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THE BIOLOGY OF THE OPOSSUM, DIDELPHIS VIRGINIANA IN SOUTHCENTRAL PENNSYLVANIA

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ABSTRACT

A sample of 62 opossums, *Didelphis virginiana* L., collected in 1973-74 from Franklin and Cumberland Counties, Pennsylvania, yielded data on size, reproduction, food habits and parasites. Males were slightly larger than females with significant differences only for hind foot length and weight. Although the sex ratio of pouch young was near unity, females in the sample outnumbered males by a ratio of 1.95:1.00. Animal matter averaged 55% of stomach contents by volume with mammals the most abundant item by volume and frequency. Nematode endoparasites were recovered from 59 specimens. The common roundworm, *Physaloptera turgida,* and the pinworm, *Cruzia americana,* were the two most abundant endoparasites.

INTRODUCTION

The opossum, *Didelphis virginiana* Kerr, is the only extant marsupial native to the United States (1) and represents a southern element in the mammal fauna of Pennsylvania. The species is of considerable biological interest because of its high reproductive potential (2, 3, 4, 5, 6, 7) and its rapid range expansion (8, 9, 10, 11, 12, 13). Research on the opossum in Pennsylvania has been meager compared to the numerous and extensive studies of this species in other parts of its range. Notable exceptions have been studies of food habits (14), parasites (15, 16), ecology (17), and the general coverage of this species in the Pennsylvania Game Commission Mammal Surveys (18, 19, 20, 21, 22, 23).

In 1973 a study of the opossum was initiated to complement these earlier studies and to provide a more detailed description of the biology of *D. virginiana* in southcentral Pennsylvania. This paper presents the results of an examination of a sample of 62 specimens and includes information on size, sex ratios, reproduction, habitat, food habits and parasites. The quantitative analysis of internal parasites in this paper represents an advance over earlier studies that have been qualitative in nature.

METHODS AND MATERIALS

The 62 opossums examined during this study were collected along two north-south transects, 32 km apart, spanning the Cumberland Valley of Pennsylvania (Cumberland and Franklin Counties) from the Blue (North) Mountain to the South Mountain. The Cumberland Valley is a mosaic of habitat types with agricultural land a dominant component. Mixed deciduous woodlots dot the valley proper and grade into even-aged oak stands at the mountain bases. Edaphic variation is pronounced between the northern shale and the southern limestone halves of the valley.

Each transect consisted of 24 trap stations spaced at one to two km intervals. To facilitate analysis of capture data for habitat preference and parasite abundance, the trap stations were divided equally between four edge-habitat types: woodland, agricultural, stream edge and residential.

Trapping was conducted from March 1973 through January 1974. One Coni-bear #220 body-hold trap, baited with chicken parts, was staked in an above-ground set at each trap station. Opossums were collected during eight months of field work. Traps were closed every third month to permit replacement of captures by neighboring individuals. Traps were checked daily and rebaited frequently until each month's quota of eight opossums had been collected. Captured specimens were tagged, placed in sealed plastic bags and transported to the laboratory.

The first phase of laboratory examination was removal of ectoparasites. Each opossum was thoroughly combed, and debris adhering to the collection bag was saved. Ear wax samples were taken from both auditory meati and inspected for mites. Ectoparasites were individually removed from the fur combings, dry-stored, and later identified using Borror and Delong (24) and Fox (25).

The following data were recorded for each specimen: sex; number of pouch young; appearance and condition of the marsupium, ears, tail tips, and fur; total body, tail, hind foot, and ear lengths; weight; and dentition. Ages were estimated primarily by dental characteristics (3, 26). Opossums were grouped into three age-classes: class one included juveniles aged five to eight months; class two was comprised of nine to eleven-month old specimens; and class three represented captures one year old or more.

While specimens were being skinned for preparation as museum specimens, examinations for endoparasites were made on the dermis, fascia, and superficial musculature. The gut was clamped at the pharynx, cardiac and pyloric sphincters, and at the caecum and anus. The contents of each segment and the gut tissue itself were washed over triple-layer 1mm^2 screening and inspected for helminths. Other organs excised and inspected included the liver, urinary and gall bladders, spleen, kidneys, uteri, diaphram, lungs, trachea, and heart. The pleural, pericardial, and peritoneal cavities were examined and the carcass discarded. The liver, spleen, and lungs were coarsely macerated and washed. Examination for and removal of parasites was facilitated by the use of a dissecting microscope (10-70X).

