FOOD HABITS OF THE MOLE SALAMANDER AMBYSTOMA TALPOILEUM IN MONTGOMERY COUNTY, TENNESSEE

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FOOD HABITS OF THE MOLE SALAMANDER *AMBYSTOMA TALPOIDEUM* IN MONTGOMERY COUNTY, TENNESSEE

An Abstract

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in Biology

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by

Jonathan Maxwell Wert

June 1968

A food habits study of the Mole Salamander, Ambystoma talpoideum, was conducted by examining the stomachs of 289 individuals (including 219 sexually immature larvae, 40 neotenic larvae, and 30 metamorphosed adults). The stomach contents of 25 Spotted Salamanders (15 larvae and 10 adults), and 25 Newts were also analyzed to determine any food competition with the Mole Salamander.

All specimens were collected from the same shallow, permanent, rain-fed woodland pond, located approximately eight miles northeast of Clarksville, Tennessee. Specimens were collected during daylight by dip net, drift trap, seine, casting net, and dredge net, between November 1, 1966 and October 31, 1967. The stomachs were injected in the field with 10 per cent formalin to arrest digestion. The contents were later preserved in 90 per cent ethanol and identified and quantified by using a dissecting microscope.

Sexually immature and metamorphosed adult Mole Salamanders fed chiefly upon crustaceans, insects, and gastropods, in that order. Adult forms fed sparingly or not at all while in the breeding pond. Neotenic larvae of A. talpoideum fed chiefly upon insects, crustaceans, and gastropods, in that order, and took their food principally from the benthic leaf litter. No conspicuous dietary changes occurred from one ontogenetic stage to another with the exception that neotenic forms consumed principally insects during periods when the other stages of A. talpoideum were feeding primarily upon crustaceans. The Mole Salamander consumed mostly those organisms that were available and most numerous in its feeding zone. No evidence of predilection was detected. Mole Salamander larvae were capable of seining small invertebrates from the water by use of their

gill rakers, and data indicate that this straining occurred principally during periods of high turbidity and/or darkness. During periods of illumination all stages of A. talpoideum fed upon the larger invertebrates. Food competition occurred between the common urodelan inhabitants of the pond.

FOOD HABITS OF THE MOLE SALAMANDER *AMBYSTOMA TALPOIDEUM* IN MONTGOMERY COUNTY, TENNESSEE

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June 1968

To the Graduate Council:

I am submitting herewith a Thesis written by Jonathan Maxwell Wert entitled "Food Habits of the Mole Salamander Ambystoma talpoideum in Montgomery County, Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biology.

David H. Snyder
Major Professor

We have read this thesis and recommend its acceptance:

Edward D. Chesser
Second Committee Member

Charles D. Bodkins
Third Committee Member

Accepted for the Council:

Wayne C. Stamps
Dean of the Graduate School

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Mr. David H. Snyder under whose supervision this study was conducted, and to Dr. Edward W. Chester and Mr. Charles N. Boehms for their critical reading of the manuscript. Thanks is also due to Mr. Gerald L. Tenney for his help with photography.

Acknowledgement is made to Charles W. and James W. Bell for use of the pond, without which this study would not have been possible.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

The Mole Salamander, Ambystoma talpoideum (Holbrook), is restricted mainly to the southeastern United States, and is neither common nor widely distributed in Tennessee. This species feeds on a variety of foods, mostly invertebrates, and may have a dynamic effect on the trophic dynamics of a pond community.

Statement of the problem. The purpose of this study was to gain knowledge about the food habits of A. talpoideum. More specifically, data were collected relative to the following problems:

1. What food items were available to a population of A. talpoideum in Montgomery County, Tennessee?
2. What were the major features of seasonal fluctuations in food availability?
3. What were the seasonal changes in food habits of larvae?
4. What were the dietary items of the immature larvae and of the neotenic forms, and what difference, if any, existed between the food habits of these two developmental stages?
5. What changes occurred in the food habits of maturing larvae?
6. What was the relationship between food availability and food utilization?
7. What did the metamorphosed adults feed on while in the breeding pond, and to what extent?
8. Was there competition for food between the three common urodelan inhabitants of the pond, the Mole Salamander, the Spotted Salamander A. maculatum, and the Red-spotted Newt Notopthalmus viridescens?

