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gramineus (*heterophyllus*);

2+ × 2- mm.

A low rim is present along trap door margins.

friesii; 2+ × 2- mm.

Comma head large; trap door rounded, inconspicuous.

alpinus; 2½- × 2- mm.

Very distinctive in its truncate, saddle-back top; much like a miniature of *pectinatus* but with acute apex of trap door.

pusillus; 2 × 1½ mm.

Wall proportionately heavy; trap door smoothly rounded and becoming obscure with wear; comma variable, often broader than drawn. The closely-

related *berchtoldi* differs from this and the next species in having its seam enter the comma head.

foliosus; 2 × 1½ mm.

Wall thin; ridge on trap door narrow and becoming obscure with wear; points at top and base may also be eliminated by digestive abrasion.

spirillus (*dimorphus*); 1½+ × 1½ mm.

Like the next species below but broader and larger. Wall very thin, comma slender, and embryo strongly spiral.

diversifolius (*hybridus*); 1½ × 1+ mm.

Smaller than *spirillus*; indistinguishable from *capillaceus*.

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THE FOOD OF THE OPOSSUM IN NEW YORK STATE

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Despite its abundance and wide distribution, the food of the opossum, *Didelphis v. virginiana*, has not been thoroughly investigated. Most food studies have been made from scat analyses or of trapped animals taken in November and December. Audubon and Bachman (1849), Dearborn (1932), and Taube (1947) have made contributions to our knowledge of the food of northern opossums, while Lay (1942) has studied the food of the Texas opossum.

The present study is concerned with the food of the opossum in New York State. More than 200 stomachs have been examined. Of these, 186 have contained food in sufficient quantity to

warrant study. Trapped animals which obviously contained nothing other than detritus, fur and flesh from their feet, are not considered in the determinations. The majority of specimens were taken in the central and western part of the state. A few were collected in the southern tier counties that border Pennsylvania. Six specimens were trapped in a bird sanctuary at Quogue, Long Island. One hundred twenty-nine opossums were collected from May through October, while 51 individuals were trapped in raccoon "sets" on the Montezuma marshes of central New York during November and early December. The majority of the specimens were

taken from 1946 to 1950; a few were collected or found on highways from 1932 to 1941.

Stomach analyses give a far better clue to the dietary of a species than do fecal remnants, since the food remains are less digested and thus more readily determined. The almost complete digestion of certain foods before reaching the rectum (earthworms, slugs, etc.) precludes the recognition of these items in the scats. Moreover, scats are not always possible of specific identity unless long field experience with predators has been undertaken. If passed by captive animals, feces are of no worth in natural food analyses unless they are recovered shortly after capture of the animal.

MATERIAL AND METHODS

Large numbers of specimens were secured on the highway. Six dead animals have been observed on a 42-mile stretch of road, three of which were freshly killed and thus suitable for examination. Highway victims may quickly be eviscerated with a single-edged razor blade; the head and reproductive tract may also be removed for study. It is my practice to carry a quart jar of 10 per cent formaldehyde in the car in which the stomach and intestines are placed. Whenever possible, the stomach contents are examined immediately, since the ingested food is easier to determine. Stomach analysis is relatively simple in an animal as large as an opossum. Contents are washed in a large food strainer, a stream of water removing dirt and small debris. The residue is floated in large enamel pans, the various items being separated and computed to frequency and volume. A knowledge of the biota of the habitat frequented by

the species under consideration is essential, as is a good reference collection of the larger invertebrates, vertebrates and plants.

ACKNOWLEDGMENTS

I am indebted to members of the New York State Conservation Department for much assistance in securing summer specimens. Dr. W. C. Senning, John Wilson and Lloyd Signs secured the cooperation of several state trappers. Sylvester Vanderbilt supplied specimens from the Montezuma marshes, as did several men trapping the federal refuge on these marshes. Arthur Cooley provided the Quogue animals.

OPOSSUM FOODS

Table 1 includes the analyses of animals taken during the warmer months.

TABLE 1.—STOMACH ANALYSES OF 129 OPOSSUM TAKEN IN NEW YORK, MAY TO OCTOBER. MAJORITY OF SPECIMENS SECURED 1946-1950

FOOD	Per cent of occurrence	Per cent by volume
Insects.....	59.7	13.4
Fruit.....	45.7	18.0
Amphibia.....	36.4	17.2
Mammals.....	32.6	14.2
Grasses.....	30.2	6.6
Worms.....	20.3	5.4
Molluscs.....	18.6	3.2
Reptiles.....	19.4	5.3
Birds.....	13.2	5.0
Carrion.....	7.0	4.8
Grain.....	2.3	1.6
Undetermined plants..	6.2	1.3
Undetermined animals	6.2	3.4
Centipedes.....	1.6	.2
Millipedes.....	.8	trace
Fungi.....	.8	.2
		99.8

The incidence of food items is reflected in their seasonal occurrence. These items are generally presumed to be taken in proportion to their availability. The opossum does appear to have a spe-

cial predilection for toads, as these amphibians are eaten more frequently than their numbers would indicate.