Trematodes and cestodes were fixed in warm AFA stained in Turtox CMC-S or aceto-carmine, and permanently mounted on glass slides. Nematodes were fixed in hot 70% ethanol and later cleared in lactophenal for identification. The number of helminths of each species was recorded for each opossum autopsied. In addition, specimens of two gut nematodes were sexed, and those too small to sex at 70X magnification were classified as larvae. Primary sources used for helminth identification included Voge (27), Yamaguti (28), and York and Maplestone (29).

Following extraction of helminths, the gut contents were sorted on a small dissecting pan. Different food items were separated and identified, and their relative volumes estimated visually. Unidentifiable dietary materials were set aside and not included in the volumetric estimates.

Quantitative data were tested for significant differences using Student's t-test, Chi-square and computer-run analysis of variance. Comparisons of present findings with earlier studies usually were qualitative due to the use of untested data by past investigators.

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RESULTS AND DISCUSSION

SEX RATIO AND SIZE: The 62 free-ranging specimens collected had a sex ratio of 21 males (38.9%) and 41 females (66.1%). This represents a significant deviation from a 1:1 sex ratio ($x^2 = 6.45$, df = 1, $P < .05$). Females exceeded males in abundance in three seasons, spring (2.80:1.00) summer (4.33:1.00) and fall (1.33:1.00), but not in winter (0.86:1.00). Previous studies by Apgar (17), Bennett and Nagel (30), Lay (4) and Reynolds (5) have reported sex ratios in favor of males of approximately 1.00:0.75. In this study 183 pouch young had a male:female sex ratio of 1.00:0.98. The reason for the differences in sex ratio between the pouch young and free-ranging individuals in this study is inexplicable, although two obvious possibilities are differential mortality in males or some undetermined sampling error.

Twenty-eight specimens (10 males, 18 females) judged to be at least 12 months old on the basis of the aging criteria of Hartman (3) and Butler (26) were used to determine the size characteristics of the Cumberland Valley opossums. The data presented in Table 1 reveal that males averaged larger than females for all standard measurements except ear length, although the only significant differences were for hind foot and weight.

TABLE 1

Comparison of external measurements of 10 male and 18 female *D. virginia* from Franklin and Cumberland Counties, Pennsylvania

External Measurements	N	Mean	SE	SD	Range	t-ratio
Males:						
Total length (mm)	10	778.6	19.4	61.5	698-883	1.37
Tail length (mm)	10	290.6	13.2	41.6	221-356	0.14
Hind foot (mm)	10	69.2	1.2	3.9	63-75	4.61*
Ear length (mm)	10	54.0	1.4	4.5	44-60	0.77
Weight (kg)	10	3.4	0.2	0.6	2.19-4.00	5.82*
Females:						
Total length (mm)	18	753.2	8.7	37.0	666-828	
Tail length (mm)	18	288.8	6.1	26.1	216-319	
Hind foot (mm)	18	64.1	0.5	2.0	60-68	
Ear length (mm)	18	55.1	0.7	2.8	49-60	
Weight (kg)	18	2.4	0.1	0.3	1.82-2.99	

*Two-tailed T-test, df = 26, $P < .001$.

The occurrence of frostbitten ears and lost tips of tails has been reported previously in other studies of the opossum in the northern portions of its range (31, 32). Severe frostbite was noted on most specimens captured in southern Ontario (33). In this study 21 specimens (34%) exhibited frostbitten ears and 14 specimens (23%) had lost at least one distal caudal vertebra to frostbite.

REPRODUCTION: Twenty of 24 females captured between 5 March and 17 July carried young in the marsupium. On the basis of the pouch young aging techniques of Petrides (34) and the 12-13 day gestation in *D. virginiana,* it was estimated that the earliest and latest matings in the sample took place during the last week in January and the second week in June, respectively. This late January to June breeding season agrees with reports by Reynolds (5) for Missouri and Richmond and Roslund (18) for northwestern Pennsylvania. The breeding season commences about a month earlier in the southern portions of the opossum's range (3) but does not begin until March in Wisconsin (35).

The aging of pouch young revealed two periods of reproductive activity in Cumberland Valley opossums. A major early reproductive period extended from late January through March that produced 13 of the 20 litters with 7 of these a result of February matings. There was a second less active breeding period in May and June; five of these seven litters were products of May matings. These data suggest that Cumberland Valley females may produce two litters per year. Two litters per year is common throughout the southern portions of the opossum's range (36, 37). In Wisconsin, however, one litter per year is the rule, and two are an exception (35).

Similarly, the opossum exhibits a latitudinal cline for litter size. In this study litter sizes ranged from one to 14 with a mean of 9.2, which is equivalent to the average of "about 9" for Wisconsin specimens (35). The mean in this study is considerably larger than the average litter size of 6.8 for *D. virginiana* in Texas (4). Golley (38) notes that opossum litter size appears to be smallest in the southern portions of its range (average litters of seven in Georgia and six in Florida) and increases northward.

