 Juv. ♂	11	1	South	11 days
48512 - 13 Juv. ♂	28	35	East	7 mo.
48518 - 19 Ad. ♀	27	6.5	Northeast	5 mo.
*48552 - 58 Juv. ♂	10	.25	South	15 days

*Retrapped and released.

Reaction to Humans

Coyotes which encountered human tracks in the snow seemed frequently disturbed so that they altered their direction of travel, or at times they would back-off and attempt to circle the track. If after several tries this effort failed they would run and jump over the human track, then continue along their intended course. Stebler (1951) made similar observation. Erickson (1955) found that bobcats chose to follow snowshoe trails of man, while coyotes behaved in the above described manner.

When coyotes sighted human tracks near deer carcasses they would not feed on or approach the carcass. On January 20th I found a deer carcass on the east side of the island which coyotes had been visiting regularly for several weeks. After I examined the deer, and coyotes noted my presence, they did not feed on the deer carrion for the remainder of the winter. Although, they repeatedly inspected the deer carcass from nearby knolls. As a contrast in behavior toward human sign, foxes continually visited and fed on the same carrion despite the human disturbance. I had not observed fox activity in the immediate vicinity while coyotes fed on the deer. Coyotes revisited other deer carcasses after I examined them, only after snowfalls covered my foot prints.

Some coyotes on nightly forays expressed exceptional boldness in feeding near houses and farm buildings. A coyote which I trailed on January 21st spent considerable time scratching at a deer hide in an open field about 70 yards from a house. The animal then traveled to a small apple orchard near another occupied house, and fed upon apples within 75 feet of the building. Few coyotes exhibited this tendency, however, as most seemed to traverse protective cover when passing near human dwellings.

Reaction to Roads

Trailed coyotes came in contact with roads 58 times during the 227.7 "coyote-miles" logged on the island. They traveled directly across roads on 46 occasions, and actually followed roads only 12 times. The greatest observed distance traveled by any coyote on a road, while conducting normal hunting activities, was .25 miles. The average distance per encounter was .1 miles. Most coyotes were extremely wary when crossing roads. When they crossed plowed roads, they commonly stopped prior to crossing, then ran across.

None of the 48 coyote scats collected during the winter was taken from roads. However, nearly half of the coyote scats collected during snow-free months were gathered from island roads. The majority of these road collected scats were procured in summer and autumn, when young coyotes were especially active. According to available evidence, a large percentage of the road collected scats were deposited by coyote pups.

Effects of Weather

Soft fluffy snow throughout most of January, and at times in February, generally suppressed coyote movements, reducing the distance and area traveled, and the rate of travel. Similar conditions prevailed in December, 1961. Loose snow also resulted in a change in travel mannerisms, causing increased use of deer trails and coyote trails, dense coniferous cover, and the Lake Michigan shore line. Hardwood areas and open cleared land were not so readily traveled. Snow conditions

were never so severe, however, as to vastly impair travel, or limit travel to areas of readily available food supplies.

Conversely, crusted snow allowed more flexible movements. Coyotes more readily crossed expansive open areas and large blocks of mature hardwoods when travel was easy. Rapid running and trotting movements were characteristic on crusted snow in such areas. Winter coyote movements were not noticeably influenced by temperature fluctuations, other than the indirect effect of changing snow conditions.

COYOTE FOOD HABITS

The food habits of coyotes on Beaver Island were studied through the examination of 274 coyote skulls, representing all seasons and by noting prey remains and evidence of coyote feeding along 314.3 miles of winter coyote trails. Inspection of coyote dens and observations of coyote feeding during the summer provided minimal coyote-prey information.

Special effort was made while in the field to determine the relative abundance of prey species, where foods were available, and whether vertebrate food items were secured as fresh kills or as carrion. Latham (1951) lists the following ecological data as necessary before predator food habits tables can be interpreted from an economic standpoint; availability of prey cyclic species, weather conditions, physical condition of prey, amount of protective cover provided by habitat, effects of introduced species, density of predator population, past and present predator-prey relationships, and abundance or scarcity of buffers. He diligently points out that, "Without this ecological data concerning both predator and its prey, food habits tables cannot be interpreted accurately, and as such, are of little value." Murie (1940) emphasized the importance of knowledge concerning the relationships of the predator and its various prey to the environment. He stated, "In cases where food-habits study shows that a species is eaten to only a limited extent, it usually can be concluded that any coyote depredation taking place is not harmful to the species. Conversely, when the status of a prey species is unsatisfactory it becomes important to determine the part that the coyote is playing. In some circumstances all factors bearing on the species must be studied".

Table 9. Classification of food items found in 247 coyote scats from Beaver Island, 1960 and 1961.

	Frequency		Volume	
	(number)	(percent)	(cc.)	(percent)
MAMMAL	(221)	(89.46)	(3,352.1)	(62.70)
Deer.....	(89)	(36.03)	(1,097.1)	(20.52)
Adult.....	58	23.48	631.2	11.81
Fawn.....	31	12.55	465.9	8.71
Muskrat.....	(55)	(22.27)	(1,003.9)	(18.77)
Snowshoe hare.....	(70)	(28.34)	(863.0)	(16.15)
Cow.....	(23)	(9.31)	(99.5)	(1.86)
Other mammals.....	(78)	(31.58)	(288.6)	(5.40)
Gray squirrel.....	20	8.10	77.1	1.44
Eastern chipmunk.....	12	4.86	29.8	0.56
Deer mouse.....	10	4.05	47.0	0.88
Beaver.....	7	2.83	111.0	2.08
Raccoon.....	1	0.40	23.0	0.43
Woodchuck.....	1	0.40	trace	trace
Coyote (hair).....	27	10.93	0.7	0.01
BIRD	(53)	(21.46)	(159.2)	(2.98)
Ruffed grouse.....	13	5.26	99.9	1.87
Ruffed grouse egg.....	5	2.02	12.6	0.24
Song bird.....	4	1.61	9.0	0.17
Song bird egg.....	2	0.80	0.2	trace
Duck.....	4	1.61	11.5	0.22
Herring gull.....	1	0.40	1.8	0.04
Crow.....	1	0.40	4.0	0.07
Bird, unclassified.....	17	6.88	16.7	0.31
Bird egg, unclassified	6	2.42	3.5	0.06
COLD-BLOODED VERTEBRATE	(27)	(10.92)	(21.8)	(.41)
Fish.....	7	2.83	15.6	0.29
Turtle egg.....	9	3.64	2.5	0.05
Snake.....	10	4.05	3.1	0.06
Frog.....	1	.40	0.6	0.01
UNIDENTIFIED ANIMAL	(12)	(4.86)	(11.0)	(0.21)
Bone.....	8	3.24	9.1	0.17
Flesh.....	4	1.62	1.9	0.04

Table 9. (continued)

INVERTEBRATE	(114)	(46.15)	(224.7)	(4.20)
Beetle.....	57	23.08	138.4	2.59
Grasshopper.....	59	23.89	63.8	1.20
Bee and wasp.....	8	3.24	6.8	0.11
Dragonfly.....	5	2.02	10.4	0.19
Harvest fly.....	4	1.62	2.5	0.05
Plant bug.....	4	1.62	0.8	0.01
Tick.....	3	1.21	trace	trace
Crayfish.....	2	0.81	2.7	0.05
Spider.....	2	0.81	trace	trace
Snail.....	1	0.40	trace	trace
Unclassified.....	4	1.62	0.1	trace

PLANT	(204)	(82.59)	(1576.5)	(29.50)
Sarsaparilla.....	50	20.24	511.1	9.56
Blackberry, dewberry and raspberry.....	44	17.81	312.0	5.84
Apple.....	43	17.41	278.9	5.22
Strawberry.....	19	7.69	145.4	2.72
Beechnut.....	12	4.86	32.2	0.60
Sand cherry.....	9	3.64	157.7	2.95
Barberry.....	5	2.02	11.6	0.22
Hemlock cone.....	3	1.21	1.5	0.03
Maple seed.....	3	1.21	0.3	0.01
Seed, unclassified.....	13	5.26	2.6	0.05
Grass and sedge.....	151	61.13	71.6	1.34
Evergreen leaves.....	109	44.13	2.9	0.05
Deciduous leaves.....	68	27.53	34.3	0.64
Wood.....	37	14.98	5.2	0.10

The procedures for scat collection and analysis were discussed earlier. Coyote trailing techniques have also been described and the results partly analyzed. The following sections will emphasize coyote food habits and coyote-prey relationships. Some attempt will be made to evaluate the effect of coyote preying activities upon the more economically important species.

Items comprising the foods of coyotes on Beaver Island, as determined from the laboratory analysis of 247 coyote feces, are listed in Table 9, along with the frequency and volume with which they occurred in the scats. These scats were collected in 1960 and 1961; 64 scats were collected in the spring (April-June), 111 in the summer (July-August), 24 in the autumn (September-November), and 48 in the winter (December-March). Table 10 lists the frequency with which food items were identified in 27 coyote feces taken on August 5, 1962, and analyzed in the field. Percentage figures for the seasonal occurrence of food items, and total percent occurrence of food items, provided in discussion of specific coyote foods do not include the field analysis findings.

Figure 6 represents the relative seasonal fluctuation in coyote use of mammalian, bird, cold-blooded vertebrate, invertebrate, and plant foods, as determined from the scat analysis. These major food groups follow those designated by Scott (1947), and were likewise employed by Fichter et al. (1955). The general coyote feeding trends depicted in Figure 6 illustrate the variation in coyote food usage with changes in availability, namely, the change from a highly carnivorous winter and spring diet to consistent utilization of plant fruits and insects as they became available in the summer and autumn. Birds also appeared most

Table 10. Frequency of food items identified in 27 undated coyote feces collected from Beaver Island on August 5, 1962.

Food Item	Number of Occurrences	Percent Frequency
Snowshoe hare.....	12	44.4
Muskrat.....	9	33.3
Beetle.....	6	22.2
Unidentified birds.....	4	14.8
Newborn fawn deer.....	4	14.8
Mice (species uncertain).....	3	11.1
Sarsaparilla.....	3	11.1
Strawberry.....	3	11.1
Adult deer.....	3	11.1
Song bird.....	2	7.4
Crayfish.....	2	7.4
Ruffed grouse.....	1	3.7
Turtle egg.....	1	3.7
Bird egg shell.....	1	3.7
Apple.....	1	3.7
Beechnuts.....	1	3.7
Conifer needles.....	6	22.2
Grass.....	5	18.5
Total	57	

frequently in spring and winter coyote scats, somewhat less in the summer scats. No bird remains were found in the autumn feces. The deficiency of bird materials in autumn scats may be the result of inadequate scat sampling for that period. Remains of cold-blooded vertebrates occurred with slight seasonal variation in the examined feces.

Fichter et al. (1955) revealed similar seasonal feeding trends in coyotes. They also noted the highest frequency of mammalian materials in the winter and spring diet, lower in summer, and lowest in autumn. They attributed the decrease in coyote usage of mammalian materials in summer and autumn to increased availability of birds, plant fruits, and insects during that same period. Fichter et al. stated, "The most striking seasonal shift is the enormous autumnal increase in the frequency of fruit in coyote droppings, accompanied not only by the lowest seasonal occurrence of mammalian remains but by well-defined declines in the frequency of remains of birds and insects." Such obvious seasonal variation in coyote food usage is indicative of their ability to subsist upon a highly omnivorous diet. As elsewhere, coyotes on Beaver Island are opportunists, eating whatever happens to be available.

While the subject of specific food abundance, availability, and seasonal consumption by coyotes will be more adequately covered in later sections, it seems appropriate at this time to present some seasonal patterns of coyote feeding activity on the island. Figures 7 and 8 illustrate the general seasonal fluctuations in occurrence of the more important mammal and plant items in the analyzed coyote feces.

The island coyote study was not of sufficient length to note many yearly variations in the availability and use of food items by

coyotes, but it should be kept in mind that such variations undoubtedly exist. Changes in populations of prey species, in prey availability due to climatic conditions, species introductions, amount of plant fruit produced, etc., will result in considerable variability in the coyote diet. Table 11 reflects some yearly variation in the frequency of certain mammal and plant foods noted in summer coyote scats collected in 1960 and 1961.