It is possible that some of the material taken from the stomachs was of secondary origin, i.e., snails, slugs and insects may conceivably have been eaten by amphibians and later exposed in the stomach of the opossum. This possibility is largely precluded in the instance of molluscs, since large numbers were often recovered from the animals when no primary molluscan predator had been eaten. Grasshoppers are usually recovered from stomachs that contain no primary predator.

DISCUSSION OF MAY-OCTOBER FOODS

Insects. When insects are available, they are eaten more frequently than any other food, although the volume may be relatively small. Three-fifths of the stomachs contained insect remains, the incidence of the various orders being in proportion to their size, abundance and ease of capture. Grasshoppers occurred in a third of the stomachs; they were eaten more frequently as the summer waned and these abundant orthopterans increased in size. These insects provide an important food for the opossum well into the winter, when only the dried exoskeletal parts may be found hanging to grass tussocks. Other Orthoptera include numerous crickets, principally *Gryllus* and *Nemobius* and a single mantid, *Stagmomantis*. Lepidopterous larvae occurred in 13.2 per cent of the stomachs. These were principally the larvae of Noctuidae and other small moths, although large saturnid larvae, *Samia* and *Polyphemus*, were eaten. Woolly bear caterpillars, *Isia isabella*, were found in three stomachs. The opos-

sum does not rub the hair from these caterpillars, a trait sometimes credited to the skunk. Beetles were present in 9.7 per cent of the stomachs. Carabids and several large coleopterous larvae were recognized. Tipulid larvae and numerous fly maggots were present in several stomachs. Since maggots were present when no trace of carrion was evident, it is presumed that the opossum may eat the maggots in preference to the carrion on which the fly larvae feed.

Fruit. Occurring in 59 stomachs, fruits constitute an important food of the opossum during and well after the growing season. The animals grub under berry bushes and small shrubs for the fallen fruit, securing these foods long after they have matured and fallen to the ground. In the order of their frequency, grapes, both cultivated and the wild *Vitis vulpina* occurred in 18 stomachs; *Prunus serotina* and *P. virginiana*, 15; raspberries and blackberries, 9; apple, 9; *Cornus amomum*, 3; *Viburnum* sp., 2; tomato, 2; and *Physalis*, 2. Strawberries, blueberries, nightshade, *Solanum dulcamara*, *Rhamnus*, *Amelanchier* and pokeweed were found in single stomachs.

Amphibia. More than a third of the examined specimens had eaten amphibians, a fact quite contrary to the findings of other investigators. These amphibians, in the order of frequency in the stomachs, include the following: *Bufo a. americanus*, 28; *Rana pipiens*, 6; *Rana sylvatica*, 6; *Ambystoma maculatum*, 4; *Plethodon cinereus*, 3; undetermined ranids, 3; and one occurrence each of *Ambystoma jeffersonianum*, *Plethodon glutinosus*, and an undetermined plethodontid. The astonishing large number of toads eaten by the opossum (21.7 per

cent of all stomachs) suggests that this animal may have a pronounced predilection for bufonids. The legs and viscera alone are often recovered from the stomach, although the large parotid glands do not appear to act as a deterrent, for the remains of an entire *Bufo* are frequently encountered in the stomach. A single Florida opossum examined by Pournelle (1950) contained *Bufo* remains.

Mammals. Almost a third of the opossums had eaten mammals. Opossum fur and claws in the stomachs of trapped animals were not considered a natural food, since the animal is known to chew on the foot and leg held by the trap jaws. It is known that opossums will occasionally kill their own kind (Pray, 1921; Seton, 1929). Field mice, *Microtus pennsylvanicus*, occurred in 12 stomachs; *Blarina brevicauda*, 12; *Peromyscus* sp., 6; *Tamias*, 5; *Sylvilagus floridanus mearnsi*, 4; *Sorex cinereus*, 2; *Ondatra*, 2; while each of the following were recovered from single stomachs: *Zapus*, *Condylura* and *Rattus*. Nest young of cottontails, field mice and short-tailed shrews had been eaten. Muskrats were juveniles, as indicated by the small leg bones and metatarsals.