HABITAT PREFERENCES: The opossum inhabits a broad spectrum of habitats throughout its range but tends to prefer and reach its greatest abundance in woodlands containing small streams (4, 19, 20, 21, 39). The data from the present study revealed a preference in Cumberland Valley opossums for agricultural lands. Although trapping effort was evenly distributed between four major valley habitats, 30 of 62 (48.4%) captures were from agricultural edges. The remainder were as follows: woodland, 13 (21.0%); stream edge, 10 (16.1%) and residential, 9 (14.5%). These data indicated a significant preference for agricultural lands ($x^2 = 18.4$, df = 3, $P < .005$) by Cumberland Valley opossums. However, the complex mosaic of these four habitats in the valley makes this finding somewhat less significant than if the sampling had been conducted in a region of extensive habitat blocks.

FOOD HABITS: Fifteen categories of stomach contents were identified from the 62 specimens, as follows: mammals, grass and grains, insects, fruits and seeds, leaves, earthworms, mollusks, birds, egg shells, amphibians, fish, arachnids, stems, sand and stones, and trash. The occurrences of all these items have been reported previously by other workers. During this study mammals, grasses and grains, and insects were the most frequently encountered food items, occurring in at least 75% of the specimens (Table 2). Mammals, grasses and grains, and fruits and seeds accounted for 51% of the total volume of stomach contents in the study (Table 3). These tabular data reveal that opossums in the Cumberland Valley are somewhat opportunistic in their dietary habits, since there are pronounced shifts to consumption of seasonally abundant food items such as earthworms in the spring, and birds and insects in the summer.

TABLE 2

Percent frequencies of occurrence by season of food items utilized by opossums in the Cumberland Valley of Pennsylvania

Food Item	Spring	Summer	Fall	Winter	Total for Year
Mammals	95	100	100	100	98
Grasses and Grains	89	88	93	92	90
Insects	68	94	93	85	85
Leaves	63	56	93	100	78
Fruits and Seeds	79	75	79	69	76
Sand and Stones	84	63	64	77	72
Stems	63	13	29	69	44
Earthworms	74	31	36	31	43
Mollusks	5	25	64	62	39
Birds	5	56	29	31	30
Eggshell	5	13	7	8	8
Arachnids	0	19	14	0	8
Fish	5	13	0	8	6
Trash	0	0	0	23	6
Amphibians	5	0	0	0	1

Four species of small mammals, the short-tailed shrew, *Blarina brevicauda,* the white-footed mouse, *Peromyscus leucopus,* the house mouse, *Mus musculus,* and the meadow vole, *Microtus pennsylvanicus,* plus remains of opossums were identified in the stomach contents. The frequency of occurrence of mammals in this study was substantially higher than has been reported from Missouri, Michigan or New York (5, 40, 41, respectively). However, Pennsylvania Game Commission survey data support the present findings (19).

The occurrence and volume of grasses and grains in the local opossums also were higher than those previously reported by other investigators.

TABLE 3

Percent volumes by season of food items utilized by opossums in the Cumberland Valley of Pennsylvania

Food Item	Spring	Summer	Fall	Winter	Total for Year
Mammals	24	25	25	30	26
Grasses and Grains	13	16	10	13	13
Fruits and Seeds	12	14	14	10	12
Insects	6	12	7	11	9
Earthworms	18	6	7	3	8
Leaves	7	6	10	10	8
Sand and Stones	9	6	7	7	7
Mollusks	<1	2	6	8	4
Birds	2	9	3	4	4
Stems	5	1	4	6	4
Amphibians	1	0	0	0	<1
Arachnids	0	<1	<1	0	<1
Eggshell	1	1	<1	<1	<1
Fish	<1	2	0	<1	<1
Trash	0	0	0	2	<1

Comparisons were difficult because most other studies listed only a single plant category (4, 14, 42). However, data from New York approximate the present findings (41). Hamilton (41) noted that grasses were not secondarily ingested but were actually a preferred food item.

Insect consumption by Cumberland Valley opossums paralleled findings from other northern areas (5, 14, 40). Southern investigators have found considerably greater volumes of insect remains (4, 43). The relatively higher winter volume (11%) and frequency (85%) of insect materials likely indicate the importance of this food item during a season of food stress. Among the insect material recovered from the winter captures were adult flies, crickets, grasshoppers, various beetles, and lepidopterous larvae and pupae.

