Portland State University

PDXScholar

Dissertations and Theses

Dissertations and Theses

11-24-1976

Some Aspects of the Ecology of the Virginia Opossum (*Didelphis virginiana virginiana* Kerr 1792) in an Urban Environment

David Hopkins
Portland State University

Follow this and additional works at: https://pdxscholar.library.pdx.edu/open_access_etds

Part of the [Biology Commons](#)

Let us know how access to this document benefits you.

Recommended Citation

Hopkins, David, "Some Aspects of the Ecology of the Virginia Opossum (*Didelphis virginiana virginiana* Kerr 1792) in an Urban Environment" (1976). *Dissertations and Theses*. Paper 2547.
<https://doi.org/10.15760/etd.2544>

This Thesis is brought to you for free and open access. It has been accepted for inclusion in Dissertations and Theses by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

AN ABSTRACT OF THE THESIS OF David Hopkins for the Master of Science in Biology presented 24 November 1976.

Title: Some Aspects of the Ecology of the Virginia Opossum (*Didelphis virginiana virginiana* Kerr 1792) in an Urban Environment

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Richard B. Forbes, Chairman

John (H.) Wirtz

Earl Rosenwinkel

Thomas M. Newman

Eighty-three *Didelphis virginiana* from the Portland metropolitan area were collected and studied from December 1974 through May 1976. Males averaged 3394 g, females 2318 g. An annual sex ratio of 68.7:31.3 was recorded. Data indicate the possibility of a year-round breeding season and suggest the occurrence of three peaks of reproductive acti-

vity: January-February, April-May and October-November.

The six primary foods consumed annually are: leaf litter, mammals, gastropods, earthworms, grasses and pet food.

Seasonal composition and diversity in the diet is marked.

Five new parasite-host records were established. These include mites: *Androlaelaps fahrenheitsi*, *Haemogamasus nidi*, *Eulaelaps stabularis*; a tick, *Ixodes angustus*, and a nematode, *Toxocara canis*. Both minimum and maximum temperature, and perhaps precipitation to a lesser degree, affect the activity of the species. Nest building by an immature opossum is described.

SOME ASPECTS OF THE ECOLOGY OF THE VIRGINIA OPOSSUM

(*Didelphis virginiana virginiana* KERR 1792)

IN AN URBAN ENVIRONMENT

by

David Hopkins

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
BIOLOGY

Portland State University
1976

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of
David Hopkins presented 24 November 1976.

Richard B. Forbes, Chairman

John H. Wirtz

Earl Rosenwinkel

Thomas M. Newman

APPROVED:

W. Herman Taylor, Chairman, Department of Biology

Stanley E. Ranch, Dean, Graduate Studies and Research

ACKNOWLEDGEMENTS

A study of this kind cannot be achieved by one individual. I am deeply grateful to my advisor, Dr. Richard B. Forbes, for helpful suggestions, support and encouragement throughout this investigation. My thanks also go to the other committee members: Drs. Thomas M. Newman, Earl Rosenwinkel and John Wirtz. I also wish to thank the following persons for their assistance during the course of this study: Drs. Edward Campos, Q. D. Clarkson, R. B. Eads, R. Harkema, C. S. Herrin, G. W. Krantz, Ralph Macy, Leonard Simpson, Mr. Peter Paquet, Ms. Mary Scriver and all the persons who brought opossums to me.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS.....	iii
LIST OF TABLES.....	v
LIST OF FIGURES.....	vi
INTRODUCTION.....	1
MATERIALS AND METHODS.....	4
RESULTS AND DISCUSSION.....	8
Weights and Measurements.....	8
Sex Ratio.....	11
Reproductive Biology.....	14
Food Habits.....	18
Parasites.....	44
Distribution and Activity Patterns.....	48
Tail Use in Nest-Building by Immature Virginia Opossums.....	55
SUMMARY.....	58
BIBLIOGRAPHY.....	60

LIST OF TABLES

TABLE		PAGE
I	Average Seasonal and Annual Weights (in grams) and Head and Body Lengths (in mm) of 70 Virginia Opossums Weighing More than 1360 g from Portland, Oregon....	9
II	Seasonal and Annual Sex Ratios of 83 Free-Ranging Virginia Opossums from Portland, Oregon.....	12
III	Seasonal and Annual Percent Volume, Percent Frequency and Importance Values for Food Items Recovered from 64 Virginia Opossums from Portland, Oregon.....	20
IV	The Six Most Important Foods Seasonally and Annually (Based on 64 Virginia Opossums from Portland, Oregon).....	24
V	Seasonal Food Diversity Values and Numbers of Equally Important Foods as Determined from 64 Virginia Opossums from Portland, Oregon.....	42
VI	Results of Multiple Regression Analysis of the Activity Patterns of 1,625 Virginia Opossums from Portland, Oregon during 1973 and 1974.....	54

LIST OF FIGURES

FIGURE		PAGE
1	Ranges and Median Points of Conception of 20 Post-Pouch Virginia Opossums (weighing less than 1900 g and measuring less than 680 mm) and Five Litters from Portland, Oregon.....	13
2	Annual Percent Volume of Stomach Contents from 64 Portland, Oregon Virginia Opossums.....	23
3	Seasonal Volumetric Percent of Gastropods Consumed by 64 Virginia Opossums in Portland, Oregon.....	27
4	Seasonal Volumetric Percent of Earthworms Consumed by 64 Virginia Opossums in Portland, Oregon.....	28
5	Seasonal Volumetric Percent of Mammals Consumed by 64 Virginia Opossums in Portland, Oregon.....	34
6	Seasonal Volumetric Percent of Fruits Consumed by 64 Virginia Opossums in Portland, Oregon.....	38
7	Seasonal Volumetric Percent of Gramineae Con- sumed by 64 Virginia Opossums in Portland, Oregon.....	40
8	Seasonal Percentage of Empty Stomachs in 77 Virginia Opossums from Portland, Oregon...	43

FIGURE

PAGE

9	Monthly Percent of Siphonapterous Infestation of 77 Virginia Opossums in Portland, Oregon.....	46
10	Distribution of the Virginia Opossum in Portland, Oregon (Based upon 768 1974 traffic kill locations).....	49
11	Monthly Number of Reported Virginia Opossum Traffic Deaths for 1973 and 1974 in Portland, Oregon.....	52
12	Monthly Mean of Reported Virginia Opossum Traffic Deaths for 1973 and 1974 in Portland, Oregon.....	53

INTRODUCTION

The ecology of urban wildlife is an important but, until recently, a generally neglected aspect of vertebrate ecology. Despite the importance of the urban fauna to society, few investigations have been conducted except on species that serve as zoonoses reservoirs. Because the city is a distinct ecosystem, a full understanding of the ecology of a given species is not complete until this, as well as the ecology of the animal in its more "natural" habitat, is known. Towards this end I have attempted to shed some light on a prominent urban species--the "possum."

The Virginia opossum (*Didelphis virginiana virginiana* Kerr 1792) is a relatively recent arrival in Oregon. Several introductions occurred in the early twentieth century in various areas of the state. Between 1910 and 1921 at least four animals brought into Umatilla County as pets eventually escaped or were released (Jewett, 1929). Three of these animals are known to have escaped at about the same time and were thought by Jewett to be the basis of the then-current population. Jewett (1929) reported that during the 1927-28 trapping season at least 12 opossums were caught in the lower McKay Creek region near the area where the original animals escaped; he considered the opossum well established in the McKay and Johnson Creek areas of Umatilla County at that time. This population is thought to have died out later (Mace, 1970). In 1930,

opossums were brought to Oregon for food and as pets by southerners working in the Civilian Conservation Corps (CCC). Known releases occurred near Warrenton (Clatsop County) and Troutdale (Clackamas County). Animals kept as pets were released in 1939 when the CCC program was terminated. A wild opossum was first recorded in the Astoria region in 1942 (Anon. 1946). Six years later an opossum was found one mile east of Salem (Anon. 1948). Opossums continued to expand their range for the next six years, and on 24 March 1954 the Virginia opossum was first reported in northeast Portland where one was captured and taken to the Washington Park Zoo. In the ensuing 22 years, the opossum has become well-adapted to western Oregon.

The earliest significant studies of opossum biology were made by Hartman (1923, 1928) in Texas on the animal's reproduction. These data, along with information on the general biology and folklore of the opossum were published by Hartman in 1952. Reynolds (1952) also investigated the reproductive biology of the species, but in California. Other important contributions include those by Fitch and his colleagues (1953, 1970) concerning the ecology and spatial relationships of opossums in Kansas. McManus has published studies on temperature regulation (1969) and behavior (1970). Hamilton (1958) and Reynolds (1945) have studied the life history and ecology of opossums in New York and Missouri respectively.

All previous studies on the ecology of opossums have been carried out in rural areas east of the Rockies; no studies have been conducted where the animal has been introduced in the western United States, nor in urban areas. It is the purpose of this study to examine some of the ecological parameters of the opossum in and near Portland, Multnomah County, Oregon. Those aspects of the opossum's ecology that are discussed include: physical measurements, sex ratio, reproductive biology, food habits, parasitology and distribution and activity patterns. A note on nest building is included.

MATERIALS AND METHODS

Seventy-seven dead opossums (excluding pouch young) were collected from December 1974 through May 1976, primarily from within the city limits of Portland, Multnomah County, Oregon. Eight opossums were from outside the city limits but within nearby urbanized areas. Later references to Portland opossums include all these animals. Except for two killed by dogs and one shot, all the animals were road kills. Six live animals were also examined with only sex and breeding conditions noted.