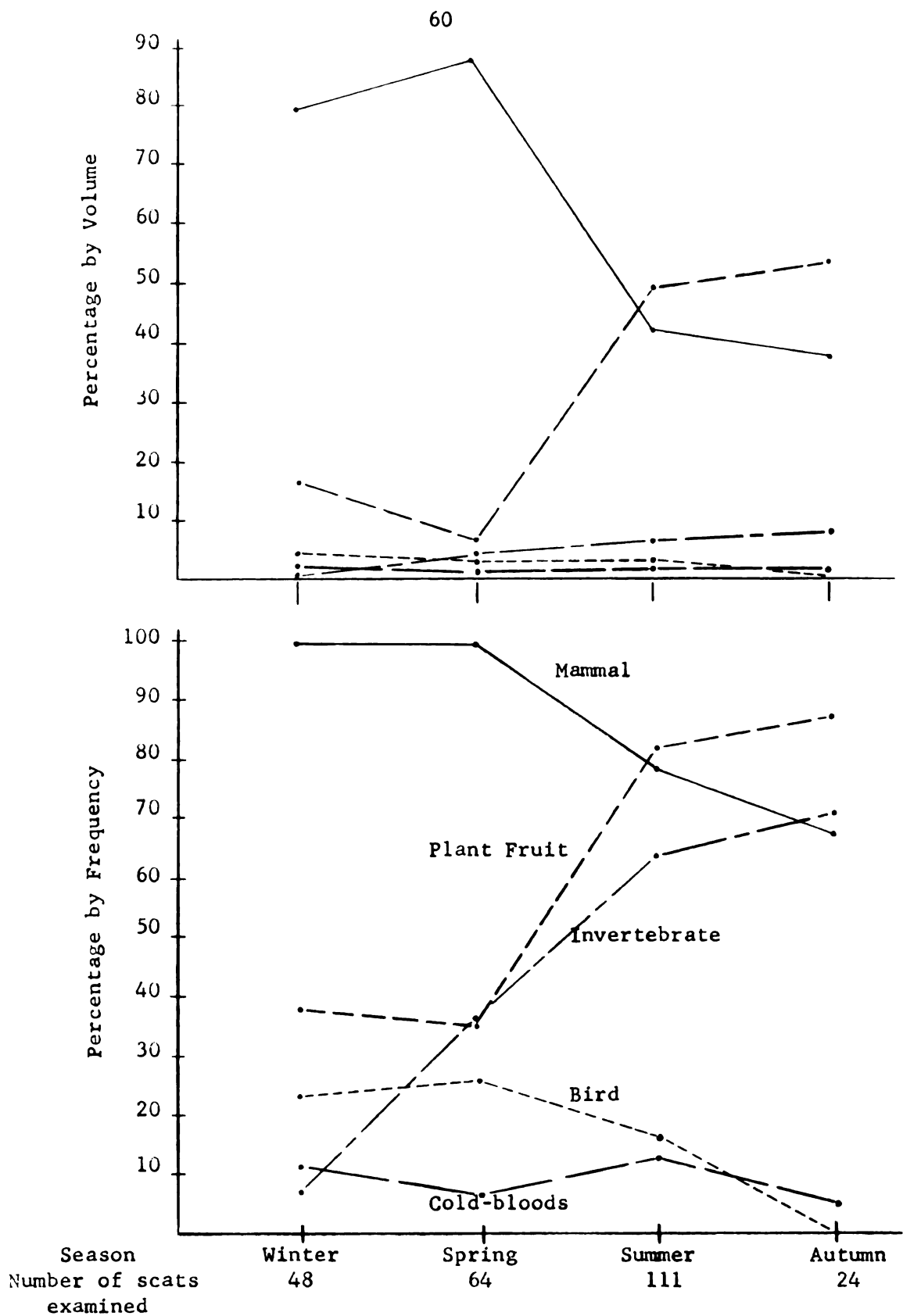


Figure 6. Seasonal variation of the major food groups in 247 coyote feces collected from Beaver Island, 1960 and 1961.

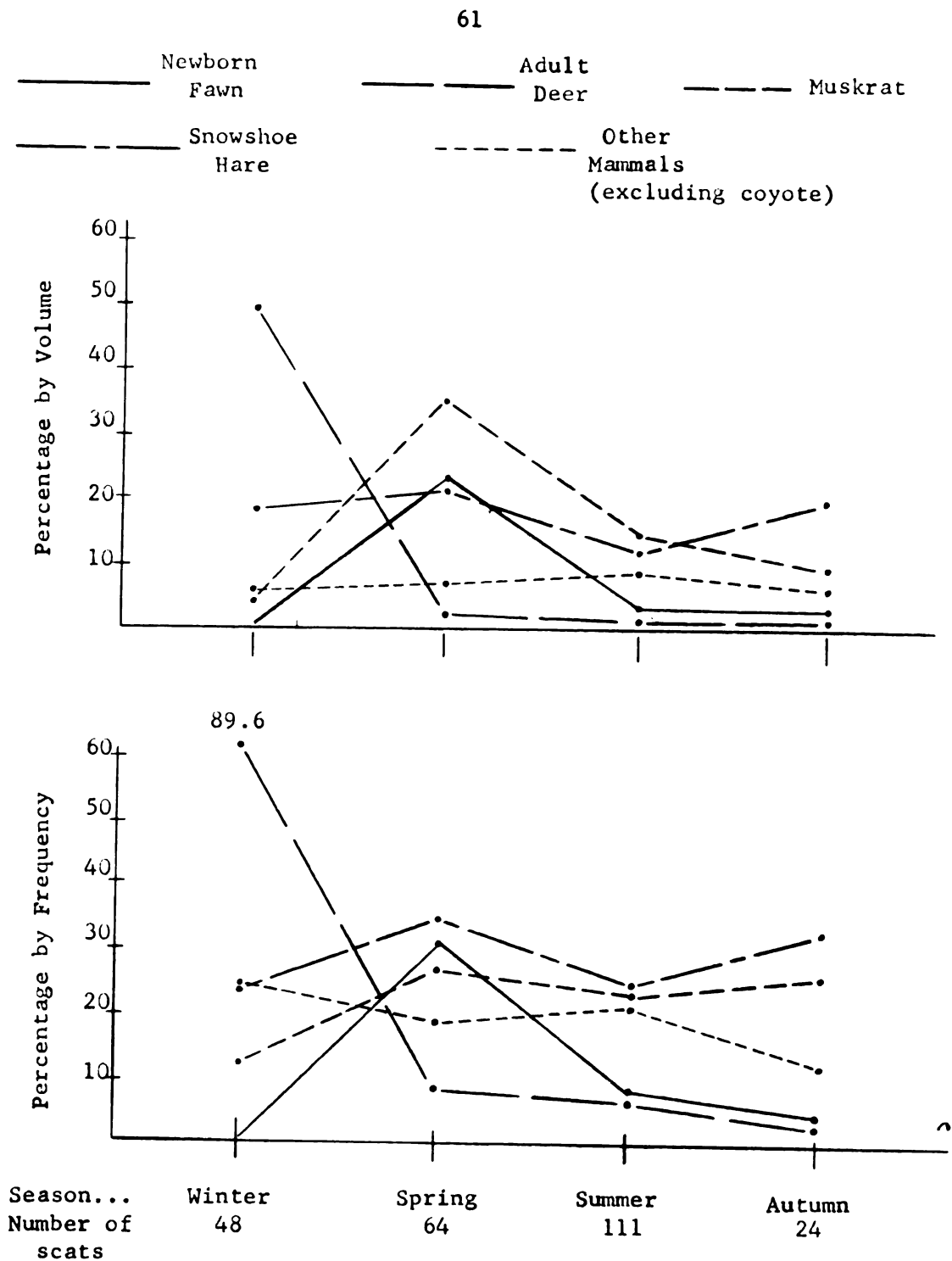


Figure 7. Seasonal variation of the primary mammalian foods in 247 coyote feces collected from Beaver Island, 1960 and 1961.

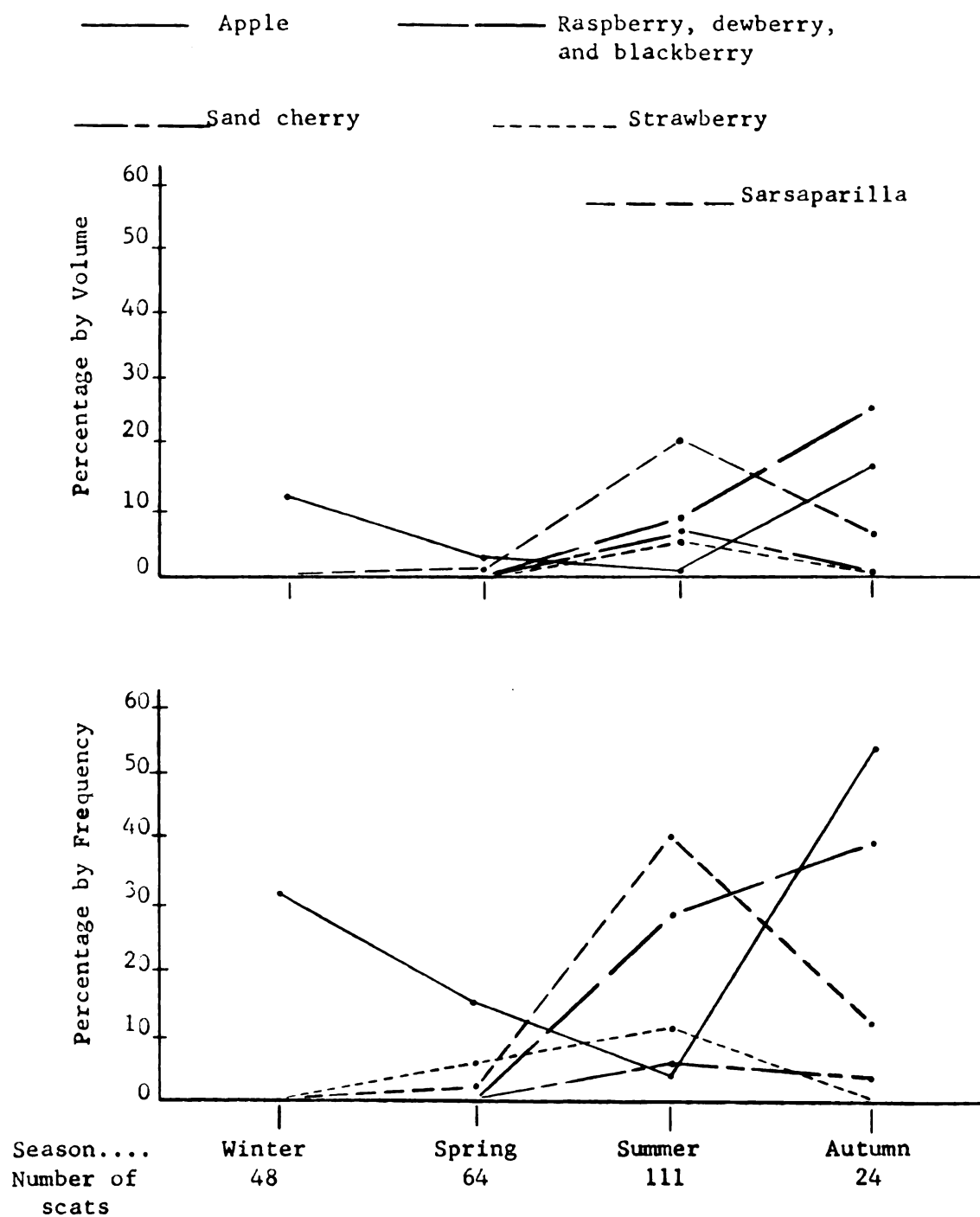


Figure 8. Seasonal variation of the primary plant foods in 247 coyote feces collected from Beaver Island, 1960 and 1961.



Table 11. Frequency comparisons of the more important mammal and plant foods represented in the 1960 and 1961 summer coyote scats examined.

Food Item	<u>1960</u>		<u>1961</u>	
	Number of scats		52	
	59			
	<u>Frequency</u>		<u>Frequency</u>	
	(number)	(percent)	(number)	(percent)
Adult deer.....	6	10.2	2	3.8
Newborn fawn deer.....	6	10.2	4	7.7
Snowshoe hare.....	12	20.3	15	28.8
Muskrat.....	4	6.8	22	42.3
Cow.....	4	6.8	12	23.1
Gray squirrel.....	5	8.5	2	3.8
Chipmunk.....	4	6.8	3	5.8
Beaver.....	3	5.1	3	5.8
Sarsaparilla.....	28	47.5	18	34.6
<u>Rubus</u> sp.....	27	45.8	7	13.5
Apple.....	2	3.4	3	5.8
Sand cherry.....	7	11.9	1	1.9
Strawberry.....	13	22.0	3	5.8

WHITE-TAILED DEER IN RELATION TO COYOTES

The Deer Population

White-tailed deer did not inhabit Beaver Island prior to R. W. Bundy's release of three bucks and 10 does in 1927 (Duvendeck, 1958). By 1938, the herd had increased substantially, and the Michigan Department of Conservation opened deer hunting under a buck law. The island deer seasons have coincided with that on the Michigan mainland each year since. Shooting of antlerless deer was legalized under a permit system in 1957. Antlerless seasons followed until 1961, when the buck law was reinstated.

According to island residents, deer increased gradually in number following their introduction. A deer pellet survey conducted in 1958 indicated a deer population of about 27 animals per square mile (Duvendeck, 1958). Current deer population estimates by islanders are generally somewhat less. Starvation of deer in the winter has rarely been observed.

During the snow-free months deer are commonly sighted over the entire island. However, in winter they exhibit the special habit of migrating to southern areas of the island, which are less interspersed with openings, and more densely wooded with coniferous vegetation. Weather conditions were not severe during the winter study (1960-61), and deer moved freely from one swamp to another. Southward movement of deer appeared complete by late January. Northward movement was noted early in March, when deer entered the openings at Hanigan's Corners, and near the airport.

Table 12. Records of deer hunting seasons on Beaver Island.