Although volumes of fruit and seeds found in this study were similar to those in previous findings, frequencies of occurrence were about 50% higher in Cumberland Valley specimens (40, 41). Perhaps the edge locations of traps contributed to the inflated values, because many of the soft-fruited plants, such as blackberry and elderberry, are edge species. Weed seeds predominated over fleshy fruits during the winter and early spring. Gooseberries, *Ribes* sp., blackberries and raspberries, *Rubus* sp., wild grapes, *Vitis* sp., apples, *Pyrus* sp., elderberries, *Sambucus* sp., and pokeweed fruits, *Phytolacca* sp., were common during the warm months.

Leaf material, stems, twigs, sand, stones, and trash, such as cellophane and aluminum foil, were found most frequently and in the greatest quantities during the cold months. It is likely that most of these items were ingested secondarily as a result of foraging for more substantial food items. Lay (4) reported a fall leaf volume of 11 percent which corresponds to the findings in the present study.

Earthworms, primarily large *Lumbricus terrestris*, ranked second in importance for spring dietary material. Cumberland Valley opossums appeared to consume earthworms 40% more frequently than specimens from Michigan (40) or New York (41). Similarly, snails and slugs were more common from local opossums than from other regions, although these items appeared more often during the fall and winter. Volume estimates from all areas within the opossums' range, however, are relatively constant for both earthworms and mollusks. The higher frequencies of occurrence of these invertebrates in our area were likely due to the moister and richer edaphic conditions for which the Cumberland Valley is noted.

Bird and eggshell remains, as expected, were consumed most frequently during the summer. This material was most likely from ground-roosting species or carrion, because the nocturnal opossum has little opportunity for preying on diurnally-active birds (41). Frequencies of occurrence of bird and eggshell remains match frequencies found in Michigan (40) and Pennsylvania (19). Previously reported volumes of avian material from both northern (5) and southern (43) studies, approximate the present findings.

ECTOPARASITES: Ectoparasites were removed from 40 opossums during the study period. The data have not been analyzed statistically due to the highly variable conditions in which their hosts were obtained (e.g., freshly killed vs. fully rigored).

Of the 319 ectoparasites recovered, 15 (4.70%) were Siphonaptera. Tentative flea identifications include *Ctenocephalides* sp., *Peromyscopsylla* sp., *Ctenopthalmus* sp., and *Orchopeas* sp. These genera have been reported from the opossum by Mohr and Morlan (44) and Fox (25).

Acarina (302 specimens), including 293 mites and 9 ticks, were found on 29 hosts. Two lice (Mallophaga) were removed from two summer captures.

Marked seasonal differences in ectoparasitemia were exhibited with spring and winter levels of 30.9 and 61.8 percent, respectively. These data indicate the positive relationship between ectoparasite burden and extended cold season denning and cohabitation by the opossum with other mammal hosts (44, 45).

CESTODE ENDOPARASITES: Mesocestoides latus Mueller were removed from the small intestines of 11 opossums, 5 males and 6 females. A total of 192 scolices were recovered from opossums captured in each season and habitat type. This tapeworm was found most commonly in age-class 2 opossums, indicating possible young-host specificity (46). Infections ranged from 1 to 107 worms per host. Babero (47, 48) has reported similar burdens from Illinois and Georgia opossums. A mammal intermediate host has been indicated for this genus (49).

TREMATODE ENDOPARASITES: Two species of parasitic trematodes were removed from gut sections of ten opossum hosts. Flukes were found only in the contents or tissues of the small intestines.

Brachylaima virginiana (Dickerson) were found in nine host animals, three males and six females. Ninety-six flukes were recovered from age-class 1 and 2 opossums, and twelve worms from one age-class 3 female host. Infections ranged from one to 29 worms and averaged 12.0 worms per host. All but two hosts of *B. virginiana* were captured in the northern half of the Cumberland Valley, but infestations did not appear to be seasonal or habitat related. This fluke has been reported from all regions of the United States, and the present data are supported by the Illinois findings of Leigh (50) and Babero (48). Snails and mammals are known to be the first and second intermediate hosts, respectively.

Four specimens of *Echinostoma revolutum* (Froelich) were removed from one female host captured near the North Mountain. *E. revolutum* has been reported from the northeast (51). This trematode may employ up to ten species of snails as first intermediate hosts. Sixteen species of Pulmonate snails along with several species of Amphibians and silurid fishes are known secondary intermediate hosts (52).

ACANTHOCEPHALAN ENDOPARASITES: Twenty-three *Travassosia tumida* Van Cleave were collected from the small intestines of six hosts captured in the spring and summer. All but one host were taken from the northern trap stations. Host age ranged from nine months to adult, and the mean burden was 3.8 worms.