Grasses. Green vegetation, principally grasses and clover, occurred in sufficient quantity in 30 per cent of the stomachs to suggest that this is an important food. The amount in several stomachs indicates grasses are not ingested fortuitously with other food. Some stomachs of animals removed from the highway contained 50 cc. or more of green grasses; this item is not eaten for lack of other foods. Feces do not indicate the green nature of ingested vegetation.

Earthworms. A fifth of all stomachs contained earthworms, principally remains of large *Lumbricus*. Occasionally four or five large nightcrawlers would constitute the greater bulk of the contents. Worms are eaten well into the early winter, long after freezing spells have limited the insect supply. No evidence of this food was found in fecal remains of captive animals that had fed copiously on worms.

Molluscs. Snails were eaten by 16 opossums, slugs by 10. The former included *Triodopsis* and *Anguispira*, while slugs of *Deroceras reticulatum* and *Arion circumscriptus* were eaten in some quantity. One stomach contained 29 *Arion* slugs.

Reptiles. Snakes were found in 25 stomachs. Garter snakes, *Thamnophis s. sirtalis*, occurred in 14 individuals, the red-bellied snake, *Storeria occipitomaculata* in 3, and the ring-necked snake, *Diadophis punctatus edwardsi*, milk snake, *Lampropeltis t. triangulum* and DeKay's snake, *Storeria dekayi* each in one stomach. Undetermined snakes (all with keeled scales) were contained in 5 animals. A recently hatched snapping turtle had been eaten by one individual. I have found a small box turtle in an opossum taken on the Vanderbilt Forest at Ashville, North Carolina.

Birds. Eaten by 17 animals, birds make up a prominent part of the dietary. Trace of cock pheasants occurred in 4 stomachs; in three instances these remains consisted of a few breast or flank feathers. It appears probable that the fragmentary remnants do not represent a kill but rather the ingestion of stray feathers. Robins had been eaten 3 times,

crow, meadow-lark, bronzed grackle and vesper sparrow once each, while undetermined birds were found in 7 opossums. These latter are represented by flesh and a few feathers. Quite likely some of the birds were carrion; it appears unlikely that an opossum could capture such a wary bird as the crow. Moreover, the opossum is almost strictly nocturnal and its opportunity for capturing birds must be largely restricted to ground roosting species.

Carrion. Birds, some mammals and other species are killed in large numbers by highway traffic. The opossum probably secures some of its food from this provident table. Items were considered as carrion when maggots accompanied primary food in the viscera.

Grain. Ripening buckwheat had been taken sparingly by 3 animals. The amount of grain eaten by this animal is negligible, in marked contrast to the large amount taken by the raccoon.

Miscellaneous. Undetermined animal and plant material constitute 4.7 per cent of the volume. Fragmentary remains of centipedes and millipedes are presumed to be of primary origin. A single stomach contained fungi which has been tentatively determined as a *Coprinus*.

COMPARISON OF RACCOON AND OPOSSUM FOODS

An excellent opportunity was afforded to contrast the late fall food of the raccoon and opossum on the Montezuma Marsh in 1948. This area has been briefly described elsewhere (Saunders, 1926; Hamilton, 1940). From early November through mid-December trappers

take a number of opossums in sets made expressly for the raccoon. No attempt was made to trap opossums since the pelts at this time (1948) had little value and were scarcely worth the skinning effort. The contrast between the dietary of the two species, collected in an identical habitat, is thus easily made through stomach analyses of the trapped animals.

Trapping was conducted in wet woods bordering large cattail swamps. Many hundreds of ducks and muskrats make their home in this haven. Amphibians, particularly the leopard frog, are extraordinarily abundant. The woods are bordered with arable fields planted to corn, buckwheat, some wheat and oats.

This comparison provides several interesting contrasts and similarities in the dietary of the two species, even though the numbers examined are small. Mammals occur almost twice as frequently in the opossum as in the raccoon. The reverse obtains when insect food is considered. Amphibians were eaten in much the same ratio in both species. Grains provided a substantial part of the raccoon diet at this season; these foods are of minor importance in the dietary of the opossum. Green vegetation, principally grasses, clover and other low growing vegetation are taken in nearly the same proportion by both species. Fruits and berries had been eaten more frequently by the opossum. The much greater preponderance of birds in the opossum food may represent carrion, as mortality among the thousands of waterfowl provide a ready source of food which appears to be eaten more frequently by the opossum than the raccoon. From what we know of the habits of the two animals, the

raccoon would appear to be a more formidable predator of such large prey than would the marsupial. Of the 12 opossum stomachs in which birds were found, 7 contained duck remains; none of the raccoon had eaten ducks.