Year	No. of Hunters	No. of Deer Killed	Percent Success
1938	93	18	19.4
1939	80	23	28.8
1940	81	23	29.4
1941	132	78	51.5
1942	189	72	38.1
1943	265	61	23.0
1944	197	66	33.5
1945	227	65	28.6
1946	278	75	27.0
1947	280	43	15.4
1948	200	33	16.5
1949	160	27	16.9
1950	162	40	24.7
1951	165	26	15.8
1952	130	35	26.9
1953	138	30	21.7
1954	132	29	22.1
1955	189	34	18.1
1956	186	45	24.2
1957	262	107*	40.8
1958	335	147**	43.9
1959	425	172***	40.5
1960	475	112****	23.6
1961	225	24	10.7

* Includes 45 antlerless deer

** Includes 79 antlerless deer

*** Includes 90 antlerless deer

**** Includes 51 antlerless deer

Coyote trackers sighted 124 deer along 86.6 miles of coyote trails from 1956 through 1958. In nine weeks on the island during the 1960-61 winter I sighted a total of 90 deer; 31 were observed while trailing coyotes 217 miles. The average of one deer sighted every two miles during the total 314 "coyote-miles" logged on the island suggests that coyotes most certainly had frequent encounters with deer.

Importance in the Coyote Diet

Residues of white-tailed deer were the most frequently detected animal item in the coyote feces collected on Beaver Island. Deer remains were identified in 36 percent of the droppings, and comprised 20.5 percent of the total scat bulk. Deer residues present in coyote fecal materials were analytically separated into adult deer and newborn fawns. The term "adult deer" was meant to include weaned deer. "Newborn fawns" included all younger deer. Coyotes were found to rely primarily upon deer carrion throughout the winter. In late spring they fed readily upon newborn fawns. The fawn occurrences in the diet could not be distinguished as carrion or fresh kills.

(Of 48 winter coyote feces examined 43 contained evidence of deer, and this item represented nearly half of the entire winter scat bulk. The number of scats containing deer, identified as adult, steadily decreased from winter to autumn (Table 13).

(In spring newborn fawn remains were identified in 31.6 percent of the examined scats. Summer coyote feces contained fawn remains with 9 percent frequency.

Table 13. Percent frequency and volume, by season, of adult deer in 247 coyote scats.

Season	Total Number Scats	Percentage by Frequency	Percentage by Volume
Winter	48	89.58	49.85
Spring	64	9.38	2.04
Summer	111	7.21	1.01
Autumn	24	4.17	.39
Total	247	23.48	11.81

Table 14. Percent frequency and volume, by season, of newborn fawn deer in 247 coyote scats.

Season	Total Number Scats	Percentage by Frequency	Percentage by Volume
Winter	48	0.00	0.00
Spring	64	31.25	22.33
Summer	111	9.01	4.36
Autumn	24	4.17	2.14
Total	247	12.55	8.71



Figure 9a. Large buck crippled and lost during the deer hunting season, serving as carrion to coyotes.



Figure 9b. Right front leg of the above deer. Bones shattered by rifle bullet.

Sperry (1941) reported that deer remains occurred more frequently in coyote stomachs from Michigan than from most other states. He indicated that there were three distinct peaks in the curve representing the annual consumption of deer in each state. Those highs occurred late in winter, in the fawning period, and in the hunting season. Stebler (1951), Dearborn (1932), and Schofield (1959) found frequent occurrences of deer in the diet of coyotes in northern Michigan, but concluded that most deer flesh was secured as carrion.

Deer Carrion in the Coyote Diet

Deer killed or severely crippled by deer hunters in November appeared to be the primary winter food of coyotes on Beaver Island in recent years (Tables 15 and 16). On the average, coyotes visited individual deer carcasses every 16.5 miles; only one of 19 deer visited had definitely been killed by coyotes.

Coyotes fed upon deer carrion throughout the 1960-61 winter. Those carcasses in highly active coyote areas were almost entirely consumed (Figure 11). Remaining skeletal portions and hair were widely scattered by March. Deer carcasses located in cover not intensively traveled by coyotes still maintained large quantities of flesh and remained intact (Figure 12).

Trailed coyotes visited and fed upon entrails from 17 hunting season deer kills. They generally spent considerable time digging at deer viscera, and apparently consumed large quantities.

Numerous other sites were observed where coyotes dug in the snow for small scraps of deer carrion, such as pieces of bone, flesh,

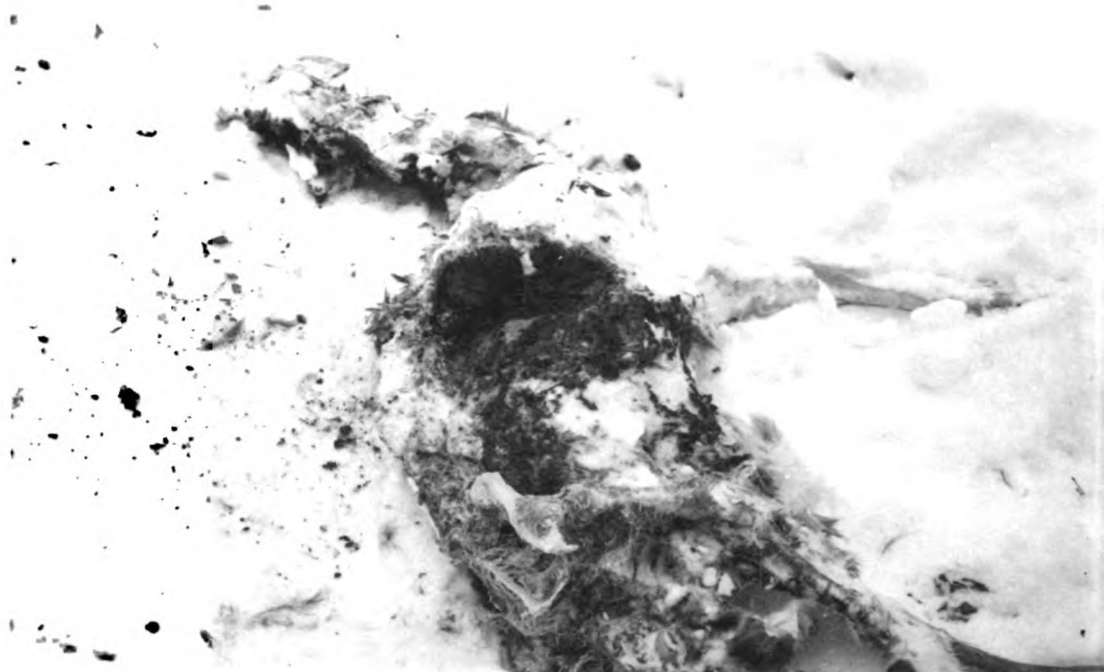


Figure 10. Juvenile doe shot but not retrieved by hunters, serving as carrion for coyotes. Note manner in which carcass is consumed.



Figure 11. Example of maximum utilization of deer carrion by coyotes.

intestine, and patches of hide. Coyotes apparently carried away quantities of carrion from deer carcass sites, but no large caches of the materials were noted. In most instances small pieces of deer flesh were abandoned atop the snow, or occasionally lightly covered with snow. In addition to those excavations made by trailed coyotes which produced carrion, 59 such endeavors provided no apparent reward.

Deer and Coyote Relations in Winter

Unsuccessful deer pursuits. Unsuccessful deer pursuits of 20 yards, 200 yards, and 2.7 miles were made by trailed coyotes. Incomplete deer pursuits by coyotes not being trailed were for 100 yards and .6 miles. The origins of these incomplete chases were not located, but the results were unsuccessful. Deer pursuits by coyotes were observed as follows:

February 5, 1961. About six inches of loose snow covered an inch of crusted snow; the total snow depth was about 14 inches. Tracks of a coyote pursuing a deer were observed on the island's east side. Both animals had emerged from mixed hardwood and conifer cover, crossed the east side road, and entered the narrow band of red pine between the road and Lake Michigan. The deer had been running, until it reached the lake. It then walked out onto the ice, which was formed for about 50 yards out into the lake. The deer presumably had considerable difficulty walking on the glare ice; as tracks indicated that it slipped and fell several times. The coyote, obviously some distance behind, abandoned the chase immediately upon encountering the beach. It did, however, continue to walk along the beach for some distance, possibly watching

the deer out on the lake. The coyote then backtracked, and continued southward along the lake shore. The deer's tracks returned to the shore about 100 yards north of where it first went out onto the lake. Small quantities of blood along the deer's trail as it left the lake could not be explained. No blood, or contact between coyote and deer was observed during the chase. The blood may have been from injuries sustained when the deer fell on jagged ice at the lake edge.

February 12, 1961. Four inches of heavy wet snow had fallen the previous night, adding to the 12 inches already accumulated. A two inch crust of snow six inches below the surface supported the coyote's weight. I trailed a pair of coyotes for some distance along a series of beaver ponds when one member turned sharply from its line of travel and bounded toward the pond margin. Track evidence indicated that the coyote rushed three deer which were feeding along the pond. The coyote evidently made contact with one deer but failed to bring it down; patches of deer hair were scattered along the animal's trail of retreat. The chase consisted only of a 20 yard dash by the coyote, and no further pursuit as the deer fled. Just one coyote participated in the attempt, the second investigated the site later.

February 20, 1961. A three inch snow crust was covered with a mere skim of fine snow, and coyotes were able to travel freely on the surface. A coyote which I trailed apparently encountered three deer entirely by accident. The three deer scattered from their beds with the coyote in vigorous pursuit, but dense swamp conifer cover seemed to retard the coyote's efforts. The unsuccessful chase was for approximately 200 yards.

March 7, 1961. Base snow was frozen solidly after rains and above freezing temperatures in late February, followed by lower temperatures. While trailing a pair of coyotes I encountered tracks of a deer being chased by a lone coyote. The pair promptly became interested in the pursuit and hurriedly followed. All three coyotes trailed the deer for .6 miles. The deer continued to flee until it reached Lake Michigan, where it walked out onto the ice. The coyotes abandoned the track several hundred yards before reaching the lake. Track evidence was sufficient to definitely establish that the actual deer chase was by a single coyote, and did not involve cooperative hunting by the three coyotes.

March 10, 1961. Tracks of a coyote which pursued a deer for 2.7 miles were followed on snow crusted sufficiently to support both the deer and coyote. The coyote jumped the deer at the southwest edge of Fox Lake, and chased it through upland hardwood cover westward. The coyote appeared to be very close to the deer much of the time, as judged from the frequent dodging and swerving of their trails. While the deer's trail followed a more wavering course, the coyote's trail was fairly straight, often seeming to cut corners and shorten the distance between it and the deer. The deer finally made its escape by going out onto Lake Michigan ice north of Green Bay. Track evidence indicated that the coyote relinquished the chase shortly before reaching the lake.

Coyote trackers on Beaver Island from 1956 to 1959 noted only one instance where coyotes pursued deer. On March 7, 1957, a trailed coyote rushed two deer which were bedded, and chased them for about 50 yards without success.

Table 15. Food items found along 86.6 miles of coyote trails on Beaver Island during January, March, and December, 1956-1958.

KILLS:

- 1 - red-backed vole
- 1 - masked shrew
- 1 - gray squirrel

CARRION:

Mammal--

- 8 - individual deer carcasses visited
 - 3 - probably deer season losses
 - 5 - reason for death uncertain
- 4 - snowshoe hares visited
 - 3 - reason for death uncertain
 - 1 - killed by unknown predator
- 2 - gray squirrels visited, reason for death uncertain
- 3 - eastern chipmunks, probable predator kills
- 1 - muskrat, reason for death uncertain
- 1 - masked shrew, reason for death uncertain
- 1 - unidentifiable mammal

Bird--

- 10 - ruffed grouse visited
 - 8 - reason for death uncertain
 - 2 - killed by predatory birds
- 1 - unidentifiable bird

VEGETABLE MATTER:

- 3 - different apple trees were visited. Digging beneath trees and scattered apple fragments indicated direct feeding.
-

Table 16. Food items found along 227.7 miles of coyote trails on Beaver Island, during January, February, March and December, 1961.

KILLS:

- 1 - deer mouse
- 15 - mice, species uncertain (probably deer mice)
- 2 - masked shrews
- 1 - gray squirrel

CARRION:

Mammal--

- 15 - deer carcass visits (to 11 individual carcasses)
 - 8 - losses from deer season
 - 2 - reason for death uncertain
 - 1 - previous coyote kill
- 17 - deer entrails visited
- 16 - deer fragments visited
- 11 - snowshoe hares visited
 - 9 - reason for death uncertain
 - 2 - previous coyote kills
- 5 - muskrats visited, reason for death uncertain
- 5 - eastern chipmunks visited, reason for death uncertain
- 2 - black squirrels visited
 - 1 - red fox kill
 - 1 - reason for death uncertain
- 1 - masked shrew, reason for death uncertain

Bird--

- 9 - ruffed grouse visited
 - 4 - predatory bird kills
 - 2 - reason for death uncertain
 - 1 - red fox kill
 - 1 - previous coyote kill
- 7 - ducks visited, reason for death uncertain
- 3 - herring gulls visited, reason for death uncertain

Miscellaneous items--

- 5 - leopard frogs
- 1 - frog, species uncertain
- 1 - turtle, species uncertain
- 1 - sturgeon
- 3 - common garter snakes
- 2 - visits to unidentifiable animal matter

VEGETABLE MATTER:

- 27 - different apple trees were visited. Digging beneath trees and scattered apple fragments indicated direct feeding.