Importance of the study. This study is important because it has revealed an annual cycle of food choice in relation to food availability in several developmental stages of a poorly-known component of our local fauna. In addition to contributing to the knowledge of the life history of A. talpoideum, the study may benefit future research by

serving as a basis for any studies conducted on the habits or taxonomy of this species in Tennessee.

Limitations of the study. The study concerned a single woodland pond in Montgomery County, Tennessee and extended over a period of one year, from November 1, 1966, through October 31, 1967. The contents of 289 stomachs were examined.

Literature review. A review of the literature failed to reveal any published works concerning the food habits of A. talpoideum. Allen (1932) collected larvae from a pond in Harrison County, Mississippi, from April 20 through May 15, 1931 and mentioned that the food seemed to consist largely of mosquito larvae.

A number of published works have reported foods eaten by other members of the genus Ambystoma. Dineen (1955) studied the food habits of larval Tiger Salamanders, A. tigrinum, in a large pond in Cass County, Michigan, and found that species of Diptera (chiefly Chironomidae and Chaoboridae) were the predominant food organisms. Dobie (1962) analyzed the stomach contents of 288 larval A. tigrinum taken from 15 White Sucker (Catostomus commersoni) rearing ponds and found that Daphnia made up 31.3 per cent of the total volume, Corixidae 24.4 per cent, and Chironomus larvae 13.2 per cent.

Although no adult A. talpoideum were collected from their terrestrial environment, such studies have been conducted on other members of the genus Ambystoma. Judd (1957), in studying the foods of 29 adult Jefferson's Salamanders, A. jeffersonianum, in Rondeau Park, Ontario, found that the four species consumed most often were all snails--Nemobius

carolinus, Parcoblatta pennsylvania, Porcellio rathkei, and Zonitoides arboreus. Farner (1947) analyzed foods from adult A. macrodactylum collected around the damp edges of Crater Lake in Oregon. He found that "19 of the 27 stomachs examined contained food, 14 of these (74 per cent) contained terrestrial arthropods and seven (37 per cent) contained the larvae of coleopterous, dipterous, and trichopterous aquatic insects." Auerbach (1952) examined a series of adult A. jeffersonianum collected in Porter County, Indiana, and mentioned that one contained a centipede in its stomach. Duellman (1948) stated that an adult A. tigrinum ate a small snake, Thamnophis s. sirtalis.

CHAPTER II

METHODS AND MATERIALS

Description of the study area. The pond from which collections were made is located in Montgomery County, Tennessee, approximately eight miles northeast of Clarksville. It lies less than ten yards south of a paved highway (Dunlop Lane) that passes through the James W. Bell farm.

At normal pool, the long axis of the pond extends in an east-west direction for 270 feet, and the short axis extends north-south for about 120 feet. The pond normally contained about one-fourth acre foot of water. Dunlop Lane is the northern boundary of the 150-acre wooded tract enclosing the pond with cultivated fields lying immediately north of this road. The woods extends east of the pond for approximately fifty yards, where it adjoins a cultivated field. The west and south banks are bounded by woodland extending some 300 and 1500 yards respectively.

The region is generally one of karst topography. The study pond represented such a natural depression which was filled by runoff waters. In or about the year 1953, the pond was cleaned out with a caterpillar tractor, and a leak developed. Since then it has never held a large amount of water over a long period of time. However, the pond has never been completely devoid of water even during the driest summer months. From 1930 until 1956 the pond was utilized for watering livestock and was stocked with sunfish and catfish. The fish never reproduced well, if at all, and by 1956 they were gone, probably having been either caught by fishermen or eaten by turtles. Since 1956, the pond has not

been utilized as a source of water for farm animals.

The pond averaged 38 inches deep at its deepest point. Its minimum depth during the year of this study was 17 inches in February, 1967, and its maximum was 76 inches in the following May. Drastic and frequent fluctuations occurred during the months of high precipitation, as evidenced by a rise in water level of 49 inches between March 3 and March 10. Heavy rains of March, April, and May caused great turbidity of the water, which persisted until June and dramatically affected the aquatic community.

The highest recorded water temperature measured six inches below the surface was 25 degrees centigrade on July 19, 1967, and the lowest was 2 degrees centigrade on January 21 of the same year.