T. tumida previously has been reported only from Oklahoma (53). Intermediate hosts of this spiny-headed worm include the American cockroach, *Periplaneta americana,* May beetles, *Cotinus* spp., and June beetles, *Phyllophaga* spp. (52, 54).

NEMATODE ENDOPARASITES: A total of 7,908 nematodes were collected from 59 opossums. The parasites identified included *Physaloptera turgida* Rudolphi, *Cruzia americana* Maplestone, *Gongylonema longispiculum* Schults, *Dipetalonema pricei* (Vaz and Pereira), and *Toxacara canis* (Werner). One group of nematodes was identified to the subfamily Heterakinae Railliet and Henry.

Two specimens of *Gongylonema longispiculum,* both females, were collected from the esophagus of a female opossum captured in March.

The host was carrying eight pouch young. *Gongylonema* are known to be old-host parasites (46) which require dung beetles as intermediate hosts. Babero (48) has reported *G. longispiculum* from Georgia opossums.

The subcutaneous fascia of one male and five female opossums contained 21 female *Dipetalonema pricei.* These hosts were summer captures, and all were at least 11 months of age. Dog and cat fleas, *Ctenocephalides* spp., serve as intermediate hosts. *Dipetalonema* have been reported to occur in Georgia opossums (48).

Seven partially decomposed *Toxacara canis* were collected from the stomach of an eleven month old opossum captured in the northern half of the transect. *T. canis* are not known from opossums, and it is assumed that these nematodes were ingested as adults from carrion. Unidentified ascarids have been found in Kansas opossums (55).

Two adult female hosts with pouch young were parasitized by 17 heterakids. These opossums were taken from two northern trap stations. Gapeworms have direct life cycles (52), are passively carried by earthworms (56), and are primarily parasites of fowl (29).

A total of 6,461 *Physaloptera turgida* were recovered from 57 hosts. Of these, 1129 were males, 1383 were females, and 3949 were unsexed larvae. Most specimens were removed from the stomach, but many were collected from the small intestine, esophagus, oral cavity, and trachae. This common roundworm has been reported from most areas in the southern and northern United States. The 92% infestation rate in the Cumberland Valley specimens has been approximated in other localities (50, 57). Leigh (50) reported mean and maximum *P. turgida* burdens from Illinois of 18 and 49, respectively. The mean number of adult worms per local host was 42.6, and the mean for adult and larval worms combined was 109.5. Parasite loads ranged from one to 1101 *P. turgida* per host. The German cockroach, *Blatella germanica* L., is the major intermediate host of *P. turgida* (41). Nematode larvae consumed by *D. Virginiana* encyst in gastric tissues until host stress triggers excystment (52).

Adult opossums harbored a mean of 66.8 adult *P. turgida,* a figure significantly different from those means of age-class 2 (22.8) and 1 (2.4) opossums (F-test = 6.89; df = 2, 59; $P < .005$); *P. turgida* is known to be an old-host parasite (58). Female opossums carrying pouch young also exhibited significantly greater adult worm burdens (56.8) than did females of the same age-class without pouch young (26.6) (F-test = 4.42; df = 1, 35; $P < .05$). In addition, hosts from the northern half of the Cumberland Valley were more heavily parasitized by *P. turgida* adults and larvae (127.0) than were hosts from the southern townships (81.4) ($x^2 = 9.99$; df = 1; $P < .005$). Analyses of habitat, sex, and seasonal variations in nematode burdens revealed no significant differences.

Pinworms, *Cruzia americana,* were removed from 43 of the 62 opossums examined (69.4%). In other studies, *Cruzia* parasitism has varied from 25% (50) to 90% (59). Of the 1,250 worms recovered in this study, males, females, and larvae numbered 523, 404, and 323, respectively. These parasites were collected primarily from the caecum and large intestine, but occasionally specimens were found in the small intestine and stomach. The mean *C. americana* burden was 29.1, and infections ranged from 1 to 165 pinworms per host. The mean reported by Leigh (50) from Illinois of 44 pinworms per host was higher than our findings. *Cruzia* spp. have a direct life cycle, do not utilize an intermediate host, are not known to encyst within host tissues (52), and are pathologically innocuous organisms compared to *P. turgida* (59).

The analyses of habitat, age-class, sex, reproductive condition and seasonal variances in adult *C. americana* burdens showed no significant differences. The latitudinal distribution of this pinworm, however, differed significantly between the northern and southern halves of the Cumberland Valley with mean pinworms per host of 22.1 and 7.8, respectively ($x^2 = 6.89$, df = 1, $P < .01$). Augustine and Smillie (60) and Andrews (61) have reported on edaphic variation in nematode distribution.

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