Incidence of the more important opossum food items listed in Table 2 are:

Mammals: *Microtus*, 16; *Blarina*, 7; *Sylvilagus*, 4; *Condylura*, 2 and *Cryptotis* 1.

Insects: Grasshoppers, 5; beetles, 3; tipulid larvae, 2 and maggots, 2.

Amphibia: *Rana pipiens*, 12; *Bufo americanus*, 1 and *Hyla versicolor*, 1.

Fruits: Grapes (principally *Vitis vulpina*), 9; *Physalis*, 6; one occurrence for *Prunus*, *Solanum dulcamara* and *Cornus paniculata*.

Birds: Ducks, 5; crow, 3; undetermined species, 3; robin and red-winged black-bird once.

Molluscs: *Triodopsis*, 5 and one *Anguispira*.

Reptiles: *Thamnophis sirtalis*, 2; a *Natrix sipedon* and undetermined snake one occurrence.

Winter Food. The severest winter weather may reduce activity of the opossum in central New York, but the animal seldom remains denned for more than a few days at a time. Its fresh tracks attest to activity on nights when temperatures drop to 10° F. or lower. These travels are apparently aimless and usually cover a circuitous route, little more than a mile in a night. The animal usually returns to the original den site. Since a substantial layer of fat is acquired in the fall, the opossum presumably can fare on a minimal food supply during the colder months. Certainly fare is scanty during the late winter. Several times I have followed the winter snow trails of these animals without observing any evidence of feeding activity. Tussocks of grass are explored, particularly on south facing slopes, where grasshoppers seek shelter in the fall. The insect remnants are uncovered by foraging opossums.

Four opossums trapped at Quogue, Long Island, February 10–15, 1950 contained the following items: (1) *Sorex cinereus*, *Microtus* and field corn; (2) *Microtus* remains and fragments of

TABLE 2.—COMPARISON OF NOVEMBER-EARLY DECEMBER, 1948 FOODS OF THE RACCOON AND OPOSSUM ON THE MONTEZUMA MARSH, CENTRAL NEW YORK

FOOD	58 Raccoon		51 Opossum	
	Per cent of occurrence	Per cent by volume	Per cent of occurrence	Per cent by volume
Mammals.....	32.8	19.0	56.9	30.2
Insects.....	48.3	9.7	21.6	3.5
Amphibia.....	29.3	10.4	23.5	8.8
Fruits and Berries.....	24.1	15.1	37.3	16.7
Grains.....	36.2	25.3	7.4	4.3
Green Vegetation.....	27.6	4.2	33.3	5.6
Earthworms.....	12.1	5.1	25.5	11.2
Reptiles.....	8.6	4.7	7.9	2.0
Birds.....	5.2	1.2	23.5	8.3
Molluscs.....	3.5	1.8	13.5	1.9
Fish.....	3.5	.8	0	0
Carrion.....	1.7	2.1	5.9	3.1
Undetermined.....	6.9	.6	7.4	4.2
		100.0		99.8

green grass; (3) *Microtus*, *Blarina*, grasshopper fragments and mast (probably *Quercus*), green grasses; (4) *Microtus*, *Peromyscus*, carabid beetle fragments, clover leaves. An individual trapped at Quogue, March 30, 1950 had last eaten poultry, a leopard frog, a fringillid and green grasses. Another taken on April 21, 1950 contained poultry feathers, remains of a toad, *Bufo woodhousii fowleri*, *Microtus* and *Sylvilagus* fur.

Every stomach examined had a moderate to heavy infestation of roundworms, *Physaloptera turgida*. More than 200 worms have been removed from a single animal. The infectious stage of this nematode develops in Coleoptera, which constitutes one element in the normal diet of the definitive host. The parasite was determined by Dr. E. W. Price.

SUMMARY

The dietary of the opossum in New York State is reported from 186 stomach examinations, of which 129 were collected from May through October. The principal foods taken in the warmer months, in order of their frequency, are insects, fruits, amphibians, mammals, grasses, earthworms, molluscs, reptiles and birds. Toads occurred in 21.7 per cent of the May-October stomachs.

A comparison of the late fall foods of the opossum and raccoon trapped in the

Montezuma marshes of central New York was made. Mammals occur twice as frequently in the opossum as in the raccoon. The reverse obtained with insects. Amphibians occurred slightly more frequently in the raccoon. The opossum eats little grain, an important item in the dietary of the raccoon.

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