The soil around and at the bottom of the pond was analyzed during January and July of 1967 to determine the pH which was found to be consistently acid, ranging between 5.8 and 6.7. During the same period, the water exhibited a similar range of pH, with a mode reading near 6.

The most common trees of the area surrounding the pond are listed as follows in approximate order of dominance. Scientific and common names used are in accord with Fernald (1950). Black Oak (Quercus nigra), Sweet Gum (Liquidambar styraciflua), and Sycamore (Platanus occidentalis) contributed the majority of the leaf litter in the pond. The understory vegetation included Pawpaw (Asimina triloba), Honeysuckle (Lonicera japonica), Black Cherry (Prunus serotina), Box Elder (Acer negundo), Sugar Maple (Acer saccharum), Pepper-vine (Ampelopsis sp.), American Elm (Ulmus americana), Slippery Elm (Ulmus rubra), Sassafras (Sassafras albidum), Cat Grape (Vitus palmata), Red Cedar (Juniperus virginiana), Silky

Dogwood (Cornus Amomum), Virginia Creeper (Parthenocissus quinquefolia), Hackberry (Celtis occidentalis), Tulip Tree (Liriodendron tulipifera), and Snowberry (Symphoricarpos orbiculatus). The two most common herbaceous plants on the banks of the pond were Dayflower (Commelina sp.) and Johnson-Grass (Sorghum halepense). Filamentous algae were prevalent in areas of intense sunlight, the most common genus being Spirogyra. Aquatic plants floating on the water surface included Water-flaxseed (Spirodela polyrhiza) and Water-meal (Wolffia sp.). These plants almost completely covered the water surface from June through August.

Vertebrate inhabitants of the pond, in addition to the Mole Salamander, were the Spotted Salamander (Ambystoma maculatum), Tiger Salamander (Ambystoma tigrinum), Newt (Notopthalmus viridescens), Bullfrog (Rana catesbeiana), Common Snapping Turtle (Chelydra serpentina), Red-eared Turtle (Pseudemys scripta elegans), and Painted Turtle (Chrysemys picta). The stomach contents from one individual of each species of turtle were examined but failed to reveal the presence of salamanders.

Forms studied. The Mole Salamanders collected included 219 sexually immature larvae, 40 neotenic larvae, and 30 metamorphosed adults. Twenty-five adult Newts (Notopthalmus viridescens) and 25 Spotted Salamanders (Ambystoma maculatum), of which 15 were larvae and 10 adults, were also collected. The stomach contents of all specimens collected were examined and the data compared to determine the extent of food competition between these three species. Although the Tiger Salamander was sometimes present in the pond, it was not encountered in great enough numbers to justify comparison of foods consumed by it with similar

data for the other species.

Sampling techniques. Two hundred eighty-nine Mole Salamanders were collected between November 1, 1966 and October 31, 1967. Five or more specimens of A. tàlpoideum larvae and/or adults were taken during each of the 52 weekly collecting trips. Newts and Spotted Salamanders were collected during their breeding season while they were either in the pond or moving to or from it.

All collections were made during daylight, but some attempts were made to observe feeding behavior at night using artificial light. Specimens were collected with a dip net by wading along the edges of the pond. Usually one complete encirclement was made, thus insuring a more random sample than could have been secured from any one area of the pond. When the banks of the pond were not flooded some specimens were taken by means of drift traps. Others were captured by seining. During those periods when the water was over five feet deep, a casting net, a dredge net, and a dip net were used to capture specimens.

Invertebrates were collected weekly from debris retrieved with the dip net and placed in 70 per cent alcohol. These collections were identified and quantified in the laboratory as an index of food availability. A reference collection was made which included all invertebrates found in the pond during the study.

Preservation and examination of specimens. Captured specimens were immediately injected with 10 per cent formalin and placed in the same to arrest digestion of the stomach contents and preserve the

specimen. In the laboratory the specimen was slit lengthwise along the midventral line and the stomach freed from the esophagus and small intestine. The stomach was slit longitudinally and the contents washed into a petri dish containing a grid to facilitate accurate counting of the contents under a dissecting scope. Identification was not difficult because little digestion had taken place in the stomach. The contents were later placed in a separate vial containing 90 per cent ethanol and numbered to correspond with the salamander from which it was taken.