Portland is a city of 378,000 located near the confluence of the Columbia and Willamette Rivers. The city's elevation ranges from about 10 meters above sea level to 384 M in the Tualatin Mountains; mean elevation is 53.4 M. The city is geomorphologically diverse, being located primarily on level alluvial deposits but also on hilly terrain. Parks and undeveloped areas are scattered throughout parts of the city. The mean annual weather parameters are: temperature, 12.5°C; maximum temperature, 16.8°C; minimum temperature, 8.2°C; precipitation, 101.37 cm; snowfall, 23.37 cm; percent of possible sunshine 44%. The city is located in the moist transition zone (Bailey, 1936).

The dead animals were weighed to the nearest 50 g and measurements (mm) were taken of the total length, tail length, hind-foot length, ear length, upper-canine length, and distance between upper canines. Collector's name,

date, location and condition of the opossum were also recorded. The opossums were thoroughly combed and all ectoparasites removed and preserved in 70% ethanol. If large numbers of fleas were present, the opossum was washed in 70% ethanol to facilitate their capture. Once ectoparasites were collected, the stomach was removed, the contents emptied and both stomach and contents placed in 0.9% saline solution to be examined for endoparasites. The stomach lining was scraped to remove any attached endoparasites. The carcass was then discarded. Other viscera were also examined in the first nine specimens but because of the paucity of parasites recovered and time constraints this was discontinued. After examining the stomach and its contents for endoparasites, the contents were placed in a number 20 U.S.A. standard testing sieve fitted over a number 60 screen. When the stomach contents were thoroughly washed under running water, the two-screen assembly effectively separated coarse and fine materials. After washing, the two portions were stored in 70% ethanol for later examination. However, if green plant material or unusual matter were present, at least partial separation was made immediately. Separation was accomplished by taking a portion from each aliquot and placing it in a petri dish. Each sample was scanned with a variable magnification dissecting scope (10-45x) to check for small items which might not have washed through to the lower screen. Each stomach item

was removed from the mass and placed in a petri dish for later measurement and storage. Upon completion of separation of the larger items, the smaller items from the second aliquot were carefully examined in a petri dish, also under the dissecting scope. The volume of each item was measured and recorded. Items measuring less than 0.1 cc were recorded as trace, as were items amounting to less than 0.1% of the seasonal or annual volumes.

The distribution pattern of the Virginia opossum within Portland was examined by collecting the date and location of every road-killed opossum in the city for the year 1974 from the Multnomah County Animal Control. The location and season of kill of 768 opossums was plotted on a map (scale: one inch = 2,000 feet) of the city. Over this an arbitrary quadrant system was established on an overlay. Each kill point was measured to the nearest 0.25 inch (500 feet) and the co-ordinate and season recorded. Cluster analysis (K-MEANS) was performed using a CYBER computer to examine the distribution of the population within the city.

In order to examine activity patterns of the animals, data were collected from 1973 as well as 1974. In addition to the date of kill for both years, photoperiod, maximum temperature, minimum temperature, precipitation and amount of traffic were recorded. These data were also used to investigate the effects of the change in amounts of pre-

precipitation and the change in temperature from the day of kill as compared to the previous day. Weather data were collected from the U. S. Weather Bureau and traffic data from the Portland city engineer's office. Using an IBM 1130 computer, multiple regression analysis (MREGR) was applied to examine the significance of all the previously mentioned elements as well as the effects of time of year or of unknown and nonquantifiable parameters. The kill data was first transformed according to the following formula

$$y = \sqrt{\text{Kill} + 1}.$$

RESULTS AND DISCUSSION

Weights and Measurements

Relatively little specific information has been published on the weights and measurements of Virginia opossums. Hamilton (1958) recorded monthly measurements of 83 males and 60 females whose weights were greater than 1360 g, the weight at which he considered most opossums to be sexually mature. For the sake of comparison, I have followed his method. In Hamilton's study, New York opossums showed a decrease in weight in late winter and early spring, followed by a fluctuation in weight between 2100 and 3800 g for males and 1500 and 2500 g for females until October. Weights then rose to a maximum of 3626 g in February for males and 2811 g in November for females. Portland male opossums show (Table I) a continual decrease from a winter high of 3546 g to a summer low of 2925 g, while the weights of females fluctuate without showing a distinct pattern, perhaps because of the small sample size (Table I).

Hamilton recorded an average annual weight of 2718 g for males and 1886 g for females. By comparison, Portland Virginia opossums are markedly heavier. Fifty-two males averaged 3394 g; the mean weight of 18 females was 2378 g. The five heaviest males reported by Hamilton weighed 5091, 5037, 4678, 4105 and 3844 g. The five heaviest females weighed 3228, 2834, 2777, 2551 and 2523 g. The weights of the heaviest male Portland opossums were 5300,

TABLE I

AVERAGE SEASONAL AND ANNUAL WEIGHTS (IN GRAMS) AND HEAD AND BODY LENGTHS (IN mm)
OF 70 VIRGINIA OPOSSUMS WEIGHING MORE THAN 1360 g FROM PORTLAND, OREGON

Season	MALES			FEMALES		
	Number	Weight	HBL	Number	Weight	HBL
Winter	23	3546	478	7	2274	431
Spring	13	3373	457	3	2500	481
Summer	6	2925	418	5	2305	448
Fall	10	3382	451	3	2617	450
Annual	52	3394	460	18	2318	447

5250, 5100, 5000 and 4950 g. The five heaviest females weighed 3350, 3350, 3300, 2900 and 2850 g. Fitch and Sandidge (1953) recorded a maximum weight of 5000 g for Kansas opossums. A spring male which I had held in captivity for five weeks weighed 6400 grams, far more than any other opossum. Its other standard measurements were also large - total length, 915 mm; tail length, 368 mm; hind foot, 88 mm; ear, 41 mm. Because the animal was held captive before the measurements were taken they were not included in the above calculations.

It is noteworthy that, while the weights of Portland opossums are greater than those of New York animals, the head and body lengths are about the same. If Bergmann's Rule is valid for Virginia opossums, it would be expected that Portland animals would be somewhat smaller than their New York counterparts, for in general average temperatures in New York state are lower than those in Portland. No specific data have been published concerning the validity of Bergmann's Rule in this species, although it is known that opossums in Florida (Anon. 1955) are smaller than their counterparts in more northerly climes. Gardner's (1973) subspecific descriptions also indicate a smaller size for the species in the southern extent of its range. Perhaps in the urban environment, conditions - particularly food and shelter availability - are generally more favorable than under rural conditions.

Sex Ratio

Past studies have in general yielded insignificantly greater numbers of males than females (Hamilton, 1958; Holmes and Sanderson, 1965; Petrides, 1949). The 83 opossums examined in this study include an unusually high number of males (Table II). Three-quarters or more of the animals collected during fall, winter, and spring were males; only during the summer did females predominate, comprising 62.5% of the specimens. In contrast to this, the sex ratio of 41 pouch-young collected during this study indicates a predominance of females (43.9:56.1), at least before the young part from their mother.

The reasons for the disparity between these two ratios is unknown. Whether the collection methods are biased or whether the ratio truly reflects the population is not certain. A possible explanation is the greater activity recorded for males. Holmes and Sanderson (1965) found that the means of the average distances from the centers of activity were smaller for females (114.4 m) than for males (167.8 m). If this is true in Portland, then one might expect the wider-ranging males to encounter automobiles more frequently than females and hence be killed at a greater rate.

Another explanation might be related to the breeding season. The summer season is the only time in which a peak in breeding activity does not occur (Figure 1). Perhaps

TABLE II
SEASONAL AND ANNUAL SEX RATIOS OF 83 FREE-RANGING
VIRGINIA OPOSSUMS FROM PORTLAND, OREGON

Season	Number of Males	Number of Females	Sex Ratio
Winter	23	7	79.7:20.3
Spring	18	6	75.0:25.0
Summer	6	10	37.5:62.5
Fall	10	3	76.9:23.1
Annual	57	26	68.7:31.3

Figure 1. Ranges and median points of conception of 20 post-pouch Virginia opossums (weighing less than 1900 g and measuring less than 680 mm) and five litters from Portland, Oregon.

during this period most females, unburdened by a pouch full of young, range more widely over an area than when they carry their litters. However, this is speculative; only when the ecology of the urban Virginia opossum is examined with the aid of radio-telemetry can this be answered.