Deer depredation by coyotes. On March 2, 1961, I trailed a coyote to the remains of a juvenile doe (Figure 12), which had been killed by coyotes several days earlier. The details of the chase were not clearly visible, but the kill site was thoroughly marked with blood and deer hair. Once the deer had been pulled down by the coyote (or coyotes) it was apparently killed by wounds inflicted in the neck and head region. According to the condition of the deer remains, the animal was in good health when killed.

When coyotes fed upon deer carcasses secured as carrion they always started eating at the hind-quarters and gradually worked forward, leaving most of the viscera frozen into the peritoneal cavity (Figure 10). The organs of the chest cavity were eaten next, but frozen portions could be found clinging to the cavity walls. In the freshly killed deer the viscera were pulled from the body; the stomach was discarded, and the heart, liver, and lungs were evidently eaten while the body was still warm.

Judging from field observations, one of several conditions must prevail before coyotes can capture deer in winter with a high degree of success. Namely, when snow is accumulated in depths sufficient to hinder deer travel yet crusted enough to support coyotes, when deer are weakened from malnutrition, or when suffering from other injuries. Similar findings were reported by Murie (1940), Hall (1927), Yeager (1931), Dixon (1934), Stebler (1951), and Schofield (1959).

Deer on Beaver Island are not normally confronted with harsh winter weather, or lack of browse. During the winters of coyote tracking, snow depths varied from 5 to 20 inches. Snow conditions in March were



Figure 12. Juvenile female deer killed by coyotes on Beaver Island, March 2, 1961.

most conducive for successful deer capture by coyotes. Above freezing daytime temperatures softened surface snow while freezing nightly temperatures formed a hard crust several inches thick, which supported the weight of coyotes, but generally not that of deer.

The snow accumulation of over 3 feet, recorded in March, 1962, was an abnormally high amount. Fitzpatrick (in litt., 29 March, 1962) notified me that remains of three coyote-killed deer were discovered on the island that spring.

Coyotes undoubtedly kill some deer on Beaver Island each winter, and there is some reason to suspect that coyotes kill more during winters of severe weather. However, according to information obtained along the 314 miles of coyote trails, few deer normally fall victim to coyotes each winter.

Newborn Fawns in Relation to Coyotes

The high frequency with which newborn fawn residues were detected in coyote feces collected in June is difficult to explain. Designation of the material as carrion or as fresh kills is especially difficult. There is no apparent reason to suspect that the high occurrence of fawns in coyote feces resulted because excessive numbers of fawns were available as carrion. Bone structures and hooves of fawns identified in the feces indicated that coyotes preyed upon very young deer, evidently during the vulnerable period before fawns were agile enough to follow the does. Fawn bones and hair generally comprised most of the bulk of scats in which the item occurred. Table 14 reflects a significant decrease of fawn occurrences in coyote scats from the late

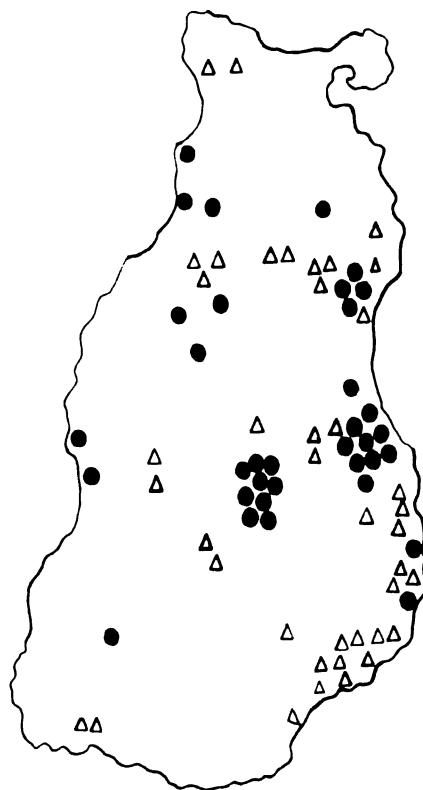


Figure 13. General locale where coyote feces containing newborn fawn remains were collected, and where fawns were sighted, 1960-1962.

- - coyote feces containing fawn
- △ - fawn sighting (to approximately 4 months of age).

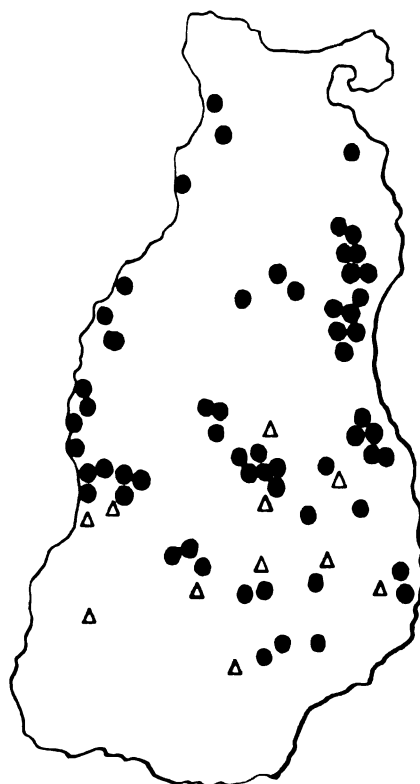


Figure 14. General locale where coyote feces containing adult deer remains were collected, 1960-1962, and where deer carcasses were found along winter trails in 1961.

- - coyote feces containing adult deer
- △ - deer carcass

summer. Conceivably, coyotes could have killed a large portion of the deer fawns represented in their diet.

Workers in various areas report conflicting opinions concerning the magnitude and effect of fawn depredation by coyotes. Sperry (1941) concluded that deer fawn remains in only 11 analyzed coyote stomachs came from fresh kills. Murie (1940) also supported the contention that coyotes kill few newborn fawns. However, in California, Horn (1941) found that coyotes played a measurable part in regulating deer numbers through deer fawn predation.

Mapping the locations where coyote feces which contained newborn fawn remains were collected seems to provide some indication as to the locale where coyotes secured fawns. Similar mapping of the distribution of coyote feces which contained cattle residues indicated that all scats were deposited within 2 miles of known cattle carcasses. Bond (1930) found that coyote scats were deposited within 3 miles of the places where food was obtained. The majority of the coyote feces collected on Beaver Island were gathered on the northern half of the island (Figures 14, 15, and 16). However, the preponderance of newborn fawn occurrences were in scats taken from the central island sectors (Figure 13).

Judging from the size of scats which contained fawn remains, most fawn consumption was by adult coyotes. About half of the scats containing fawn residues were collected from a road and open ridge east of Fox Lake, and along a sand ridge on the east side of the island. Of the 49 coyote feces which were collected from the area between Font and Barney's Lake, where coyote pups were active both summers of study, only three contained deer fawn remains. It seems possible that a small percentage of the coyotes is responsible for most of the fawn kill each year.

The predatory activities of coyotes have seldom been credited with substantially influencing deer population numbers. However, Horn (1941) reported that the removal of coyotes from 160 square miles in California resulted in increased survival of mule deer fawns. The frequent occurrence of deer fawn remains in coyote feces collected on Beaver Island during the fawning period seems suggestive that coyotes may have a similar effect on the island deer herd. This can be no more than a hypothesis, however, with present limited data. The most applicable statement regarding deer and coyote relations can be taken from Dahlberg and Guettinger (1956). They state, "...it seems likely that if coyotes exert any substantial influence on a deer population it would be through predation on fawns less than five months old rather than on mature deer." A study of the effectiveness of deer fawn predation by coyotes on Beaver Island could be conducted similar to those of Horn (1941) and Arrington and Edwards (1951). However, if coyotes are responsible for keeping the island deer population in check by preying upon fawns, the action has certainly been beneficial, since over-population of deer would probably have resulted in deterioration of the deer wintering areas years ago.

OTHER MEALS IN RELATION TO COYOTES

Snowshoe Hare

While other food items illustrated extreme sporadic seasonal importance in the coyote diet, snowshoe hares were represented with comparatively high percent frequency and volume in coyote feces collected from all seasons (Figure 7). Stebler (1951) and Dearborn (1932) reported similar findings in northern Michigan. On Beaver Island, spring coyote scats were found to contain hare remains with the greatest frequency (34.3 percent) and volume (21.9 percent). A decrease of hare frequency was noted in summer coyote scats (25.2 percent), followed by higher frequency in autumn scats (33.3 percent), and the lowest in winter (12.5 percent). Sperry (1941) found the highest occurrence of rabbits in May coyote scats, and the lowest in July scats. In general, studies have shown that where snowshoe hares are common they frequently occur in the coyote diet.

On Beaver Island, coyotes fed on remains of snowshoe hares at 11 places along 227.7 miles of coyote trails in the winter of 1960-61. At least two of the hares had been previously killed by coyotes, but the sign showed that none of the trailed coyotes killed the hares. In most instances, snowshoe hare remains noted along coyote trails consisted only of the animal's limbs, patches of fur, or entrails. Trackers found remains of four hares along 86.6 miles of coyote trails logged on the island from 1956 through 1958. Stebler (1951) reported that coyotes in the Munuscong area of Michigan's Upper Peninsula had greater success in capturing hares during the winter. Coyotes that he trailed for about 500 miles killed 17 hares, and located 8 others as carrion.

Vegetational conditions on Beaver Island, with sufficient conifer swamp and mixed hardwood conifer cover, are inductive to good snowshoe hare populations. The number of snowshoe hare tracks encountered along 28 miles of line transects in winter seemed to indicate that hares were most numerous in the conifer vegetation on the northern part of the island. Hares were abundant on the island throughout the study, most noticeably during the 1961 summer. Hare sighting success was greatest in July, 1961, when hares were sighted 61 times. However, the following month only seven were sighted. A concurrent decline in the frequency of hare remains in coyote feces was also noted.

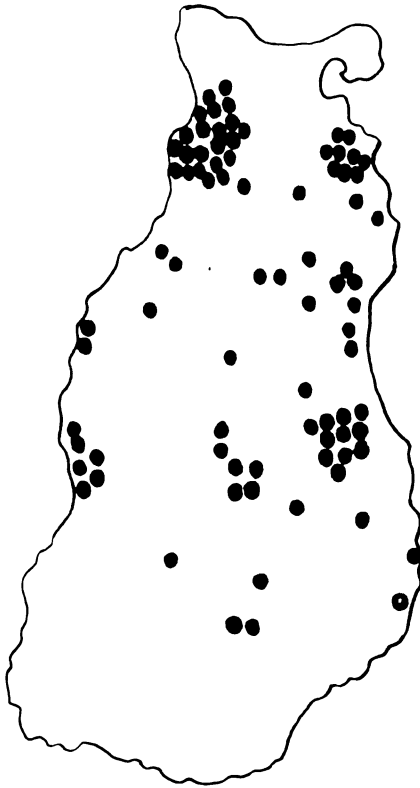


Figure 15. General locale where coyote feces containing snowshoe hare remains were collected, 1960-1962.

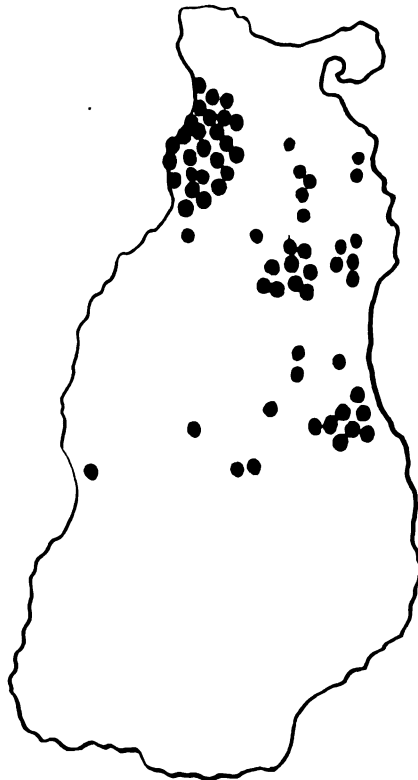


Figure 16. General locale where coyote feces containing muskrat were collected, 1960-1962.

Muskrat

Although the island does not provide favorable habitat for muskrats, and the animals were not overly abundant during the study, coyotes evidently found frequent opportunity to capture them away from water. Deer and snowshoe hares were the only mammals which occurred more frequently in the examined coyote feces (Table 9). Muskrats were detected with nearly equal frequency in the spring, summer, and autumn feces (Figure 7). They were less frequently identified in the winter scats. Spring coyote feces contained muskrat in greatest bulk. The percent scat bulk represented by muskrat progressively decreased from the spring to winter.

Striking annual variations between 1960, 1961, and 1962, in the frequency of muskrat remains in coyote feces seemed to be correlated with fluctuations in the amount of rainfall, and consequently, of water levels on the island, which had a direct bearing upon the vulnerability of muskrats to predators. Table 17 presents the monthly fluctuation in the percent frequency of muskrat remains in coyote feces and the monthly precipitation for April through September (1960-1962). Keeping in mind that the average annual precipitation for the island is 24.66 inches (Darlington, 1940), the total precipitation for 1960 of 40.36 inches was exceptionally high, and for 1961 of 26.41 inches was near average. When I visited the island on August 4, 1962, most of the island streams were completely dry. Coyote tracks were often sighted along the lake shores and dry stream beds, where they probably captured exposed muskrats.