The bulk of the food items was not determined by weight or volume but a relative length classification was assigned to each. In determining the relative length of a food item, the average size of the first 15 individuals of each species removed from the stomachs was used as a standard. For example, assuming Cypricercus to have a relative length of one, Buenoa has a relative length of six, i.e., the latter is six times longer than the former.

Data recording. Records were made on field data sheets and included: the time of collection, date, temperature of the air and water, water level, water condition, species collected, and any general comments concerning changes in species and numbers of invertebrates. A series of pH tests of the water and soil of the pond was conducted.

In the laboratory data from individuals pertaining to species, age, sex, body length, tail length, whether neotenous or not, and food items consumed were placed on individual life history cards. In constructing the tables that appear in the next chapter, the invertebrate taxa were arranged according to Pennak (1964). Invertebrate food items were

identified and named at the generic level by means of Pennak's (1953) manual.

The results were tabulated by determining (1) per cent composition by number of items (obtained by dividing the number of times a specific item appeared by the total number of items), and (2) per cent of stomachs with item (obtained by dividing the number of stomachs which contained a specific item by the total number of stomachs examined). These calculations were made for the month, season, and year.

CHAPTER III

RESULTS

Food items available. The results of this investigation are summarized in graphic and tabular form. The graphs present food items identified to class, the tables to order level. Table I lists the results of a survey of the invertebrate fauna in the pond and shows which items were eaten by the Mole Salamander. These organisms were found in varying abundancies and at least during some season of the year.

Dietary items of sexually immature larvae of A. talpoideum. Of the 219 sexually immature larvae examined, the stomachs of 217 contained food. Tables II and III list the food items eaten, by month and by year, respectively. Figures 1 and 2 depict graphically the relative abundance of the food items eaten, by month and by year, respectively. Sexually immature larvae were collected during every month except October, when all larvae taken were neotenic.

Dietary items of neotenic larvae of A. talpoideum. Of the 40 neotenic larvae of A. talpoideum examined, all stomachs contained food. Figure 3 represents graphically the food items eaten for the year. Twenty of the neotenic individuals were taken during October, and the other 20 were taken between November and April. Due to the limited sample size and collection period, the data presented in Figure 3 can not be assumed to reveal an adequate picture of the food items consumed for each month of the year.

TABLE I

INVERTEBRATES PRESENT AND THEIR UTILIZATION AS FOOD BY THE MOLE SALAMANDER, BASED UPON 52 WEEKLY COLLECTIONS*

Item Present	Consumed by Mole Salamander
Phylum Annelida	
Class Oligochaeta	
Order Opisthopora (earthworms)	
Family Lumbricidae	Yes
Class Hirudinea (leeches)	No
Phylum Arthropoda	
Class Crustacea	
Order Cladocera (water fleas)	
Family Daphnidae	Yes
Order Eucopepoda (copepods)	
Family Cyclopidae	Yes
Order Podocopa (seed shrimps)	
Family Cypridae	Yes
Order Amphipoda (amphipods)	
Family Gammaridae	Yes
Class Arachnoidea (spiders)	No
Class Chilopoda	
Order Scutigeromorpha (centipedes)	Yes
Class Insecta	
Order Odonata (dragonflies)	
Family Libellulidae	Yes
Order Hemiptera (true bugs)	
Family Belostomatidae	Yes
Family Corixidae	Yes
Family Nepidae	No
Family Notonectidae	Yes
Family Gerridae	No
Order Megaloptera (dobsonflies)	
Family Corydalidae	Yes
Family Sialidae	Yes
Order Coleoptera (beetles)	
Family Dytiscidae	Yes
Family Gyrinidae	Yes
Order Diptera (true flies)	
Family Culicidae	Yes
Family Tendipedidae	Yes
Family Tipulidae	Yes

TABLE I (continued)

Item Present	Consumed by Mole Salamander
Phylum Mollusca	
Class Gastropoda	
Order Ctenobranchiata (snails)	
Family Amnicolidae	Yes
Order Pulmonata (limpets and orb snails)	
Family Ancylidae	Yes
Family Planorbidae	Yes
Class Pelecypoda	
Order Eulamellibranchia (fingernail clams)	
Family Sphaeriidae	Yes

*Present indicates that they were to be found in the pond, although perhaps not available to the salamanders because of burrowing or hibernating habits.