Reproductive Biology

In general, studies of the Virginia opossum have indicated that the onset of breeding and its subsequent peaks occur later in the year with increasing latitude. In Texas, at 31°-32° N latitude (Hartman, 1928; Lay, 1942), and Florida, at 30° N latitude (Burns and Burns, 1957), the breeding season commences in early January with peak activity extending into February. In Texas, a second peak was recorded in May and June. Further north, Reynolds (1952) recorded the first estrus of the season on 9 January in California (37° N) with peak activity in later January through March. Llewellyn and Dale (1964) found that mating occurred in Maryland (38.5° N) in early February and continued in March with a second peak in June and July. Similarly, Kansas (39° N) opossums breed in mid-February and March with a second peak in June (Fitch and Sandidge, 1953). In nearby Missouri (39° N), the breeding season begins around the first of February (Reynolds, 1945), with a peak later in the month and a second peak in late May and early June. In Ohio (40° N) Grote and Dalby (1973) recorded an

unusually early litter which indicated that copulation occurred on the third or fourth of January. However, this is the only information they recorded concerning the local breeding season. Early- to mid-February is the beginning of the breeding season in Iowa (41° N), with peak activity taking place in that month and March as well as in June (Wiseman and Hendrickson, 1950). Finally, in New York, the most northerly investigation prior to the current one, mating activity begins in late January and extends into March, with a second peak in June and July (Hamilton, 1958). Allied with an increasingly late onset of the breeding season in the northern reaches of the animal's range is the occurrence of increasingly large litters. At latitudes between 30° N and 37° N, an average of between 6.2 (Hartman, 1928) and 7.2 (Reynolds, 1952) opossums per litter are produced. Above 38° N latitude the reproductive potential increases so that on the average 7.4 (Fitch and Sandidge, 1953) to 9.0 (Wiseman and Hendrickson, 1950) young are recorded per litter.

The onset of the breeding season of the Virginia opossum in Portland (45.3° N latitude) is remarkably early in the year, comparable to the season's onset in Texas (Hartman, 1928; Lay, 1942) and Florida (Burns and Burns, 1957). The litter with the earliest date of conception was collected on 10 February 1975. The five young had an average snout-rump length (SRL) of 50 mm, indicating an age of 29-35 days

(Reynolds, 1952). The age plus a 13-day gestation period indicates that conception occurred between 26 December and 1 January, with 28 December as a median date. Two other litters of the five collected during this investigation also point to early breeding activity in Portland. A litter of six young was examined on 9 April 1975. The average SRL was 147 mm; the corresponding age is 76-85 days, which would denote a conception range of 2-11 January (median 6 January). The third early litter contained nine individuals collected on 28 March 1976. With a mean SRL of 84 mm (53-60 days), conception probably occurred between 14 and 21 January. The two other litters collected were conceived in February and May.

Vesey-Fitzgerald (1965) suggests that suburban foxes (*Vulpes vulpes*) in England begin breeding activity up to three months earlier than foxes inhabiting rural areas. Perhaps urban opossums respond similarly to their new habitat.

To gain a more complete picture of the breeding season, the estimated dates of conception were calculated for 20 post-pouch opossums weighing less than 1900 g and measuring less than 680 mm total length. Petrides' (1949) growth curves were used to estimate the earliest and latest dates on which matings producing the measured opossums would have occurred. These estimates were derived by using the weight and total length of the animal to establish

minimum and maximum dates. From these dates, a median date was calculated. Both the range and median point are diagrammed in Figure 1.

These data suggest three peaks of breeding activity: one in January and February, another from mid-April through early May and a third from October through mid-November. It is the third peak that is so unexpected. No previous study has reported a peak so late in the year. Whether this represents a third litter is uncertain. Hartman (1928) suggested the presence of a third litter in Central Texas. However, no other investigator has found evidence for this. Although winters in Portland have been relatively mild for the last two years, it is difficult to believe that the survival rate of these litters is very high because the young would leave the relative safety of their mother and her pouch during the middle of winter. However, deleting the pouch young from consideration, the number of opossums conceived in the October-November peak is comparable to the number in the earlier January-February peak. Further research in this area is needed.

The number of young present in the five litters were 5, 6, 9, 10, 11. This is an average of 8.2 young per litter, slightly lower than one might expect at this latitude, but the figure is open to question owing to the small sample size. However, if it is reasonably accurate and if there are indeed three litters per year, then this reflects a

reproductive potential greater than any previously recorded for this species, perhaps the result of a generally less stressful urban environment.

The length of the breeding season is geographically variable. The breeding season is the period from the earliest conception to the latest weaning period. In eastern Texas, Lay (1942) reported that it extended from January to August when females were no longer found with young. Hartman (1928) believed that in central Texas it covered the nine months from the first week of January until the end of September. Reynolds (1952) indicated that the season ends around the first of September in Missouri and not until mid-October in California, where it begins in early to mid-January. The breeding season extends from early February to August in Maryland (Llewellyn and Dale, 1964) and from late January to early November in New York (Hamilton, 1958). The data from the present study indicates the presence of a virtually year-round breeding season in the Portland metropolitan area.

Food Habits

Studies of food habits of the Virginia opossum reveal that a wide variety of edible, and sometimes inedible, materials is consumed (Bewick, 1800; Audubon and Bachman, 1852; Linneum, 1872; Dearborn, 1932; Lay, 1942; Reynolds, 1945; Taube, 1947; Grimm and Roberts, 1950; Gifford and

Whitebread, 1951; Llewellyn and Uhler, 1952; Sandidge, 1953; Hamilton, 1958; Stieglitz and Klimstra, 1962). Both geographic and temporal variations in the diet are marked.

Many studies have been carried out over short periods and the data lumped in such ways as to make comparisons between studies difficult. While I will compare the results of other studies with mine, one must remember that the findings are not necessarily for corresponding periods.

The results of my analysis of 64 opossum stomachs (13 of the 77 stomachs were empty) is presented in Table III and Figure 2. Seasonal and annual percentages are given for both volume and frequency. Because either figure alone can be misleading, a third series, the importance value (I.V.), is also included. This figure was derived simply by multiplying the percent frequency times the percent volume. In this way a single figure may be used to examine the relative importance of items to each other. The number of full, or partially full, stomachs examined during the course of this study for each season were: winter, 23; spring, 16; summer, 13; fall, 12.

The seasonal variation of the diet is pronounced (Table IV). Mammals are of major importance during the winter and spring. Leaf litter ranks first or second year-round. Slugs and snails are consumed in relatively small amounts in the winter but are the most important food during the summer before declining again with the advent of fall.

TABLE III

SEASONAL AND ANNUAL PERCENT VOLUME, PERCENT FREQUENCY AND IMPORTANCE VALUES FOR
FOOD ITEMS RECOVERED FROM 64 VIRGINIA OPOSSUMS FROM PORTLAND, OREGON

	WINTER			SPRING			SUMMER			FALL			ANNUAL		
	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.
ANIMAL FOODS	68.6	95.8	6571.8	41.4	100.0	4140.0	55.9	100.0	5590.0	39.4	91.7	3613.0	52.9	96.9	5116.3
Unidentified animal matter				1.7	12.5	21.3							0.6	3.1	1.9
Invertebrate eggs*	T	13.0		T	50.0		T	61.5		T	41.7		T	37.5	
Mollusca	6.6	60.9	401.9	8.6	62.5	537.5	24.9	61.5	1531.4	11.3	58.3	658.8	10.4	60.9	639.5
Gastropoda															
<i>Limax</i> sp.	0.6	4.4	2.6										0.2	1.6	0.3
<i>L. maximus</i> *				0.5	6.3	3.2							0.2	1.6	0.3
<i>L. marginatus</i> *	0.4	8.7	3.5	0.1	6.3	0.6	8.1	7.7	62.4				1.3	6.4	8.3
<i>Deroosras reticulatum</i> *	0.8	4.4	3.5	0.9	6.3	5.7	1.5	15.4	23.1				0.8	6.4	5.1
<i>Arion ater</i> *				2.5	18.8	47.0	14.4	21.1	303.8	1.5	8.3	12.5	3.0	11.1	33.3
<i>A. hortensis</i> *	1.0	8.7	8.7	0.1	12.5	1.3	0.1	7.7	0.8	4.5	16.7	75.2	1.1	11.1	12.2
<i>Prophysaon andersoni</i> *	2.8	4.4	12.3	3.7	12.5	46.3				3.5	8.3	29.1	2.8	6.4	17.9
Snails	0.1	4.4	0.4	0.2	12.5	2.5	T	7.7		T	8.3		0.1	9.5	0.9
Unidentified	1.0	26.1	26.1	0.5	6.3	3.2	0.8	15.4	12.3	1.8	16.7	30.1	0.9	15.9	14.3
Annelida															
Oligochaeta															
<i>Lumbricus terrestris</i>	9.8	65.2	639.0	6.4	62.5	400.0	12.9	23.1	298.0	8.8	50.0	440.0	8.9	53.1	472.6
Tardigrada*															
Heterotardigrada*	T	4.4		T	18.8					T	8.3		T	6.4	
Arthropoda	5.1	87.5	446.3	0.8	100.0	80.0	3.5	92.3	323.1	1.2	91.7	110.0	2.8	92.2	258.2
Arachnida	T	21.7		T	41.7		T	23.1		T	16.7		T	25.0	
Acari*	T	21.7		T	18.8		T	23.1		T	16.7		T	20.3	
Araneida				T	12.5					T	8.3		T	4.7	
Crustacea	T	8.7		T	6.3		T	7.7					T	6.4	
Diplostraca*	T	4.4											T	1.6	
Isopoda	T	4.4		T	6.3		T	7.7					T	4.7	
Diplopoda	T	4.4											T	4.7	
Insecta	5.1	87.5	446.3	0.8	93.3	74.6	3.5	92.3	323.1	0.1	16.7	1.7	T	4.7	
Unidentified insect parts	T	26.1		T	18.8		T	23.1		1.1	91.7	100.9	2.8	90.6	253.7
Unidentified insect larvae	T	8.7		T	12.5		T	23.1		T	16.7		T	21.9	
Collembola*	T	20.8		T	12.5		T	15.4		T	25.0		T	17.2	
Sminthuridae*	T	17.4		T	6.3					T	16.7		T	17.2	
Poduridae*										T	8.3		T	9.4	
Entomobryidae*	T	4.4					T	7.7		T	8.3		T	3.1	
Isotomidae*				T	6.3		T	7.7		T	8.3		T	3.1	
Orthoptera													T	3.1	
Acrididae															
Dermaptera*							T	7.7					T	1.6	
Forficulidae*										0.1	8.3	0.8	T	1.6	
Hemiptera	T	4.4								T	8.3		T	3.1	
Unidentified										T	8.3		T	1.6	
Tingidae*	T	4.4											T	1.6	
Homoptera*													T	1.6	
Aphididae*							T	7.7		T	25.0		T	6.4	
Coleoptera	3.7	33.3	123.2	0.8	53.3	34.1	2.8	53.8	150.6	1.0	66.7	66.7	2.2	48.4	106.5
Unidentified larvae	T	8.7											T	3.1	
Unidentified imagines	T	17.4		T	31.3		0.6	23.1	13.9	T	8.3		0.1	20.3	2.0

* indicates item not previously reported from the Virginia opossum's diet.