Five muskrat carcasses were located along coyote trails during the 1960-61 winter, but none was killed by the trailed coyotes. One of

the muskrats may have been killed by predators earlier in the winter, since blood was found in snow nearby. Several others were badly tainted, and probably died in autumn. In winter, tracks of muskrat were seldom sighted, and coyotes probably found little chance to capture them during that season. One muskrat carcass was also found along coyote trails in March, 1958.

Figure 16 illustrates the general locale where coyote feces which contained muskrat residues were collected. The concentration of such scats on the north and east portion of the island coincides with areas where muskrat evidence was most frequently observed. Font Lake probably supports more muskrats than the other island water bodies.

In other areas of Michigan, Dearborn (1932) found four of 78 coyote feces examined to contain muskrat remains. In the Munuscong area of Upper Michigan, Stebler (1951) found muskrat remains in two of 99 analyzed coyote feces. Other investigators report infrequent consumption of muskrat by coyotes, and suggest that most muskrat in the coyote diet is obtained as carrion. Muskrat carrion might be available on Beaver Island in April, as beaver trappers were known to discard many muskrats accidentally taken in beaver traps.

The high frequency of muskrat in coyote scats seemed to indicate that coyotes preyed heavily upon them in 1961 and 1962. However, it appears that the coyotes are preying upon the surplus of muskrats, and that habitat conditions are not adequate to favorably support a large muskrat population.

Table 17. Percent frequency of muskrat in coyote scats per month, in relation to monthly precipitation.

Month	Precipitation in Inches			Percent of Coyote Scats Containing Muskrat		
	1960	1961	1962	1960	1961	1962
April	5.09	.71	2.24	10.0*	29.6*	
May	6.87	1.58	1.80			
June	5.22	5.11	1.47	0	33.3	33.3**
July	3.93	2.53	.89	0	38.1	
August	3.04	.57	5.17	7.8	46.4	
September	4.61	4.09	3.02	23.0	18.2	
Totals	28.76	14.59	14.59			
Average percent frequency.....	9.8	35.0	33.3			
Total number of scats.....	82	117	27			

*Scats from April and May combined

**Scats from April, May, June and July combined

Cattle

Evidence of cattle was found in 9.3 percent of the coyote scats collected on the island (Table 9). Five spring, 16 summer, and two winter scats contained cow hair. In a few instances cow hair represented as much as 90 percent of the individual scat bulk, but usually the remains constituted only a small portion of each scat. Higher frequency of cattle remains were noted in scats collected in 1961, as compared to 1960 (Table 11).

Dearborn (1932), Stebler (1951), and Sperry (1941) found no indication of cattle remains in coyote stomachs or feces examined from Michigan. Murie (1951), Fitch (1948), Gier (1957), and others, suggest that cattle are most frequently available to coyotes as carrion, although calves are occasionally killed by coyotes. Three cow carcasses were located on the island during the study, and few others were probably present. In October, 1960, island residents deposited a large cow carcass in an area which coyotes often traveled. The residents anticipated using the carrion to lure coyotes into the area, and retain them there, where they could be easily hunted with dogs. Despite this large quantity of readily available carrion, in a select coyote area, coyotes failed to feed on the cow remains during the entire 1960-61 winter.

Several island farmers have reported the loss of newborn calves to coyotes. Expectant cows were known to break out of fenced pastures on occasion and bring forth their calves in wooded areas, possibly resulting in either stillborn calves, available as carrion, or calves in a state vulnerable to coyotes. With additional beef cattle brought to the island in recent years, cattle as carrion will probably become more important in the coyote diet.

Gray Squirrel

According to Vernon Fitzpatrick (personal interview), island conservation officer, 15 squirrels in gray and black phases were released on Beaver Island in 1923. The island squirrel population seems to be characterized by drastic fluctuations in numbers, with enormous increases during favorable years. This squirrel population build-up was pronounced during the island coyote studies. During the 1960 summer I sighted only four squirrels on the island in 60 days of field work. The following summer, in 75 days, I observed squirrels on 101 occasions; squirrels were sighted over most of the island. Carl Phillips, a student who collected mammals on Beaver Island for the Michigan State University Museum, reported that squirrels were scarce during the summer of 1962. He sighted only several during the entire month of July, 1962. Whether the severe 1961-62 winter resulted in high squirrel mortality, or other factors were involved in the sudden decrease in squirrel numbers is unknown.

Remains of squirrels were identified in 8.1 percent of 247 laboratory analyzed coyote feces (Table 9). They were recognized with greatest frequency, 12.5 percent, in spring scats, but occurred in scats from all seasons. The increased abundance of squirrels in 1961, as compared to 1960, did not result in higher frequency of squirrel remains in coyote feces collected that year. In fact, the percent frequency of squirrels in the 1961 summer coyote feces was lower than in 1960 (Table 11).

A coyote trailed through beech-maple hardwoods near Green Lake surprised and killed a gray squirrel on January 10th. Coyotes also located two other squirrel carcasses as carrion along the 1960-61 winter coyote trails.

Murie (1945) found that squirrels were acceptable as food by coyotes, but were not often captured. He stated, "Such animals apparently are not easily caught and do not lend themselves so readily to a routine hunting technique for the coyote". Since squirrels occur most abundantly in upland hardwood cover of the island, and coyotes seem to spend little time hunting such areas, the opportunity for coyotes to capture squirrels probably does not arise too frequently. Naturally, the tree dwelling and diurnal squirrel habits add to their protection from coyotes.

Eastern Chipmunk

Evidence of chipmunks was found in 12 coyote scats; all occurrences represented but a small portion of each individual scat. Their remains occurred in 6.3 percent of the summer scats, in 8.3 percent of the autumn, and 4.2 percent of the winter scats. Only 1.6 percent of the spring coyote feces contained chipmunk remains.

In December, I found five dead chipmunks along 10 miles of coyote trails, all were available as carrion. Shrews or mice had evidently eaten some of the flesh, but coyotes merely uncovered the remains and abandoned them atop the snow. Chipmunk carrion was recorded three times along 23.1 miles of coyote trail followed in 1958.

The chipmunk population on Beaver Island apparently undergoes fluctuations in abundance comparable to the gray squirrels. In 1960, chipmunk numbers were especially low. The following summer chipmunks seemed to be everywhere, one could ride through upland hardwood cover, and see five or six scurry across the road per mile. In 1962, chipmunks were still numerous. Despite noticeable differences in availability of

the animals between the summers of 1960 and 1961, they occurred with nearly equal frequency in coyote feces from both years (Table 11). Because of the chipmunk's diurnal and alert habits, coyotes probably expend little time hunting the rodents, regardless of their abundance.

Woodland Deer Mice

Woodland deer mice occurred in 4 percent of the coyote feces examined in the laboratory. The winter scats contained deer mice with the greatest frequency, 14.6 percent. Hair and bone of deer mice made up as much as 95 percent of one winter scat and 40 percent of another, but other occurrences were of small amounts.

Coyotes trailed in winter were credited with 16 mouse kills. An entire deer mouse was found at only one site, all others were designated as mouse kills because of blood and fur found where trailed coyotes pounced in apparent attempts to capture mice. While the species of mice was not definitely determined in 15 cases, I assumed they were deer mice, because they were the only species identified in the analyzed scats, and because of the scarcity of other mouse species during the study.

As noted in Table 5, most mouse kills located along winter coyote trails were on cleared open land. Lone traveling coyotes killed 14 mice while failing on 39 attempts to capture mice (or shrews). Paired coyotes accounted for only three mouse kills; they failed when attempting to capture mice on four occasions.

Mouse hunting seemed to be a trait exhibited by certain coyotes, especially those which concentrated their hunting activities on northern parts of the island. On January 21st I trailed a coyote for 5.3 miles on

this northern area; it killed and consumed three mice. A masked shrew was also killed, but abandoned. The coyote pounced five times in apparent attempt to capture mice or shrews, but failed. I trailed what I believe was the same animal for 5.3 miles on January 27th, it killed and ate one mouse while five others escaped its grasps. A coyote which I trailed for 3.2 miles on December 18th captured three mice while missing on four other attempts. The following day I trailed a coyote in the same area, it attempted to capture mice seven times, without success. These were the most pronounced examples of mouse hunting expressed by coyotes I trailed on the island.

Mouse hunting by coyotes was noted with greatest effort early in winter, before hard crusted snow formed. In December and January half of the coyotes which I trailed either captured or attempted to capture mice. Twenty percent of the coyotes trailed during February attempted to capture mice, and only 15 percent of those coyotes trailed in March hunted mice. However, greater percent success was noted in February and March, probably because of crusted snow during that time which prevented mice from rapid burrowing and escape.

Woodland deer mice occurred in tremendous numbers on the island throughout the 1960 and 1961 study. Peromyscus maniculatus gracilis is normally confined to forested area (Burt, 1957), but, on Beaver Island, due to the apparent lack of interspecific competition, occurred in nearly every ecological niche. Robert Tuck (personal interview) reported capturing deer mice with greatest trap success (15 mice per 100 trap-nights) in open areas occupied by juniper. Trap success, per 100 trap-nights, in beech-maple (14 mice), in coniferous cover (12 mice), and in marsh vegetation (6 mice) followed in that order. A decline in deer mouse numbers

was reported on the island by Carl Phillips (personal interview) in 1962. He indicated that one line of 140 trap-nights in beech-maple hardwood cover produced no mice.

Sperry (1941) found deer mice (Peromyscus sp.) in 6 percent of 8,339 coyote stomach examined, generally in small amounts. He concluded that coyotes seldom captured deer mice in numbers because the mice were especially adept at escaping mammal predators. Murie (1940) identified deer mice in only 34 of 5,086 coyote feces analyzed, despite an abundance of the creatures in the study area. Because deer mice did not restrict their movements to runways, but instead scurried from cover to cover, Murie felt that coyotes could not capture them as readily as Microtus which confined their movements to fixed runways. This apparent inability of coyotes to capture deer mice consistently is probably why the rodents did not occur in the diet of Beaver Island coyotes with greater frequency, despite their overwhelming numbers, and occurrence in all cover types.

Beaver

Beaver are common on much of Beaver Island, particularly along streams through mixed aspen-conifer stands on the island's east side. Six or eight trappers who participate in beaver trapping each spring rarely complete the season without their individual limit of eight beaver.

Remains of beaver occurred in one spring scat and six summer coyote scats collected on the island. Beaver fur and bone comprised nearly the entire bulk of these scats. Two of the summer occurrences consisted of remnants from juvenile animals, as determined by bone fragments, teeth, and claws. Since preferred coyote hunting areas seemed to coincide rather closely with beaver dwellings, the opportunity for coyotes to capture

young beaver must certainly have arisen, and probably accounted for the representation of juvenile beaver in the examined feces.

While coyotes which I trailed in winter showed considerable interest in beaver trails leading away from water, it is uncertain whether they would attempt to capture adult beaver, or whether they are capable. Sperry (1941) found beaver remains in only one coyote stomach of over 8,000 which he examined; from field observations he concluded that a lone coyote would have an elusive quarry if attacking an adult beaver near a stream. According to Young and Jackson (1951), "beavers are notoriously lacking in defense of themselves when attacked by predators". Murie, O. J., (1935) and Murie, A., (1940) reported beaver remains in examined coyote feces, but failed to provide field evidence as to how coyotes may have obtained beaver flesh.

On Beaver Island, as elsewhere, trappers were noted to skin beaver in the field, and leave the bulky carcasses rather than transport them for any distance. Small beavers were known to be discarded by trappers because of their low value. Such practices would tend to provide significant quantities of beaver flesh as carrion for coyotes.

Raccoon

Remains of raccoon have been found in stomachs and feces of coyotes (Fitch and Packard, 1955, and Sperry, 1941), generally in small amounts. But, Stains (1956) states that coyotes and owls feed upon raccoons more frequently than any other animals. Raccoon fur comprised about 90 percent of one coyote scat collected on Beaver Island during the spring of 1961. Due to the presently sparse island raccoon population their occurrence in the coyote diet can be considered uncommon.

According to information obtained from islanders, four to six raccoons were introduced on the island in 1956. Since then they have increased, and become sparsely scattered over much of the island, with evident concentrations in beaver pond areas. Jones (in litt., 9 November 1961) reported that he captured and released two raccoons on the island while trapping foxes and coyotes in 1959. I trapped and tagged an adult female raccoon in August, 1961. These are the only available records of raccoons taken on the island following their introduction.

It is difficult to determine what will be the outcome of coon introductions on Beaver Island. According to track evidence, their numbers have been increasing. The cover requirements of mature denning trees and a permanent water supply along with adequate food in form of crayfish, frog, snake, mollusk, beechnut, etc., seem to be met on the island, and might be an indication that a coon population could flourish. Corn, often considered the favorite plant food of the coon is rarely planted on the island. Since few raccoon would probably be taken through trapping and hunting in future years, coyotes might offer one of the few immediate checks on their increasing numbers.