	WINTER			SPRING			SUMMER			FALL			ANNUAL		
	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.
Carabidae	3.7	26.1	96.6	0.8	18.8	15.0	2.2	30.8	67.8	1.0	58.3	58.3	2.1	31.3	65.7
Larvae	1.7	21.7	36.9	0.1	6.3	0.6							0.7	9.4	14.2
Imagines	2.0	26.1	52.2	0.7	18.8	13.2	2.2	30.8	67.8	1.0	58.3	58.3	1.4	31.3	28.4
Staphylinidae				T	6.3					T	8.3		T	3.1	
Erotylidae*	T	8.7											T	3.1	
Lepidoptera															
Cocoon	1.1	4.4	4.8										0.4	1.6	0.6
Diptera	0.3	21.7	6.5	T	26.7		T	23.1		T	25.0		0.1	23.4	2.3
Unidentified larvae	0.3	21.7	6.5	T	18.8		T	23.1		T	25.0		0.1	21.9	2.2
Unidentified imagines							T	7.7					T	1.6	
Tipulidae				T	6.3								T	1.6	
Siphonaptera*	T	21.7		T	25.0		T	38.5		T	50.0		T	31.3	
Pulicidae*	T	12.5		T	6.6		T	30.8		T	25.0		T	17.2	
Dolichopsyllidae*	T	12.5		T	20.0		T	23.1		T	25.0		T	18.8	
Hymenoptera	T	26.1		T	6.3		0.7	38.5	27.0	T	8.3		0.1	17.2	1.2
Unidentified							0.2	7.7	1.5				T	1.6	
Formicidae	T	26.1		T	6.3		0.1	23.1	2.1	T	8.3		T	17.2	
Vespidae							0.4	7.7	3.1				0.1	1.6	0.2
Chordata	47.3	45.8	2166.3	23.9	73.3	1751.9	14.6	36.4	531.4	18.1	50.0	905.0	30.2	45.3	1327.3
Unidentified cartilage							1.2	7.7	9.2				0.2	1.6	0.3
Unidentified bone							0.2	7.7	1.5				T	1.6	
Unidentified meat										0.5	8.3	4.2	0.1	1.6	0.2
Osteichthyes															
Ctenoid scales							T	7.7					T	1.6	
Reptilia															
Squamata															
Thamnophis sp.	0.6	4.4	2.6										0.2	1.6	0.3
Aves	1.4	25.9	36.3	5.2	37.7	196.0	0.1	23.1	2.3	1.4	25.0	35.0	2.5	28.2	70.2
Unidentified feathers	T	13.0		0.6	18.8	11.3	0.1	23.1	2.3	0.1	16.7	1.7	0.2	17.2	3.4
Passeriformes															
Thryomanes bewickii*	0.8	4.4	3.5										0.3	1.6	0.5
Turdus migratorius	0.6	4.4	2.6	0.4	6.3	2.5				1.3	8.3	10.8	0.6	4.7	2.8
Unidentified Fringillidae				0.1	6.3	0.6							T	1.6	
Pipilo erythrophthalmus	T	4.4		4.1	6.3	25.8							1.4	3.1	4.4
Mammalia	45.3	43.3	1961.5	18.7	50.1	936.9	13.1	7.7	100.9	16.2	25.0	405.0	27.4	34.6	948.0
Marsupialia															
Didelphis virginiana	19.2	30.4	583.7	16.0	31.3	500.8				15.7	16.7	262.2	14.9	21.9	326.3
Insectivora															
Neurotrichus gibbsii*				2.5	12.5	31.3							0.9	3.1	2.8
Rodentia	15.3	8.7	133.1	0.2	6.3	1.3	13.1	7.7	100.9				7.5	6.4	48.0
Glaucomys sabrinus*	1.1	4.4	4.8										0.4	1.6	0.6
Unidentified Cricetidae				0.2	6.3	1.3							0.1	1.6	0.2
Mus musculus							13.1	7.7	100.9				1.8	1.6	2.9
Rattus norvegicus	14.2	4.4	61.1										5.2	1.6	8.3
Carnivora	10.8	4.4	46.4							0.5	8.3	4.2	4.1	3.1	12.7
Spilogale gracilis*										0.5	8.3	4.2	0.1	1.6	0.2
Felis oatus	10.8	4.4	46.4										4.0	1.6	6.4

	WINTER			SPRING			SUMMER			FALL			ANNUAL		
	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.	% Vol.	% Freq.	I.V.
PLANT FOODS	19.6	100.0	1960.0	23.0	100.0	2300.0	38.4	100.0	3840.0	54.2	100.0	5420.0	29.1	100.0	2910.0
Gramineae	3.6	82.6	297.4	4.4	87.5	385.0	5.5	92.3	507.7	11.2	83.3	933.0	5.3	85.9	455.3
<i>Zea mays</i>				0.3	6.3	1.9							0.1	1.6	0.2
<i>Oryza sativa</i> *										0.1	8.3	0.8	T	1.6	
<i>Allium cepa</i> *	0.1	4.4	0.4	0.2	6.3	1.3							0.1	3.1	0.3
<i>Malus</i> sp.				0.2	6.3	1.3	0.5	7.7	3.9	2.0	25.0	50.0	0.4	7.7	1.9
<i>Prunus</i> sp.							18.5	7.7	142.5				2.5	1.6	4.0
<i>Pyrus communis</i>	1.2	4.4	5.3	1.5	6.3	9.5							0.9	3.1	2.8
<i>Pisum sativum</i> *	1.8	4.4	7.9										0.7	1.6	1.1
<i>Juglans</i> sp.*	1.1	4.4	4.8							0.5	8.3	4.2	0.5	3.1	1.5
<i>Vitis</i> sp.	T	4.4								22.3	50.0	1115.0	3.5	10.9	38.2
<i>Daucus carota</i> *				1.0	6.3	6.3				1.9	8.3	15.8	0.6	3.1	1.9
<i>Phoenix dactylifera</i> *							1.1	7.7	8.5				0.2	1.6	0.3
<i>Helianthus annuus</i> *										0.1	8.3	0.8	T	1.6	
Green leaves	1.1	39.1	43.0	5.6	25.0	140.0	0.6	23.1	13.9	2.0	25.0	50.0	2.8	29.9	83.7
Unidentified fruits	0.1	4.4	0.4				2.0	30.8	61.6	1.0	16.7	16.7	0.5	10.9	4.4
Unidentified seeds	T	47.8		0.2	25.0	5.0	T	46.1		0.1	41.7	4.1	0.1	40.6	3.9
Leaf litter	10.6	100.0	1060.0	9.6	100.0	960.0	10.2	92.3	941.5	14.9	100.0	1490.0	10.9	98.4	1072.6
MISCELLANEOUS FOODS	11.8	79.2	934.6	35.6	87.5	3104.3	5.6	76.9	430.6	4.6	75.0	345.0	18.0	81.3	1471.5
Pet food*	9.5	17.4	165.3	16.0	12.5	200.0	3.1	15.4	47.7				9.4	12.5	117.5
Bacon grease*				15.8	6.3	99.5							5.4	1.6	8.6
Fur balls*				2.1	12.5	26.3							0.7	3.1	2.2
Soda crackers*										3.9	8.3	32.4	0.6	1.6	1.0
Paper	0.9	17.4	15.7	0.5	18.8	9.4				0.3	8.3	2.5	0.5	12.5	6.3
Macaroni*	1.1	4.4	4.8										0.4	1.6	0.6
Sand	0.3	82.6	24.8	T	73.3		1.5	61.5	92.3	0.4	66.7	26.7	0.4	71.9	28.8
Scrambled egg				0.5	6.3	3.2	0.7	7.7	5.4				0.3	3.1	0.9
Plastic wrap				0.7	12.5	8.8							0.3	3.1	0.5
Unidentified							0.3	7.7	2.3				T	1.6	2.2
Tin foil*	T	4.4		T	6.3		T	7.7					T	4.7	
Wood chips*	T	4.4											T	1.6	
Plastic fragment*	T	4.4											T	1.6	
String*	T	4.4											T	1.6	
Plastic filament*	T	4.4											T	1.6	
Mica chip	T	4.4											T	1.6	
Glass*							T	7.7		T	8.3		T	1.6	
Paint chip*										T	8.3		T	1.6	
Rubber*													T	1.6

Figure 2. Annual percent volume of the stomach contents from 64 Portland, Oregon Virginia opossums.

TABLE IV

THE SIX MOST IMPORTANT FOODS SEASONALLY AND ANNUALLY
(BASED ON 64 VIRGINIA OPOSSUMS FROM PORTLAND, OREGON)

WINTER		SPRING		SUMMER		FALL	
Item	I.V.	Item	I.V.	Item	I.V.	Item	I.V.
Mammals	1961.5	Leaf Litter	960.0	Gastropods	1531.4	Fruits	1942.5
Leaf Litter	1060.0	Mammals	936.9	Leaf Litter	941.5	Leaf Litter	1490.0
Earthworms	639.0	Gastropods	537.5	Frutis	850.9	Grasses	933.0
Gastropods	401.9	Earthworms	400.0	Grasses	507.7	Gastropods	658.8
Grasses	297.4	Grasses	385.0	Earthworms	298.0	Earthworms	440.0
Pet Food	165.3	Pet Food	200.0	Beetles	150.6	Mammals	405.0

ANNUAL

Item	I.V.
Leaf Litter	1072.6
Mammals	948.0
Gastropods	639.5
Earthworms	472.6
Grasses	455.3
Pet Food	117.5

Earthworms are always an important food but do not show well-defined seasonal trends. Several foods are important only during one or two seasons. These include pet food during winter and spring, beetles during the summer, and fruits during the summer and fall. Arthropods are not listed in the table since their high rating is an artifact resulting from a large number of trace items. Hamilton (1958) found that the six foods with the greatest volume accounted for 72.3% of the total volume. This is in close agreement with the present study in which 72.5% of the total volume is composed of six foods.

Animal matter predominates in the opossum's diet annually (52.9% by volume), and during all seasons except fall. By comparison, the diet of opossums in rural habitats in Missouri (Reynolds, 1945), Kansas (Sandidge, 1953), and Illinois (Stieglitz and Klimstra, 1962) consisted of 85.9%, 90.1% and 76.2% animal foods respectively.

The urban opossum shows a predilection towards gastropods. While gastropods are taken in quantity in Portland, their consumption by opossums in rural areas has not been found to exceed 3.9% volumetrically (Reynolds, 1945). Steiglitz and Klimstra (1962) recorded the greatest frequency at 31.3%. In most previous investigations, snails were more frequently consumed than slugs. However, I found slugs to be much more important to Portland opossums. Six species of slugs are consumed by opossums in Portland, with

all but *Prophysaon andersoni* being introduced species. Surprisingly, the locally abundant *Ariolimax columbianus* are not eaten; perhaps they have a disagreeable taste. The most important species in the diet is *Arion ater*.

The volume of slugs and snails eaten increases from a low in the winter of 6.6% to a high in summer of 24.9%, during which time it is the most important food group in the opossum's diet (Figure 3). Apparently only one species, *Arion hortensis*, is consumed year-round. The ingestion of slugs and snails and daily precipitation are correlated. Of 23 days without rainfall, gastropods were eaten only 10 times or 43.5%, while on the remaining 41 rainy days, 26 opossums or 63.4% had eaten slugs and/or snails.

Earthworms occurred in over half of the stomachs examined. This is a frequency about twice as great as any reported previously except by Dexter (1951), who found that in January seven of 13 opossums taken in Ohio had eaten earthworms. By comparison 65.2% of the winter animals in this study had consumed earthworms. The volumetric percentage is close to that of Taube (1947) and Hamilton (1958), but far greater than the 1.3% found by Steiglitz and Klimstra (1962). Reynolds (1945) and Sandidge (1953) did not record the presence of earthworms. The percent volume fluctuates between a low of 6.4% in the spring and a high of 12.9% in the summer (Figure 4). No correlation between precipitation and earthworm consumption can be shown.

Figure 3. Seasonal volumetric percent of gastropods consumed by 64 Virginia opossums in Portland, Oregon.

Figure 4. Seasonal volumetric percent of earthworms consumed by 64 Virginia opossums in Portland, Oregon.

Arthropods, other than insects, are of little importance in the diet of opossums. All of the items rate no more than trace annually, and only millipedes rate 0.1% seasonally, this during the fall. Missouri (Reynolds, 1945) is the only locale where diplopods were reported as more than a trace item annually; in other investigations millipedes were recorded as a trace item or not at all. Isopods have been recorded at a frequency of 1.5% by Hamilton. This is less than one-third as often as in this study. Other investigations have not yielded this item. Another rare item is daphnia (Diplostraca); these were found in only one opossum and were probably ingested accidentally while the animal was drinking. This item has not been previously noted. Spiders, too, are infrequently encountered, occurring only 4.6% of the time. Only in Texas were they previously reported (Lay, 1942). Water bears, or tardigrades, were infrequently ingested, occurring in only 6.3% of the stomachs. These have not been reported in prior investigations.

Mites have not been reported from the stomach contents of opossums prior to this. Both free-living and parasitic species were recovered. The following free-living genera have been identified: *Platynothrus* sp., (Camisiidae); *Scheloribates* sp., (Parasitidae) and *Ereynetes* sp., (Ereynetidae). *Ereynetes* is a mollusc parasite and probably was ingested along with the gastro-

pod found in the same stomach. Two parasitic species were also taken from the stomach contents: *Haemogamasus nidi* (Laelapidae) and *Androlaelaps fahrenheitzei* (Laelapidae). Since both were recovered externally, it is probable that their presence within the stomach was the result of grooming by the opossums.

Sixteen families of insects have been recorded from the stomachs of opossums during this investigation. Stomachs of Michigan opossums contained 30.4% insects (Dearborn 1932), those of Missouri opossums, 34.2% (Reynolds 1945), and those of Kansas opossums, 42.2% (Sandidge 1953). This is markedly greater than the 2.8% obtained from urban opossums. Stieglitz and Klimstra (1962) and Hamilton (1958) both reported volumes between two and three times greater. However, the frequency of 92.2% correlates closely with that found by Hamilton (1958) and Stieglitz and Klimstra (1962). The lower volume percentage may be the result of lower numbers of insects available in an urban environment. Insects are eaten year-round, but surprisingly the greatest amount taken occurs during winter. This is also true of opossums in central Missouri (Reynolds, 1945). Contrary to this, Hamilton (1958) found that the maximum consumption of insects occurred during the warm summer months.

Although sixteen insect families have been found, one, the Carabidae, accounts for over half of the total insect consumption during all seasons. In Missouri opossums

(Reynolds 1945) ground beetles made up 8.7% of the total volume, while their remains were found only 2.0% of the time in New York opossums (Hamilton 1958). In Portland, carabid remains were recorded in almost a third of the specimens. The dipterous larvae, vespids and cocoons were the only other items to be recorded at 0.1% volume or greater annually. Dipterous larvae are not always associated with carrion in the stomach contents. The larvae often appear to be unrelated to other items within a stomach. Apparently the stings of wasps are not sufficient to deter a hungry opossum; this has been reported once before (Reynolds 1945). Several insects are probably ingested accidentally. These include the smaller species in the following families: Sminthuridae, Poduridae, Entomobryidae, Isotomidae, Tingidae and Aphididae. The Pulicidae and Dolichopsyllidae are almost certainly ingested while the opossum is grooming, and it seems surprising that neither these nor other families of fleas have not been previously reported. Along with the two aforementioned families, the following eight families have not been reported from the diet of the opossum prior to this study: Sminthuridae, Poduridae, Entomobryidae, Isotomidae, Forficulidae, Tingidae, Aphididae and Erotylidae.

Reptiles and amphibians are virtually nonexistent in the diet of urban opossums. One garter snake (*Thamnophis* sp.) was found. Reptiles appear in varying quantities in

previous studies, ranging from no more than a trace (Taube 1947) to 5.6% and 10.0% as reported by Hamilton (1958) and Reynolds (1945) respectively. The low percentage of reptiles and absence of amphibians may be related to the probable lower number of these animals present in an urban environment.

Prior studies have indicated that birds generally do not constitute more than about seven percent by volume of the opossum diet (Hamilton, 1958; Lay, 1942; Reynolds, 1945; Sandidge, 1953). Portland opossums consume fewer birds or their remains than opossums in any other area except Maryland (Llewellyn and Uhler, 1952). In previous studies chickens often predominated in the avian portion of the diet (Reynolds, 1945; Sandidge, 1953; Stieglitz and Klimstra, 1962). However, none were recovered from the stomachs of opossums in this study.

The percent frequency of avian remains recorded from opossum stomachs is higher than that indicated by previous investigators. However, opossums will often glean a single feather or two when the opportunity arises (Hamilton, 1958), and this contributes substantially to the high percent frequency.

Three species of birds were identified during the course of this study; they are: Bewick's wren (*Thryomanes bewickii*), rufous-sided towhee (*Pipilo erythrophthalmus*), and American robin (*Turdus migratorius*). An unidentified

sparrow (Fringillidae) was also recorded, along with a number of unidentified feathers. Opossums are commonly blamed for taking nestlings. However, only one young bird, an American robin, was found to have been eaten, and this may well have been carrion since dipterous larvae were also present within the opossum's stomach. Stieglitz and Klimstra (1962) and others have commented on this situation, feeling reasonably certain that many of the bird remains recovered actually represents carrion feeding.