Woodchuck

Grier (1957) and Korschgen (1957) reported infrequent occurrences of woodchuck in the diet of Kansas and Missouri coyotes. However, in Michigan, Sperry (1941) found woodchuck remains in 4 of 12 coyote stomachs examined in May, and Dearborn (1932) noted woodchuck in 4.55 percent of the coyote feces he collected from Marquette, Roscommon, and Osceola Counties. Marmots were not common on Beaver Island during the study,

probably accounting for their rare occurrence in the coyote diet. Hair of woodchuck occurred as a trace amount in one summer coyote scat collected on the island. Unless woodchuck numbers increase considerably on Beaver Island it is doubtful that they will add significantly to the coyote diet.

Coyote

Hair from coyotes was found in 27 coyote scats. Since 20 occurrences were in early summer scats, when coyotes were still shedding winter fur, and all occurrences were of extremely small quantities, often only several hairs, I tend to attribute the presence to accidental ingestion. Murie (1935) and Young and Jackson (1951) indicate that coyotes do not hesitate to eat flesh of their own kind. However, no coyote carcasses were known to be available as carrion on Beaver Island during the study.

Masked Shrew

No evidence of masked shrews was discovered in the 274 coyote scats examined, despite the fact that their remains were noted along winter coyote trails (Tables 15 and 16). On January 21st, a coyote trailed into upland hardwoods killed and evidently devoured portions of a masked shrew, as only parts of the shrew's crushed body were found. The following day, a pair of coyotes which I trailed captured a shrew beneath a clump of junipers in an open area. Judging from tracks at the site, they spent considerable time playing with their prey before killing and abandoning it. Trailed coyotes also uncovered a partially decomposed shrew in December. Tracking data from January, 1958, showed that coyotes killed then discarded two shrews. Island field observations seem to support the consensus of Sperry (1941), Stebler (1951), Murie (1940), and Grier (1957), that shrews are unpalatable to coyotes.

Red-backed Vole

Hatt et al. (1948), after fairly extensive mammal collecting on Lake Michigan Islands, did not record red-backed voles on Beaver Island in 1938. In January, 1958, one red-backed vole was found killed and abandoned by a traileed coyote (Table 15). Robert Tuck collected only two such specimens in 1960, after extensive snap-trapping on the island. In 1962, however, Carl Phillips (personal interview) reported that the voles were fairly numerous. He had greater success capturing red-backed voles than woodland deer mice on the island.

Sperry (1941) and Stebler (1951) noted red-backed voles as locally important in the coyote diet at Munuscong State Park in Michigan's Upper Peninsula. If these rodents maintain their numbers on Beaver Island, as observed in 1962, they could become an important item in the diet of the island coyotes.

Red Fox

In 1959, J. Jones (in litt., 9 November 1961) trapped 45 red foxes on Beaver Island, and estimated that the total population consisted of about 65 animals. He noted that foxes occurred over the entire island (Figure 18). In 1960 and 1961, I live-trapped, tagged, and released 16 foxes on the island (Table 18). At this time foxes did not appear to travel the entire island, nor did they appear as numerous as Jones proposed. I rarely observed fox tracks on the central and north central part of the island, where coyote evidence was most common. Fox sign was most noticeable along the southern and western margins of the island, and most of the foxes which I tagged were trapped in these areas (Figure 18).

No evidence of red fox was detected in the 274 coyote feces examined. However, definite antagonism between coyotes and foxes was noted, and reported. On January 30th, a coyote that I was trailing pursued a fox for about 40 yards. The animals encountered each other at the edge of a large opening. Drifted snow was crusted enough to support the fox's weight, but the coyote plunged shoulder deep into the snow and soon abandoned the chase. On August 18, 1961, a coyote killed a fox which was caught in a steel-trap at Green Bay. The throat of the fox was lacerated and tooth punctures penetrated the animal's skull, but no flesh was eaten from the carcass.

Karl Kuebler (in litt., 4 March 1962) reported that coyotes killed two foxes in his traps during past years. He also related an instance where coyotes killed a fox on the ice of Font Lake. Kuebler, who served as the Conservation Department Fire Officer on Beaver Island for 14 years, stated that foxes were more abundant during years when low coyote populations existed on the island. It seems possible that competition for food and antagonism between foxes and coyotes resulted in the segregation of their activities during 1960 and 1961.

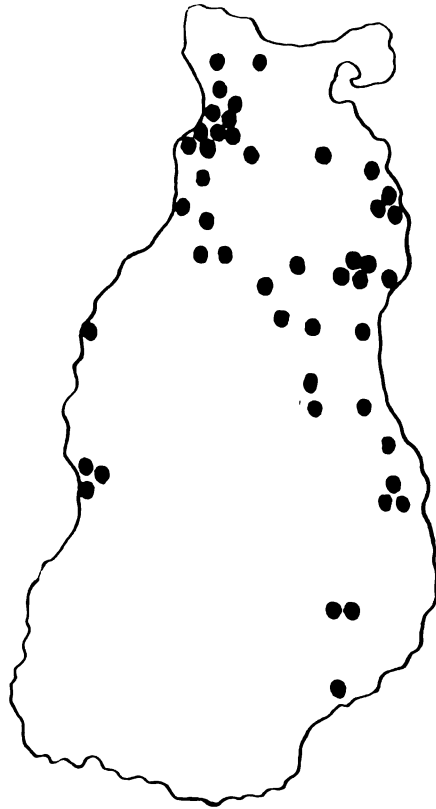


Figure 17. General locale where coyotes were captured or killed from 1958 through 1962.



Figure 18. General locale where red foxes were captured or killed from 1958 to 1962.

● --site where fox was killed in 1959.

△ --site where fox was trapped and tagged, recaptured, or killed in 1960 and 1961.

Table 18. Red foxes tagged on Beaver, Garden and Hog Islands.

Tag No.	Date	Age	Sex	Weight (lbs.)	LOCATION WHERE TAKEN		
					Section	Town	Range (north)(west)
6430	7-24-60	Imm.	F	-	19	37	10
6431	7-27-60	Mat.	M	-	25	38	11
48504	8- 6-60	"	M	-	21	39	10
48514	8-24-60	"	F	-	25	38	11
48516	8-28-60	Imm.	M	8.75	10	37	10
48521	8-31-60	"	M	8.25	25	38	11
48548	6-17-61	Mat.	M	-	22	39	10
"	12-18-61	"	M	-	23	39	10(a)
36433	6-18-61	Imm.	M	4.75	15	37	10
"	6-20-61	"	M	4.75	15	37	10(b)
36436	6-19-61	"	F	3.75	22	39	10
36438	6-24-61	"	M	5.00	15	37	10
"	7-12-61	"	M	6.50	20	37	10(c)
"	7-26-61	"	M	-	20	37	10(d)
36440	6-20-61	"	F	3.50	22	39	10
"	7- 9-61	"	F	5.00	14	39	10(e)
48550	6-21-61	Mat.	M	-	15	37	10
"	6-26-61	"	M	-	15	37	10(f)
"	7-25-61	"	M	-	20	37	10(g)
48546	6-30-61	Imm.	F	6.25	20	37	10
48551	7- 3-61	"	M	7.50	20	37	10
"	7-11-61	"	M	7.50	20	37	10(h)
36442	7-16-61	Mat.	F	-	19	37	10
"	9- 5-62	"	F	-	29	39	10(i)
"	5- 5-61	"	F	-	34	39	10(j)
36445	7-19-61	"	F	8.00	29	39	10
36447	7-31-61	"	F	-	2	39	8
36449	7-31-61	"	M	-	2	39	8
36519	8-18-61	Imm.	F	7.25	19	37	10
36517	8-23-61	"	F	6.00	26	40	10

- (a) - shot 1.75 miles east of tag site
 (b) - retrapped at same den site
 (c) - retrapped 1.50 miles southeast of tag site
 (d) - retrapped 1.50 miles southeast of tag site
 (e) - released on Garden Island after 20 days in captivity
 (f) - retrapped .75 miles east of tag site
 (g) - retrapped 1.50 miles southwest of tag site
 (h) - retrapped at same site
 (i) - retrapped 11.5 miles north of tag site
 (j) - shot raiding chickens, 9.0 miles north of tag site

BIRDS IN RELATION TO COYOTES

Ruffed Grouse

Annann and Palmer (1958) state that the island grouse population reached phenomenal numbers in 1954, five years after their introduction. The population density has since then decreased, but still remains higher than the average density for the Upper Peninsula of Michigan.

During the 1956-57 winter coyote tracks flushed 34 grouse, or an average of one bird for every 1.9 miles of trail. According to Moran (1962), ruffed grouse reached their lowest numbers on Beaver Island, since their phenomenal abundance of 1954, during the winter of 1958-59. The island grouse population was apparently on the upswing in their cycle of abundance by 1961. I flushed 73 ruffed grouse while trailing coyotes, an average of one bird per 2.9 miles of trail, in 1961.

Noticeable differences in ruffed grouse abundance occurred on Beaver Island between the two summer study periods. From July 15 through September 15, 1960, I sighted a total of 37 ruffed grouse. Only six broods were located. In 1961, from June 15 through September 8, I observed 199 ruffed grouse, and located 30 broods. Speaking in regard to the 1961 grouse population on the island, Moran (1962) wrote: "Some idea of late summer density was obtained for a 100-acre trapping area on the isolated north-east corner of Beaver Island. A 9-day trapping period during the first half of August yielded 14 juveniles and three adult females or about one bird per 6 acres. Flushing counts in the first week of October averaged 5 grouse per hour."

Seasonally, ruffed grouse were represented with the greatest percent frequency (10.4) and percent volume (2.8) in winter coyote scats. Spring and summer coyote scats contained grouse with less frequency. None was identified in autumn coyote feces. Coyote scats collected from the spring and summer periods of 1960 and 1961 contained grouse remains with similar frequencies; despite an apparently larger grouse population in 1961.

Although Beaver Island has supported an abundance of ruffed grouse in recent years coyotes neither appear especially adept at capturing such prey, nor do they devote much effort in their pursuit. Ruffed grouse seem to add considerably to the winter coyote diet, but from available evidence the majority of this food is obtained as carrion (Table 18). Similar findings are reported by Murie, O. J. (1935 and 1945), Murie, A. (1940), Stebler (1951), and Sperry (1941). While coyotes may find occasional opportunity to capture ruffed grouse, the amount of predation is certainly insignificant, and cannot materially influence the island grouse population.

Sharp-tailed Grouse

While sharp-tailed grouse are currently low in numbers on Beaver Island, any amount of predation upon them might be an important factor in their elimination. However, no sharptail remains were identified in the analyzed coyote feces, and none was located along winter coyote trails.

The birds appear far too scarce to attract the attention of hunting coyotes. During the course of study on the island, I observed a

total of 30 sharptails, all on northern cleared island areas. The largest flock, of 12 birds, was sighted on January 27, 1961. A hen with four young was observed on August 15, 1961. Other group sightings consisted of 8 and 3 sharptails. Two single birds were also flushed.

Ammann (1957) states, "Circumstantial evidence points to the two successive open seasons (1950 and 1951) as being responsible for the almost complete disappearance of sharptails on Beaver Island, inasmuch as the birds had survived under 10 years of protection previous to 1950 at a lower average population". Sharptails have been protected from hunters since 1952, but have shown no noticeable increase in their numbers. The continual decline of the island sharptail population, despite protection, according to Ammann, "...is not surprising because the few remaining birds in the spring of 1952 were widely scattered. If the birds had been together in one colony they might have done better. When populations are down to a few birds, chance alone may determine the difference between success and failure". Sharptails have evidently been at this critical point of balance for sometime; whether they will maintain their present weak hold on the island, or become eliminated is yet to be determined. Coyotes seem to play little or not part in this decision.

Duck

Beaver Island provides a fair habitat for a variety of waterfowl. Black ducks (Anas rubripes), mallards (Anas platyrhynchos), blue-winged teal (Anas discors), ringnecks (Arthya collaris), American golden-eye (Glaucionetta clangula), buffle-heads (Glaucionetta albeals), and red-breasted mergansers (Mergus serrator) were commonly sighted along the Lake Michigan shore or the island's inland waters.

Ducks were identified in only two spring and two winter coyote feces; thus, they seemed unimportant in the coyote diet. Half of a scat collected in winter consisted of duck feathers and bone; the other occurrences were in small amounts. Seven ducks were found as carrion along winter coyote trails, of which four golden-eyes, one black, and a red-breasted merganser were identified. On February 2nd, a trailed coyote visited the fresh carcass of a golden-eye on the shore of Green Bay, deposited a scat nearby, and continued on without feeding upon the duck. Other ducks located in winter were nearly completely consumed. Most of this carrion probably arose during the fall migration.

Relationships between ducks and coyotes on Beaver Island seem to be similar to those reported elsewhere by Murie, A. (1940 and 1951), Murie, O. J. (1935 and 1945), and Bond (1939), namely, that coyotes seize ducks when they have the chance, but such opportunity rarely occurs. Consequently, duck in the coyote diet is primarily secured as carrion.

Song Birds

Coyotes probably find opportunity to include various species of song birds in their diet, but evidently such occurrences supplement the coyote diet in minor amounts. Four analyzed coyote feces contained remains of small birds; the species were not readily identifiable. Small bird's eggs occurred as trace amounts in two other scats.