Mammalian remains were recorded in 34.6% of the stomachs with a volume of 27.4%. This is the lowest volume reported except by Lay (1942), who found 7% mammal remains. However, his figure represents September opossums only, a month when mammals are of less importance in the opossum's diet. In the present study mammals ranged from a low of 13.1% volume in summer to a high of 45.3% during the winter (Figure 5).

The most important mammal in the opossum's diet is the opossum which, at 14.9%, accounts for more than one-half the annual total volume. Only in Illinois opossums ate a greater percentage of their own species (Stieglitz and Klimstra, 1962). It is probable that nearly all of the opossums consumed are carrion, with a large percentage of this due to automobiles. Despite the quantity of opossum in the diet, it is unlikely that this is considered a choice item. The number of road-killed opossums available

Figure 5. Seasonal volumetric percent of mammals consumed by 64 Virginia opossums in Portland, Oregon.

is lowest in the winter when the volume consumed is greatest, but during the late spring and summer when the number of road kills are frequent, ingestion of opossum by opossum is low. The large quantity of opossum eaten during the winter is probably indicative of the scarcity of favored items and the relative abundance of road-killed opossums rather than their desirability. One instance in which this may not have been the case occurred in the spring. A young female which had been carrying pouch young recently (as determined by the condition of the marsupium) was found to have eaten an opossum of pouch-young size. Matricide and cannibalism of the young have been previously reported, but only among captives under conditions of stress (Pray, 1921; Raven, 1929). What caused this particular female to devour what may have been one of her own offspring is not known.

As might be expected, rodents are the next most important group of mammals. These have been reported frequently in the past, although this is the first report of a flying squirrel (*Glaucomys sabrinus*) remains being eaten. The house mouse (*Mus musculus*) and the Norway rat (*Rattus norvegicus*) constituted the bulk of the rodent remains. Both species have been recorded in the past but only in small amounts (Reynolds, 1945; Hamilton, 1958; Stieglitz and Klimstra, 1962).

Carnivores follow in importance. One unlikely item found was the remains of spotted skunk (*Spilogale gracilis*).

However, small amounts of the striped skunk *Mephitis mephitis* have been reported by Taube (1947) and Stieglitz and Klimstra (1962). Domestic cat (*Felis catus*) remains, like the skunk, was recorded only once although the volume was more substantial. The carnivores, as well as the majority of mammals taken, probably represent carrion feeding. McManus (1970) investigated the predatory capabilities of opossums and concluded that the species is not an efficient predator of other mammals.

In previous studies plant foods have been relatively unimportant in the Virginia opossum's diet. Reynolds (1945) reported only 14.1% plant remains, Sandidge (1953), 9.9% and Stieglitz and Klimstra (1962), 23.8%. While the figure from the latter study is within six percentage points of the annual figure of the present study, it should be remembered that it includes mostly animals examined during the fall when plant foods increase in volume. Plant material contributes a greater percentage to the diet of the urban opossums than it does to opossums in a rural environment. However, this may be the result of including leaf litter in the results. This seems justifiable for 70.3% of the stomachs contained more than 10% leaf litter, 31.3% more than 20%, 20.3% more than 30%, 9.4% more than 40%, 6.3% more than 50% and 3.1% more than 75%. Only Stieglitz and Klimstra (1962) recorded leaf litter in their stomach analyses. Plant matter ranges from a low of 19.6%

in the winter to a high of 54.2% in the fall with the increase due mainly to the greater quantity of fruits available at that time of year.

Fruits are encountered at low frequencies and volumes in winter and spring. However, with the advent of summer, they increase greatly and reach a peak in the fall (Figure 6). Grapes (*Vitis* sp.) are the most important of the fall fruits, appearing in half the animals examined and forming 22.3% of the total fall diet. Cherries (*Prunus* sp.) are the most important of the summer fruits and rank second only to grapes annually. Only New York opossums have been reported to consume cherries prior to this study (Hamilton, 1958). Other fruits and vegetables amount to less than 1.0% volume each annually. Several of the plant foods recovered were obtained in whole or in part from garbage. These include such items as onions (*Allium cepa*), peas (*Pisum sativum*), corn (*Zea mays*), carrots (*Daucus carota*), rice (*Oryza sativa*), and dates (*Phoenix dactylifera*).

Grasses are eaten in greater quantity and more often in Portland than by opossums in previous studies. Michigan opossums (Taube, 1947) consumed 5% by volume. This is only slightly less than the 6.3% indicated in this investigation. However, the Michigan opossums were collected in September, November, and December, a period when grass consumption is high--at least in Portland opossums. Reynolds (1945) and Stieglitz and Klimstra (1962) reported amounts

Figure 6. Seasonal volumetric percent of fruits consumed by 64 Virginia opossums in Portland, Oregon.

less than 1%, and Sandidge did not list grass in the stomach analysis of Kansas opossums. The consumption of grass increases throughout the year (Figure 7) from a low of 3.6% in winter to a high of 11.2% in the fall.

Other material recovered from the stomachs included a wide variety of miscellaneous items reflecting the urban environment. The most important of these is pet food, which is consumed in quantity in the winter and spring but less so during the summer. While bacon grease is recorded at 5.4% by volume annually, it appeared only once and hence is relatively unimportant. Along with the bacon grease, several other items including soda crackers, scrambled eggs and macaroni were obviously scavenged when the opportunity presented itself. Numerous indigestible items were also ingested, usually in small amounts. These range from a mica chip apparently from an electronics instrument to paper, string and plastic.

Seasonal diversity within the opossum's diet can be illustrated by utilizing Shannon's (1948) formula. This was used to express the food item diversity (FID) and food group diversity (FGD) as derived from the importance values of each item or group. The FGD was calculated from the following groups: mammals, birds, reptiles, earthworms, slugs and snails, arthropods, plants, and miscellaneous matter. The number of equally important items (E_i) and groups (E_g) was also computed from Tomoff's

Figure 7. Seasonal volumetric percent of Gramineae consumed by 64 Virginia opossums in Portland, Oregon.

(1974) formula. The absolute diversity within the diet may be expressed by the formula $H_a = I/N$ where I equals the number of different items consumed in a season and where N equals the number of samples.

The results of the above calculations are presented in Table V. The absolute diversity increases seasonally from a low of 2.48 during the winter to a high of 3.92 during the fall. As H_a increases so does FID but only through the summer; with the advent of fall, the opossum relies to such a great extent on one item (*Vitis* sp.) that FID and E_i fall to their lowest point, indicating an increased specialization in the diet. Both FGD and E_g decrease through the year as H_a increases due in large part to an increasing importance in plant foods. As a wider variety of food becomes available in greater quantities, the opossum can afford to show a degree of specialization in its choice of foods. In the winter months when the variety and quantity of foods available to the opossum are at its lowest, the species becomes more of a generalist. Regrettably, the values in Table V cannot be compared with previous studies since the data was not presented in a manner that would allow the calculation of the various diversities and numbers of equally abundant items or groups for corresponding periods.

The above information, in conjunction with the percentage of empty stomachs per season (Figure 8), indicates

TABLE V
SEASONAL FOOD DIVERSITY VALUES AND NUMBERS OF EQUALLY
IMPORTANT FOODS AS DETERMINED FROM 64
VIRGINIA OPOSSUMS FROM
PORTLAND, OREGON

	FID	E_i	FGD	E_g	H_a
WINTER	1.967	7.15	1.628	5.09	2.48
SPRING	2.095	8.13	1.473	4.36	3.19
SUMMER	2.104	8.20	1.189	3.28	3.31
FALL	1.867	6.47	0.978	2.66	3.92

FID = Food Item Diversity

E_i = Number of Equally Abundant Food Items

FGD = Food Group Diversity

E_g = Number of Equally Abundant Food Groups

H_a = Absolute Diversity

Figure 8. Seasonal percentage of empty stomachs in 77 Virginia opossums from Portland, Oregon.

that fall is a period of heavy feeding for opossums. The percent of empty stomachs falls from a winter high of 23.3%, to 21.1% in the spring, to 13.3% in the summer and 7.7% in the fall. Interestingly 85.7% of the empty stomachs occurred in males.

D. virginiana has often been thought of as an opprobrious beast, a scavenger of garbage. While this is true to a degree, surprisingly few items and little volume of the animal's diet is in fact garbage. Less than 9% of the opossum's diet in Portland is composed of garbage and of this over half is the result of the ingestion of one item (bacon grease) on one occasion. Most investigators conclude that the species is a euryphage. The results of this study are in agreement and indicate that the opossum is indeed a highly opportunistic omnivore.

Parasites

Many ectoparasites, principally siphonapterans, are known to infest opossums. At least 15 species of fleas are known to parasitize the animal (Potkay, 1970). In this study, three species of fleas were found. These were the cat flea (*Ctenocephalides felis*), the dog flea (*C. canis*) and the Northern rat flea (*Nosopsyllus fasciatus*). Both *C. felis* and *N. fasciatus* were common, neither occurring significantly more often than the other. Only one specimen of *C. canis* was found. *C. felis* has been the most

commonly reported species in the past (Sandidge, 1953; Potkay, 1970). *N. fasciatus* has been reported only once previously, and then from just four opossums (Sandidge, 1953). *C. canis* has not been reported on *D. virginiana* prior to this study; however, since only one specimen was found it is likely that this was an accidental.

Past studies have indicated that the opossum is relatively free of external parasites (Hamilton, 1958; Reynolds, 1945). However, this study indicates the contrary. In Portland, infestation is frequent, although usually not severe. The high rate of infestation may be attributable to the greater numbers of cats (*Felis catus*), dogs (*Canis familiaris*), and rats (*Rattus rattus* and *R. norvegicus*) found in an urban environment than in rural areas. It is also likely that the opossum exists in the same habitat as do rats and feral dogs and cats.

The frequency of flea infestation varies monthly, reaching a peak late in the year (Figure 9). Frequency during the winter is 53.3%. This rises slightly during the spring to 57.9% and in the summer to 66.7%. However, with the advent of fall the frequency increases greatly to 92.3%.

The degree of infestation differs significantly between the sexes. Of the 53 males examined, 38 or 71.7% were infested, while only 10 of 24 females or 41.7% were infested. The cause for this is unknown, but it is

Figure 9. Monthly percent of siphonapterous infestation of 77 Virginia opossums in Portland, Oregon.

probably not due to a difference in grooming habits since there is no difference between sexes in the percentage of infested opossums with ingested fleas. No significant difference in the occurrence of fleas was found between juveniles and adults.

Nine species of Acari were removed from opossums; eight species of mites and one tick, in addition to 15 unidentified specimens (probably mostly nonparasitic). Five of the identified mite species are nonparasitic and are apparently accidentals; these include *Scheloribates* sp., *Pergamasus* sp., *Ceratoppia* sp., and *Poecilochirus necrophori*. The other three are parasitic on mammals. All represent new host records and all were taken from more than one animal. All are in the family Laelapidae; they are: *Androlaelaps fahrenheitsi*, *Haemogamasus nidi* and *Eulaelaps stabularis*. Only one species of tick, *Ixodes angustus*, was recovered. This, too, is a new host record.

Twenty specimens of nematodes were recovered, but only three were identified. One specimen was not whole but is probably *Toxocara canis*. This is a new host record. The two other nematodes are *Physaloptera turgida* and *Oxyuris* sp. All were recovered from the stomach. Two of the 77 opossums examined were suffering from several perforated gastric ulcers; nematodes were present in both. This was also reported in two of 90 animals examined by Sherwood *et al* (1969). Three specimens representing two species of

trematodes were recovered from Portland opossums prior to this investigation by James J. Kirk in 1973. Both species have been reported previously from the small intestine of the opossum; they are *Brachylaime virginiana* and *Echinostoma revolutum*.

Distribution and Activity Patterns

The distribution of the Virginia opossum in Portland is widespread but heaviest east of the Willamette River. Cluster analysis (K-MEANS) indicates that the population is centered around three points (Figure 10); these are approximately at: N. Emerson Street and Denver Avenue (cluster 1), N. E. Hancock Street and 45th Avenue (cluster 2), and S. E. Long Street and 37th Avenue (cluster 3). These clusters are not well defined. The area of greatest density is bounded by N. E. Broadway Street to the north, S. E. Clinton Street to the south, 30th Avenue to the west and 71st Avenue to the east. Several small, isolated areas also have a high opossum density.

No apparent correlation was found with cluster centers or with the areas of greatest opossum density. Previous investigators have indicated that opossums tend to favor areas along small streams (Lay, 1942; Reynolds, 1945). There is no indication of this in urban opossums. Neither socio-economic indicators nor human population density compared favorably with the opossum populations. If, however,

Figure 10. Distribution of the Virginia opossum in Portland, Oregon (based upon 768 1974 traffic kill locations).

Legend

'-' = 1, '+' = 2, '*' = 3, 'x' = 4, '0' = 5, 'M' = 6+

driving patterns vary within the city, this might account for the lack of correlation. These data suggest that opossums find nearly every type of habitat suitable, whether it is residential, business or industrial.

The multiple regression analysis of possible factors affecting opossum activity has not yielded particularly enlightening results. Figures 11 and 12 illustrate the monthly numbers of opossums reported killed by Multnomah County Animal Control. During the 1973-74 period, 1,625 opossums were reported killed. The kill rate is lowest during November, December and January and largest during May.

In the computer analysis (Table 6), January was used as the standard month of comparison. Only in February was a change in the amount of activity found to differ significantly - this at the 0.01 level of confidence ($t = 2.597$). The reason for this increase in activity is unknown to me. During no other month was activity found to differ significantly after the kill data was adjusted for other factors (maximum temperature, minimum temperature, amount of darkness, traffic, precipitation, change in precipitation, change in maximum temperature and change in minimum temperature).

Among the physical parameters, significant positive correlations were recorded for traffic, maximum temperature and minimum temperature. Both temperature factors

Figure 11. Monthly number of reported Virginia opossum traffic deaths for 1973 and 1974 in Portland, Oregon.

Figure 12. Monthly mean of reported Virginia opossum traffic deaths for 1973 and 1974 in Portland, Oregon.

TABLE VI

RESULTS OF MULTIPLE REGRESSION ANALYSIS OF THE ACTIVITY PATTERNS OF 1,625
VIRGINIA OPOSSUMS FROM PORTLAND, OREGON DURING 1973 AND 1974

VARIABLE	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
Year	0.50275	0.50033	0.01566	0.04685	0.03337	1.40407
February	0.07713	0.26698	0.02568	0.25789	0.09931	2.59658
March	0.08539	0.27966	0.03679	0.14646	0.14678	0.99776
April	0.08264	0.27553	0.08162	0.05497	0.21008	0.26168
May	0.08539	0.27966	0.34312	0.35466	0.26781	1.32428
June	0.08264	0.27553	0.10201	-0.22112	0.30150	-0.73342
July	0.08539	0.27966	0.03487	-0.37900	0.28607	-1.32486
August	0.08539	0.27966	0.05953	-0.25632	0.23691	-1.08192
September	0.08264	0.27553	0.01056	-0.25268	0.18018	-1.40232
October	0.08539	0.27966	-0.01928	-0.05351	0.11921	-0.44891
November	0.08264	0.27553	-0.19673	-0.09762	0.08666	-1.12646
December	0.08539	0.27966	-0.27129	-0.15615	0.08687	-1.79748
Maximum Temperature	63.13912	14.70542	0.33673	0.00710	0.00323	2.19350
Minimum Temperature	46.01791	8.72551	0.30090	0.01057	0.00523	2.01932
Photoperiod	11.74586	2.39101	-0.43610	-0.04757	0.04573	-1.04007
Traffic	339.76861	100.88452	0.18086	0.00074	0.00016	4.45898
Precipitation	0.12367	0.27310	-0.18934	-0.15261	0.08733	-1.74759
Change in Precipitation	0.00000	0.31091	-0.02146	0.03907	0.06876	0.56820
Change in Max. Temp.	0.00000	6.29298	0.00561	-0.00247	0.00329	-0.75061
Change in Min. Temp.	0.00413	4.00526	0.00673	-0.00605	0.00490	-1.23494

were significant at the 0.05 level of confidence. Traffic correlates at a level far greater than the 0.01 level of confidence.

The t value for precipitation does not correlate particularly well ($0.10 < t < 0.05$), but probably does affect opossum activity to a degree. Although the simple correlation of photoperiod and kill is higher (0.436) than any other parameter, after adjusting for other factors it does not appear to be particularly important in determining the degree of activity exhibited by opossums. Interestingly, the data suggest that the longer the night, the less the kill.

The multiple correlation (0.57295) indicates that all of the factors examined account for only 32.8% of the urban opossum's activity. Whatever the other factors are that significantly affect the species activity, it is apparently not correlated with the time of the year, except perhaps February.

Tail Use in Nest-Building by Immature Virginia Opossums

The Virginia opossum's (*Didelphis virginiana*) use of its prehensile tail in nest building has been previously noted (Pray, 1921; Smith, 1941; Layne, 1951); however, no mention has been made of the age at which this behavior develops. On 4 April 1975 a live female Virginia opossum and eight pouch young (five males, three females) were

brought to me from Cedar Hills, Washington County, Oregon. On 9 April 1975 the young were age-dated (Reynolds, 1952) and found to be between 76 and 85 days old. Four days later the mother and four of the young perished as the result of a six-floor fall. The survivors (all males) were placed in a 20-gallon aquarium lined with Kimwipes (a soft disposable paper tissue). A nest box was also provided with Kimwipes.

On 21 April one of the young was seen to be carrying a large Kimwipe (15" x 17") in its tail to the nest box. I provided more Kimwipes shredded into one to three-inch widths. The opossum returned and further shredded the strips by standing on the Kimwipe, taking a mouthful of the tissue and then pulling its head up until the tissue tore. The shredded material was then packed into its tail once again. This was accomplished by standing on its hind legs with the rest of its body bent forward and using its mouth and forelimbs (either separately or in combination) to pack in the shredded Kimwipes anterior to the hind limbs under the venter. Then the hind limbs were thrust back alternately, packing the nesting material into the looped tail. In forming the loop, the tail's distal portion was directed anteriorly under the opossum's venter to form a crook. The tail was then curled around the material and directed posteriorly in a nearly horizontal plane. Unlike the opossum described by Smith (1941), all of the motions of gathering

and packing the material were slow and deliberate except for the backward thrusts of the hind limbs. Once the material was gripped in its tail, the opossum usually trundled back to its nest box, although it sometimes wandered about or fed and then went to the box with or without the tissue. Later in the same day a second individual was seen to execute a similar procedure, after which this was a commonly observed activity in three of the four animals.

The young were an estimated 88 to 97 days old when the initial observations were made. The behavior had been previously noted only in the case of adults and in individuals "more than half grown" (Smith, 1941). The opossums measured approximately 188 mm snout-rump length and weighed about 121 g.