Other Birds

In the summer herring gulls (Larus argentatus) dominate the shores of Beaver Island, although their rookeries are located on the smaller surrounding islands. In the summer dead gulls were commonly found washed ashore, especially along the west side of the island. Of the many dead gulls I found none were fed upon by coyotes. Evidence of herring gull was found in only one coyote scat. About 10 percent of a spring scat consisted of gull feathers; remains of muskrat constituted the remainder of the fecal deposit. Coyotes trailed in winter visited remains of three gulls, but did little more than paw at the carrion.

The feet and feathers of a crow (Corvus brachyrhynchos) represented a portion of one August coyote scat. I discarded a number of crows accidentally killed in traps, later check revealed that coyotes ate much of the flesh from two. Apparently, coyotes are not averse to consumption of such carrion.

Six spring, seven summer, one fall, and three winter coyote feces contained small amounts of unidentifiable bird remains. In addition, six scats contained eggshell from undetermined bird species.

MISCELLANEOUS ITEMS IN THE COYOTE DIET

Invertebrates

Grasshoppers. Numerous investigators have reported grasshoppers (Acrididae) as common food of coyotes, often utilized in surprisingly large quantities. Ferrel et al. (1953) discovered 640 of the insects in the stomach of a male coyote pup. Grasshoppers occurred in 35.2 percent of the coyote feces collected on Beaver Island during July and August. A still higher frequency of 53.3 percent was recorded in September coyote scats. As many as 49 grasshopper pronotums were identified in a single August scat. Some feces contained the insects in greater mass, but no attempt was made to count the number of individual grasshoppers present.

Beetles. Beetles (Coleoptera) were found in coyote scats with a frequency nearly equal to that of grasshoppers (Table 9). June beetles (Phyllophaga sp.) appeared to be the most frequently consumed Coleopteran, although ground beetles (Carabidae), carrion beetles (Silphidae), lady-beetles (Coccinellidae), and darkling beetles (Tenebrionidae) were also identified in the examined feces. Of the 111 summer scats examined 30.6 percent contained beetles. Coyotes ate beetles nearly as frequently in spring, since 29.7 percent of the spring coyote scats contained beetle chitin. Autumn coyote feces contained their remains with 12.5 percent frequency, and one winter scat was found to contain beetles. While beetles generally comprised but a minor portion of the scats in which they were identified, their exo-skeletons occasionally constituted 90 to 100 percent of individual scat volumes, suggesting that coyotes at times spent

considerable effort in search of such insect prey. The pups seemed to consume more beetles than did the adult coyotes.

Other insects. Bees and wasps (Hymenoptera), cicadas (Cicadidae), dragonflies (Odonata), and various bugs (Hemiptera) were also recognized in coyote feces, but such occurrences were infrequent, and relatively unimportant in the coyote diet (Table 9).

Crayfish. Two coyote scats collected in July contained pinchers and skeletal portions of crayfish (Crustacea). Two of the scats collected on August 5, 1962, also contained evidence of crayfish.

Other invertebrates. Wolf spiders (Lycosidae), identified in two coyote scats, were apparently accidentally ingested while coyotes fed on grasshoppers, as in both cases much of the scat consisted of grasshopper remains. Three ticks (Dermacentor variabilis) and one terrestrial snail (Anguispira alternata) also were identified in the scats.

Cold-blooded Vertebrates

Snakes. Reptilians are not represented by a wide variety of species on Beaver Island, but certain species of snakes occur in abundance. Watersnakes (Natrix sipedon) and the common garter snake (Thamnophis sirtalis) are especially abundant. Beaver ponds seem to provide optimal watersnake habitat, and it was nearly impossible to walk along the dams without sighting watersnakes. Coyotes included snake flesh in their diet on occasions, but only in small amounts. Six summer, one autumn, and three winter coyote feces contained evidence of snake. Three frozen garter snakes were visited by coyotes trailed in the winter (Table 16). The coyotes had spent considerable time tossing the snake remains about, and rolled over them but ate very little of the flesh.

Turtle eggs. Snapping turtles (Chelydra serpentina) and painted turtles (Chrysemys picta) seemed to be abundant in the island's inland waters. Old sand dunes and patches of exposed sand along Font Lake, and ponds adjacent the lake, served as special brooding places for turtle eggs. In the summer turtle tracks crisscrossed these areas, and invariably parched turtle egg shells could be found near holes excavated in the sand by foxes and coyotes. Pups from coyote litters raised west of Font Lake during 1960 and 1961, visited the sandy areas regularly and dug turtle eggs from nests in the sand. Turtle eggs occurred in 7.8 percent of the spring and 2.7 percent of the summer coyote feces examined, but never in large quantities.

Fishes. Scales and bone of fish were found in five summer and two winter coyote scats. The remains comprised 52 percent of a scat collected in February. A coyote trailed on February 26th located and fed upon a sturgeon (Acipenser fulvescens) about 20 inches in length, which had washed ashore from Lake Michigan. Alewives (Alosa pseudoharengus), suckers (Catostomidae), and smallmouth bass (Micropterus dolomieu) were commonly found scattered along the Lake Michigan shore during the summer months, readily available as carrion to scavengers.

Frogs. Trailed coyotes dug five leopard frogs (Rana pipiens) and one unidentified frog from the snow. Frog remains were found in only one summer scat. Moore (1929) observed coyotes catching frogs and tadpoles in shallow water, but such practices appeared to be uncommon on Beaver Island.

Vegetable Food

As indicated in previous sections, animal life was readily available on Beaver Island, and most was commonly consumed by coyotes. However, as plant fruits became available during the summer and autumn months coyotes seemed to gorge themselves with the various fruits, rather than hunt the harder to capture animal prey. Even the winter coyote diet contained respectable amounts of plant material.

Sarsaparilla. The seeds of sarsaparilla were found in 41.4 percent of the summer feces examined, and represented 22.4 percent of the total summer coyote scat bulk. Nearly all recorded sarsaparilla occurrences were in coyote feces collected in August, such fecal materials commonly contained nothing but sarsaparilla seeds.

Fruiting bristly sarsaparilla (Aralia hispida) plants were observed in abundance on the abandoned, sandy soiled, clearings of the island. This species probably accounted for most occurrences of Aralia in the coyote diet. Darlington (1940) also lists wild sarsaparilla (Aralia nudicaulis), a plant of moist woodlands, as present on the island. Coyotes probably ate its fruits as well.

Seton (1929) reported wild sarsaparilla present in coyote feces collected along the Athabaska River, Alberta, Canada. Murie (1940) states that it is relished by coyotes in certain areas. Few other workers report the fruit of Aralia as coyote food.

Judging from the frequency and volume of sarsaparilla fruits detected in coyote fecal materials, the fruit is an important and rather stable commodity in the August diet of Beaver Island coyotes.

Raspberry, blackberry, and dewberry. Coyotes ate the fruits of red raspberry, blackberry, and dewberry, but I could not distinguish between their seeds in coyote feces. Thus, all occurrences of these fruits were designated as Rubus sp. Of the 111 summer coyote feces examined 30.6 percent contained Rubus seeds, and comprised 9.5 percent of the total summer scat bulk. In the Autumn Rubus seeds were found in 40.7 percent of the feces, and formed 27.2 percent of the scat volume. Numerous coyote feces consisted nearly entirely of the Rubus seeds.

Blackberries seemed to be the most abundant Rubus species on the island, but wherever dewberries occurred they were more available to coyotes because of their low trailing habit. Raspberries were the least encountered, but coyotes were known to feed upon them occasionally. On August 10, 1960, I saw tracks of a peglegged coyote winding in and out of raspberry patches bordering a sand blow. Evidence indicated that the animal had been feeding upon the berries.

Rubus fruits were identified in about 46 percent of the coyote scats collected in July and August, but were present in only 34 percent of the feces from the same months in 1961. I could detect no noticeable decrease in the availability of the fruits in 1961; in fact, the berries seemed more abundant. The decrease in coyote utilization of the fruit was probably associated with concurrent increased availability of muskrat and snowshoe hares.

Apple. Abandoned fruit bearing apple orchards are common sights on Beaver Island, as are scattered wild growing apple trees. Two clearings east of Lake Geneserath contain the largest apple orchards. Of 24 coyote feces collected in September, 13 contained apple fragments. In the winter 32 percent of the feces contained apples. Apples were less frequently detected in spring and summer coyote feces.

The surprising aspect of apple eating by coyotes was their tremendous use of the fruit during the winter. Apples were found more frequently in the winter coyote feces than were the remains of snowshoe hares, even though hares were abundant. Trailed coyotes stopped to dig for and feed upon apples on 12 different occasions. The most exaggerated example was noted on January 21st, when a single coyote dug beneath 15 different apple trees for the fruits. One coyote scat collected in January contained 54 cubic centimeters of apple fragments.

Strawberry. Seeds of wild strawberry were found in 14.4 percent of the coyote feces collected in July and August. While the fruit's seeds could be found only as trace amounts in June and late August scats, they represented the entire bulk of certain July coyote feces. The island climate and sandy soil seems to provide an ideal situation for growth of the berries, and northern cleared island sectors produce the fruits in abundance. A higher occurrence of strawberry seeds was noted in summer coyote feces collected in 1960 as compared to those from 1961. The differential coyote use of strawberries between the two summers seemed to reflect a difference in availability of the fruit.

Sand cherry. When sand cherries (Prunus pumila) were available, coyotes ate them in large quantities. Nearly all occurrences of the fruits were from coyote feces collected in August, suggesting a brief period during which sand cherries were available and utilized as food by coyotes. Sand cherries were found in 7.2 percent of the summer coyote feces examined. One coyote dropping collected on the sand dunes at Green Bay contained 210 sand cherry seeds. Other scats contained 174, 136, 130, 98, and 63 seeds, illustrating intensive use of the fruits at times.

Beechnut. Of the 64 spring coyote scats examined 9.4 percent contained beechnut hulls. The fruits were found less frequently in scats from other seasons. Certain fecal passages collected from coyote pups contained large amounts of beechnuts, most frequently in combination with muskrat remains.

Grass and sedge. There may be some question as to whether grass (Gramineae) and sedge (Cyperaceae) occur in the coyote diet as plant food or plant debris. The items are invariably identified in coyote feces and stomachs, often in such quantity that they must be intentionally eaten. Grier (1957) states that, "Although coyotes may not digest much of this grass, it may serve a function as tonic, source of vitamins, or vermicide". Grasses and sedges were identified in 61 percent of the coyote scats examined. Many occurrences were in trace amounts, and most likely accidentally ingested while the coyotes fed on other prey. Other feces contained grass in sufficient quantities to assume that the materials were intentionally consumed. Sperry (1941) and Fichter et al. (1955) report a considerable unexplainable increase in grass consumption by coyotes during early summer, but the increase was not evident in the island study.

Other plants. To simplify identification of plant materials in the diet, only the more frequently represented and seemingly important items were identified. Thirteen seed occurrences, representing a very small bulk and presumably unimportant in the diet, were unclassified. Other unimportant, but readily identifiable plant fruits in the analyzed coyote feces were maple seeds, basswood seeds, hemlock cones, barberry seeds (Berberis sp.), and wintergreen (Gaultheria procumbens). Twenty-nine percent of a coyote scat collected in August consisted of wintergreen berries. The other items occurred in small amounts, except for the presence of three hemlock cones in a single coyote pup scat.

Debris. Reference to Table 9 reveals that coyotes frequently consumed non-food materials, generally in trace amounts. Much of the conifer leaves, deciduous leaves, and wood in the examined feces were probably accidentally ingested while feeding upon carrion. Sperry (1941), Murie (1935), Grier (1957), and others noted similar instances of non-food plant materials in the coyote diet, and likewise contributed the occurrences to accidental ingestion while eating carrion.

Small stones in one scat were probably from the crop of a ruffed grouse, since much of the scat contained grouse feathers and bone. One July scat contained snowshoe hare feces, while no hare remains were identified in the analyzed scat. Three other scats contained small amounts of paper.

SUMMARY

The effects of predation by coyotes on white-tailed deer of Beaver Island has been a controversial issue since the early 1950's. This study was undertaken to better understand the relationships between coyotes and wildlife on the island, and to gain information regarding coyote foods and habits.

Beaver Island is located on northern Lake Michigan, and has a surface area of 50.4 square miles. The flora of the island is related closely to that of counties in northern Lower Michigan. About one-quarter of the mammal species represented on the nearby mainland have been found on the island. In recent years, the island has maintained a permanent population of several hundred human inhabitants.

Field data was gathered during the summers of 1960 and 1961, and the winter of 1960-61. Coyotes were trailed for 227.7 miles during the winter, whereby behavior of the animals was studied. Ten coyotes and 20 red foxes were trapped, tagged, and released during the summer. A total of 274 coyote feces, representing all seasons, was collected and analyzed. In addition, game biologists recorded data along 86.6 miles of coyote trails, and tagged and released four coyotes on the island, from 1956 to 1959.

Evidence of coyotes was first detected on the island in 1943. The first island coyote was killed in November, 1944. Coyotes apparently established themselves on the island by traveling across the ice of Lake Michigan, coming either from Upper or Lower Michigan. Coyotes appeared most numerous on the island during the early 1950's. The largest annual coyote kill was 36 animals in 1953. In recent years, it has been estimated that the annual autumn coyote population on Beaver Island consisted of 25 to 30 animals.