SUMMARY

This is the first study of the ecology of *Didelphis virginiana* in an urban environment. The data obtained during this 18 month investigation is based upon the examination of 83 opossums taken from in and near Portland, Oregon and from the computer analysis of the 1973 and 1974 kill dates and locations of 1,625 opossums recorded by Multnomah County Animal Control. The investigation has yielded the following results:

1. With mean weights of 3394 g (males) and 2318 g (females), Portland opossums appear to be heavier than those reported elsewhere. The maximum weights recorded also exceed those recorded for *D. virginiana* elsewhere.
2. The annual sex ratio of 83 free-ranging opossums is skewed towards the males (68.7:31.3); possible explanations for this are presented. The sex ratio of 41 pouch-young indicated a somewhat greater percentage of females (43.9:56.1).
3. Breeding activity begins remarkably early in the year, with data suggesting three peaks of activity during January-February, mid-April - early May and October - mid-November. The mean litter size is 8.2 young.
4. Stomach analysis indicates a marked seasonal variation in diet diversity and composition. Animal matter constitutes 52.9% of the diet; plant matter, 29.1% and miscellaneous items 18.0%. Annually, the predominate dietary

components are leaf litter. mammals. gastropods, earthworms, grasses and pet food. The Virginia opossum is euryphagic; 98 different items are recorded from stomach analysis.

5. Five new parasite-host records were established, including three mites, *Eulaelaps stabularis*, *Haemogamasus nidi* and *Androlaelaps fahrenheitzi*; a tick, *Ixodes angustus* and a nematode, *Toxocara canis*. Flea infestation is significantly greater among male opossums than among females and shows marked seasonal trends. Three species of fleas, *Ctenocephalides felis*, *C. canis* and *Nosopsyllus fasciatus* were recovered as well, along with *Oxyuris* sp. and *Physaloptera turgida* both nematodes. Five species of free-living mites were recorded: *Poecilochirus necrophoris*, *Scheloribates* sp., *Pergamasus* sp., *Ceratoppia* sp. and *Platynothrus* sp.

6. Data suggest that the Virginia opossum finds nearly every type of habitat suitable, whether it is residential, business or industrial.

7. Minimum and maximum temperature significantly affect opossum activity, with precipitation affecting activity to a lesser degree.

8. Young opossums exhibit nest-building behavior as early as 88-97 days of age.

BIBLIOGRAPHY

- Anonymous. 1946. Oregon's Marsupial. Ore. State Game Comm. Bull., 1:5.
- Anonymous. 1948. Untitled. Ore. State Game Comm. Bull., 3:2.
- Anonymous. 1954. Untitled. Ore. State Game Comm. Bull., 9:2.
- Anonymous. 1955. The Opossum. Wildlife Leaflet No. 359. Fish and Wildlife Service. United States Department of the Interior.
- Audubon, J. J. and J. Bachman. 1851. The Viviparous Quadrupeds of North America. Vol. 2:107-125.
- Bailey, V. 1936. The Mammals and Life Zones of Oregon. United States Dept. of Agriculture. Bureau of Biological Survey. Washington.
- Bewick, T. 1800. A General History of Quadrupeds. Hodgson.
- Cooley, R. A. and G. M. Kohls. 1945. The Genus *Ixodes* in North America. National Institute of Health Bull. No. 184.
- Dagg, A. I. 1970. Wildlife in an Urban Area. Naturaliste Can., 97:201-212.
- Dexter, R. W. 1951. Earthworms in the Winter Diet of the Opossum and Raccoon. J. Mammal., 32:464.
- Evens, G. O. and W. M. Till. 1966. Studies on the British Dermanyssidae (Acari: Mesostigmata), Part II. Classification. Bull. of the Museum (of Natural History) Zoology. London. 14 part 5.
- Fitch, H. S. and H. W. Shirer. 1970. A Radiotelemetric Study of Spatial Relationships in the Opossum. Amer. Midland Nat., 84:170-186.
- Fitch, H. S. and L. L. Sandidge. 1953. Ecology of the Opossum on a Natural Area in Northeastern Kansas, Univ. Kansas. Publ. Mus. Nat. Hist., 7:305-338.
- Gill, D. and P. Bonnet. 1973. Nature in the Urban Landscape, A Study of City Ecosystems. New York Press. Baltimore.

- Hamilton, W. J. 1958. Life History and Economic Relations of the Opossum (*Didelphis marsupialis virginiana*) in New York State. Cornell Univ. Agr. Sta. Memoir No. 354, Ithaca, New York.
- Hartman, C. G. 1923. Breeding Habits, Development and Birth of the Opossum. Smithsonian Report for 1921. Publ. 2689:347-313.
- Hartman, C. G. 1928. The Breeding Season of the Opossum (*Didelphis virginiana*) and the Rate of Intrauterine and Post-natal Development. J. Morph. and Physiol. 46:143-215.
- Hartman, C. G. 1952. Possums. Univ. Texas Press. Austin.
- Holmes, A. C. V. and G. C. Sanderson. 1965. Populations and Movements of Opossums in East-central Illinois. J. Wildlife Mgmt., 29:287-295.
- Hubbard, C. A. 1947. Fleas of Western North America. Iowa State College Press. Ames, Iowa.
- Jewett, S. G. and H. W. Dobyns. 1929. The Virginia Opossum in Oregon. J. Mammal. 10:351.
- Krantz, G. W. 1970. A Manual of Acarology. OSU Bookstores. Corvallis
- Lay, D. W. 1942. Ecology of the Opossum in Eastern Texas. J. Mammal. 23:147-159.
- Layne, J. N. 1951. The Use of the Tail by an Opossum. J. Mammal. 32:464-465.
- Lincecum, G. 1872. The Opossum. Amer. Nat., 6:555-557.
- Llewellyn, L. M. and F. H. Dale. 1964. Notes on the Ecology of the Opossum in Maryland. J. Mammal. 45:113-133.
- Llewellyn, L. M. and F. M. Uhler. 1952. The Food of Fur Animals of the Patuxent Research Refuge, Maryland. Amer. Midl. Nat., 48:193-203.
- Mace, R. 1970. Oregon's Furbearing Animals. Ore. State Game Comm. Wildlife Bull. No. 6.

- Micherdzinski, W. 1969. Die familie Parasitidae Oudemans, 1901 (Acarina, Mesostigmata) Zaklad Zoologii Systematycznej Polskiej Akademii Nauk. Panstwowe Wydawnictwo Naukowe.
- McManus, J. J. 1970. Behavior of Captive Opossums, *Didelphis marsupialis virginiana*. Amer. Midland Nat., 84:144-169.
- Mohr, C. O. and H. B. Morlan. 1959. The Nature of Parasitism of the Opossum by Fleas in Southwestern Georgia. J. Paras., 45:233-237.
- Petrides, G. A. 1949. Sex and Age Determination in the Opossum. J. Mammal., 30:364-378.
- Pilsbry, H. A. 1948. Land Mollusca of North America. The Academy of Natural Sciences of Philadelphia. Vol. 2, Pt. 2.
- Potkay, S. 1970. Diseases of the Opossum (*Didelphis marsupialis*): A Review. Lab. Anim. Care, 20:503-511.
- Pray, L. L. 1921. Opossum Carries Leaves with its Tail. J. Mammal., 2:109-110.
- Raven, H. C. 1929. A Case of Matricide in the Opossum. J. Mammal., 10:168.
- Reynolds, H. C. 1945. Some Aspects of the Life History and Ecology of the Opossum in Central Missouri. J. Mammal., 26:361-379.
- Sandidge, L. L. 1953. Food and Dens of the Opossum (*Didelphis virginiana*) in Northwestern Kansas. Trans. Kansas Acad. Sci. 56:97-106.
- Shannon, C. E. 1948. A Mathematical Theory of Communication. Bell. Syst. Tech. J., 27:379-423, 623-656.
- Sherwood, B. T., Rowlands, D. T., Hackel, D. B., and J. C. Lemay. 1969. The Opossum *Didelphis virginiana* as a Laboratory Animal. Lab. Animal Care, 19:494-499.
- Smith, L. 1941. An Observation on the Nest Building Behavior of the Opossum. J. Mammal., 22:201-202.
- Smith, L. C. 1975. Urban Wildlife - Is it Wanted and Needed? Canadian Field Naturalist, 89:351-353.

- Stieglitz, W. O. and W. D. Klimstra. 1962. Dietary Pattern of the Virginia Opossum *Didelphis marsupialis virginianus* Kerr, Late Summer-Winter, Southern Illinois. Ill. State Acad. Sci. Trans., 55:198-208.
- Taube, C. M. 1947. Food Habits of Michigan Opossums. J. Wildlife Manag., 11:97-103.
- Tomoff, C. S. 1974. Avian Species Diversity in Desert Scrub. Ecology, 55:396-403.
- Tyndale-Biscoe, C. H. and R. B. Mackenzie. 1976. Reproduction in *Didelphis marsupialis* and *D. albiventris* in Columbia. J. Mammal., 57:249-265.
- Vesey-Fitzgerald, B. 1967. Town Fox, Country Fox. Andre Deutsch. London.
- Wiseman, G. L. and G. O. Hendrickson. 1950. Notes on the Life History and Ecology of the Opossum in Southeast Iowa. J. Mammal., 31:331-337.