Trailed coyotes ordinarily started their nightly hunting activities at dusk and curtailed their travel by dawn. The primary hunting techniques they employed in winter were "roving", "stalk and pounce", and "chasing". The hunting manner varied with the species of prey. Coyote movements generally involved straight-lined travel from one feeding station to another. When snow was deep and soft they frequently traveled deer trails and established their own runways.

Tracks of lone coyotes were more frequently sighted in the winter than those of pairs. No groups of three or more coyotes were noted to hunt cooperatively.

Tracks and feces of coyotes were most frequently observed on the northern part of the island, which provides a more interspersed habitat. Trailed coyotes hunted for prey most frequently in mixed aspen, white birch, and conifer cover. They appeared to shun upland hardwood cover. Cleared land, swamp conifer, upland pine, inland lakes, and most other types were utilized as they were available. Lone coyotes frequently traveled the Lake Michigan shore lines, but paired coyotes rarely traveled the beaches. Forty-two coyote beds were located while trailing coyotes. The most common bedding site was on slightly elevated sites in dense conifer cover. Beds were frequently found in close proximity to deer carcasses.

The average tracking distance from where tracking first began to where the coyote bedded down was 3.7 miles (minimum 1.3 miles, maximum 8.2 miles). The average straight-line measurement from the point where trailing first began to the beds was 2.1 miles (minimum .8 miles, maximum 3.5 miles).

Ranges of coyotes on Beaver Island overlapped; certain preferred areas were shared by a number of coyotes. Tracks of two coyotes which were missing toes were identified on 24 occasions. Minimal areas of activity for these animals were estimated to be 20 to 25 square miles.

Tagged coyotes were recovered .25, 1, 2, 6.5, and 35 miles from the original tagging sites. The latter was killed in Lower Michigan.

Feeding habits of coyotes changed with food availability, namely, from a highly carnivorous winter and spring diet to consistent utilization of plant fruits and insects as they became available in the summer and autumn.

[Residues of white-tailed deer were the most frequently detected animal item in the 274 coyote feces. In winter, 90 percent of the feces contained deer remains. Observations along coyote trails indicated that deer killed or crippled by hunters served as the primary winter food. Only one of 19 dead deer found along 314 miles of winter coyote trails from 1956 to 1962 was definitely killed by coyotes. Newborn fawn remains were identified in 31.6 percent of the spring coyote feces. It appeared that coyotes preyed upon young deer during the vulnerable period before fawns were agile enough to follow the does. However, the fawn occurrences could not be positively distinguished as carrion or fresh kills.

Snowshoe hares were the most frequently detected mammal item in scats from the spring, summer, and autumn. Remains of 15 snowshoe hares were found along the winter coyote trails, two had been killed by coyotes earlier.

Muskrat occurred in 42 percent of the scats collected during the dry 1961 summer, but were uncommon in scats from the 1960 summer when precipitation was great.

Cattle carrion was available, and often consumed by coyotes during summer months. Some predation of calves was reported.

Gray squirrels and eastern chipmunks were present on Beaver Island in tremendous numbers during 1961. However, coyotes did not appear adept at capturing such diurnal and alert prey. Their occurrence in the coyote diet was of minor importance.

Woodland deer mice were also abundant on the island, but infrequent in the coyote diet. Winter scats contained mice with the greatest seasonal frequency.

Coyotes apparently captured young beaver on occasion, and additional beaver carrion was available from the carcasses discarded by trappers.

Raccoon and woodchuck were identified in several coyote feces. Trained coyotes killed masked shrews, but the species was not identified in the examined feces.

Twenty red foxes were trapped, tagged, and released on Beaver and adjacent islands. Tagged foxes were retrapped on seven occasions. Two have been reportedly killed to date. During the study coyotes concentrated on northern cleared parts of the island and foxes in densely vegetated southern portions. Antagonism and competition between foxes and coyotes seemed to be responsible for the segregation of their activities.

Ruffed grouse were represented in about 10 percent of the winter coyote scats; tracking evidence indicated that coyotes obtained most as carrion. Ducks, song birds, herring gulls, crows, and eggshells of various birds were less frequently detected in the scats.

Grasshoppers and beetles were the most frequent invertebrates in the coyote diet.

Snakes, turtle eggs, fish, and frogs were readily available on the island, and occasionally represented in the coyote feces.

The fruits of sarsaparilla were the most frequently detected item in the coyote feces collected during August. Blackberries, raspberries, dewberries, strawberries, sand cherries, and beechnuts were readily accepted by coyotes as food when available. Apples occurred more frequently in the winter coyote feces than snowshoe hare remains. Trailed coyotes were observed to spend considerable time digging for frozen apples even though mammal prey was abundant.

LITERATURE CITED

- Ammann, G. A. 1957. The prairie grouse of Michigan. Mich. Dept. Cons., Lansing. 200 pp.
- _____, and W. L. Palmer. 1958. Ruffed grouse introductions on Michigan islands. J. Wildl. Mgmt., 22:322-325.
- Arnold, David. 1956. Red foxes of Michigan. Mich. Dept. Cons., Lansing. 48 pp.
- Bond, Richard M. 1939. Coyote food habits on the Lava Beds National Monument. J. Wildl. Mgmt., 3:180-198.
- Burt, William H. 1957. Mammals of the Great Lakes region. Univ. Mich. Press, Ann Arbor. 246 pp.
- Cronyn, Margaret and John Kenny. 1958. The saga of Beaver Island. Braun and Brumfield, Inc., Ann Arbor, Mich. 143 pp.
- Dahlberg, Burton and R. C. Guettinger. 1956. The white-tailed deer in Wisconsin. Tech. Bull. 14. Wis. Cons. Dept., Madison. 282 pp.
- / Darlington, Henry T. 1940. Some vegetational aspects of Beaver Island, Lake Michigan. Pap. Mich. Acad. Sci., Arts, and Ltrs., 23:31-37.
- Dearborn, Ned. 1932. Foods of some predatory fur-bearing animals in Michigan. School Forestry and Cons. Bull. 1, Univ. Mich. 52 pp.
- Dice, Lee R. 1927. A manual of the recent wild mammals of Michigan. Univ. Mich. Mus. Zool. Hdbk. Ser. No. 2.
- Dixon, Joseph. 1934. A study of the life history and food habits of mule deer in California. Calif. Fish and Game, 20:181-282.
- Duvendeck, Jerry P. 1958. Island deer census. Completion Rept., Job No. D-1, P-R Proj. W-95-R-2, Game Div., Mich. Dept. Cons.
- Erickson, Albert. 1955. An ecological study of the bobcat in Michigan. Unpubl. M.S. Thesis, Mich. State Univ., East Lansing. 132 pp.
- _____. 1957. Techniques for live-trapping and handling black bears. Trans. N. Amer. Wildl. Conf., 22:520-543.
- Ferrel, Carol M., H. Leach, and D. Tilloston. 1953. Food habits of the coyote in California. Calif. Fish and Game, 39:301-341.
- Fichter, E., G. Schildman, and J. H. Sather. 1955. Some feeding patterns of coyotes in Nebraska. Ecol. Monog., 25:196-207.

- Fitch, H. S. 1948. A study of coyote relationships on cattle range. J. Wildl. Mgmt., 12:73-78.
- _____, and R. L. Packard. 1955. The coyote on a natural area in northeastern Kansas. Trans. Kans. Acad. Sci., 58:211-221.
- Garlough, F. E. 1940. Study of the migratory habits of coyotes. Unpubl. U. S. Fish and Wildl. Serv. Rept., 5 pp.
- _____. 1945. Capturing foxes. U. S. Fish and Wildl. Serv. Cir. No. 8. 11 pp.
- Gier, H. T. 1957. Coyotes in Kansas. Kans. Agr. Expt. Sta. Tech. Bull. 393. 95 pp.
- Goldman, E. A. 1930. The coyote-archpredator. J. Mamm., 11:325-335.
- Hall, Raymond E. 1927. The deer of California. Calif. Fish and Game. 13:233-259.
- Hatt, R. T., J. V. Tyne, L. C. Stuart, C. H. Pope, and A. B. Grobman. 1948. Island life: a study of the land vertebrates of the islands of eastern Lake Michigan. Bull. 27, Cranbrook Press, Bloomfield Hills, Mich. 179 pp.
- Hawbaker, Stanley S. 1944. Trapping North American furbearers. Craft Press, Inc., Fayetteville, Pennsylvania. pp. 29-58.
- Horn, E. E. 1941. Some coyote-wildlife relationships. Trans. N. Amer. Wildl. Conf., 4:203-208.
- Kelker, George H. 1943. A winter census in northeastern Wisconsin. J. Wildl. Mgmt., 7:133-136.
- Korschgen, Leroy J. 1957. Food habits of the coyote in Missouri. J. Wildl. Mgmt., 21:424-435.
- Latham, Roger M. 1951. The ecology and economics of predator management. Pennsylvania Game Comm., Harrisburg. 96 pp.
- Moore, Robert D. 1929. Canis latrans lestes Merriam feeding on tadpoles and frogs. J. Mamm., 10:255.
- Moran, Richard J. 1960. Fall grouse population studies. Completion Rept., Job No. B-2. P-R Proj. W-95-R-6, Game Div., Mich. Dept. Cons.
- Mosby, Henry S. 1960. Manual of game investigational techniques. Wildl. Soc., Blacksburg, Virginia. pp. 13:1-13:9.
- Murie, Adolph. 1936. Following fox trails. Misc. Publ. Mus. Zool., Univ. Mich., No. 32. 45 pp.

- _____. 1940. Ecology of the coyote in the Yellowstone.
U. S. Dept. Int., Nat. Park Serv., Fauna Ser. No. 4. 206 pp.
- _____. 1951. Coyote food habits on a southwestern cattle range.
J. Mamm., 32:291-295.
- Murie, Olaus J. 1935. Food habits of the coyote in Jackson Hole, Wyoming.
U. S. Dept. Agr. Circ. 362. 24 pp.
- _____. 1945. Notes on coyote food habits in Montana and British Columbia. J. Mamm., 26:33-40.
- Nagel, W. O., F. Sampson, and A. Brohn. 1955. Predator control-why and how. Missouri Cons. Comm., Jefferson City. 32 pp.
- Quick, Horace F. 1953. Wolverine, fisher, marten, studies in a wilderness region. Trans. N. Amer. Wildl. Conf., 18:512-532.
- Robinson, Weldon B. 1951. Movements of coyotes from and to Yellowstone National Park. U. S. Fish and Wildl. Serv., Spec. Sci. Rept., Wildl. No. 11. 17 pp.
- _____, and Eugene F. Grand. 1958. Comparative movements of bobcats and coyotes as disclosed by tagging. J. Wildl. Mgmt., 22:117-122.
- Romanov, A. 1956. Automatic tagging of wild animals and prospects for its use. Zoological J., 35:190-205. USSR Acad. Sci., Moscow.
- Schofield, Raymond. 1959. Unpubl. Game Div. Rept. No. 2229, Mich. Dept. Cons., Lansing. 8 pp.
- _____. 1960. A thousand miles of fox trails in Michigan's ruffed grouse range. J. Wildl. Mgmt., 24:432-434.
- Scott, Thos. D. 1947. Comparative analysis of red fox feeding trends on two central Iowa areas. Iowa State Coll. Res. Bull. 353. 61 pp.
- Seton, Ernest T. 1929. Lives of game animals. Vol. I. Doubleday, Doran and Co., Inc., New York.
- Skinner, Milton. 1927. The predatory and furbearing animals of the Yellowstone National Park. Roosevelt Wildlife Forest Exp. Sta. Bull. 4:163-281.
- Sooter, Clarence A. 1946. Habits of coyotes in destroying nests and eggs of waterfowl. J. Wildl. Mgmt., 7:133-136.
- Sorensen, Harry. 1961. Notes on the geology of the Beaver Islands. Unpubl. Geology Div. Rept. Mich. Dept. Cons., Lansing. 42 pp.
- Sperry, Charles C. 1941. Food habits of the coyote. U. S. Fish and Wildl. Res. Bull. 4. 70 pp.

- Stains, Howard J. 1956. The raccoon in Kansas, natural history, management, and economic important. Univ. Kans. Nat. Hist. and State Biol. Surv., Misc. Publ. No. 10. 76 pp.
- Stebler, Adolph M. 1939. The tracking technique in the study of the larger predatory mammals. Trans. N. Amer. Wildl. Conf., 4:203-208.
- _____. 1951. The ecology of Michigan coyotes and wolves. Unpubl. Ph D. Thesis, Univ. Mich., Ann Arbor. 198 pp.
- Tiemier, Otto W. 1955. Winter foods of Kansas coyotes. Trans. Kans. Acad. Sci., 58:196-207.
- Wood, Norman A. 1922. The mammals of Washtenaw County, Michigan. Univ. Mich., Occas. Pap. Mus. Zool. No. 23.
- _____, and L. R. Dice. 1923. Records of the distribution of Michigan mammals. Pap. Mich. Acad. Sci., Arts, and Ltrs. 3:425-469.
- Yeager, Dorr G. 1931. Our wilderness neighbors. A. C. McClurg and Co., Chicago. 160 pp.
- Young, S. P. and H. T. Jackson. 1951. The clever coyote. Wildl. Mgmt. Inst., Washington, D.C. 411 pp.

ROOM USE ONLY

MICHIGAN STATE UNIV. LIBRARIES



31293101280307