TABLE II

DIETARY ITEMS OF 219 SEXUALLY IMMATURE LARVAE OF A. TALPOIDEUM, BY MONTH*

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
OPISTHOPORA	.2	...	...	...	...	...	...	...	...	(+)	...	...
CLADOCERA	12.2	11.9	20.8	71.1	1.6	36.1	21.2	44.4	36.3		.03	3.9
EUCOPEPODA	...	...	...	...	...	...	...	...	...		...	.1
PODOCOPA	52.6	42.2	16.8	5.5	1.2	1.6	6.3	10.5	8.9		96.1	83.9
AMPHIPODA	14.1	28.4	23.8	5.7	6.7	9.4	1.4	19.1	48.4		.02	4.2
SCUTIGEROMORPHA	...	...	...	.1	...	...	...	...	...		...	...
ODONATA	.2	.7	1.6	.2	2.8	.5	.2	2.0	1.6		.02	.6
HEMIPTERA	...	...	1.1	.4	1.2	.5	.4	.3	...		.01	...
MEGALOPTERA	...	.3	.5	.2	.8	.2	.3	.3	...		...	...
COLEOPTERA	...	2.6	13.2	.4	1.6	.5	.2	...	.8		...	.1
DIPTERA	8.8	5.6	17.0	15.2	72.6	47.8	64.7	22.8	3.2		1.8	3.8
CTENOBRANCHIATA	...	...	...	...	2.0	1.4	.3	...	...		.003	...
PULMONATA	9.3	4.3	1.4	1.4	5.5	1.2	1.5	.7	.8		1.4	3.4
EULAMELLIBRANCHIA	...	...	...	...	4.3	.9	3.3	...	...		...	...
MOLTED SKIN	...	...	...	...	...	...	...	...	...		...	...
EGGS (A. TALPOIDEUM)	2.5	4.0	3.8	...	...	...	...	...	...		...	...

*Data are shown by percentage composition by number of items for each month.

+Insufficient data (all specimens were neotenic or adults).

TABLE III

DIETARY ITEMS OF 219 SEXUALLY IMMATURE
LARVAE OF A. TALPOIDEUM, BY SEASON AND YEAR

ITEM	WINTER NO. EX. 80		SPRING NO. EX. 67		SUMMER NO. EX. 73		FALL NO. EX. 31		FREQ. OF OCCUR.	TOT. NO. OF ITEMS FOR YEAR	PCT. COMP. BY NO. OF ITEMS
	NO.	%	NO.	%	NO.	%	NO.	%			
OPISTHOPORA	1	.06	...	...	...	...	...	...	.01	1	.01
CLADOCERA	132	7.5	1455	56.8	676	32.6	56	1.3	10.6	2319	21.9
EUCOPEPODA	1	.1	...	...	...	...	...	...	.01	1	.01
PODOCOPA	1197	68.1	172	6.7	142	6.8	3909	93.5	24.8	5420	51.3
AMPHIPODA	194	11.0	215	8.4	195	9.4	67	1.6	3.1	671	6.4
SCUTIGEROMORPHA	...	...	1	.04	...	...	...	...	.01	1	.01
ODONATA	9	.5	16	.6	19	.9	11	.3	.3	55	.5
HEMIPTERA	...	...	14	.6	8	.4	3	.1	.1	25	.2
MEGALOPTERA	1	.1	8	.3	6	.3	...	...	.1	15	.1
COLEOPTERA	9	.5	61	2.4	4	.2	1	.02	.3	75	.7
DIPTERA	96	5.5	541	21.1	959	46.2	75	1.8	7.6	1671	15.8
CTENOBRANCHIATA	...	...	5	.2	9	.4	1	.02	.1	15	.1
PULMONATA	90	5.1	45	1.8	25	1.2	57	1.4	1.0	217	2.1
EULAMELLIBRANCHIA	...	...	11	.4	34	1.6	...	...	.21	45	.4
MOLTED SKIN	3	.2	2	.1	...	...	...	...	.02	5	.1
EGGS (A. TALPOIDEUM)	24	1.6	14	.6	...	...	...	...	.2	38	.4

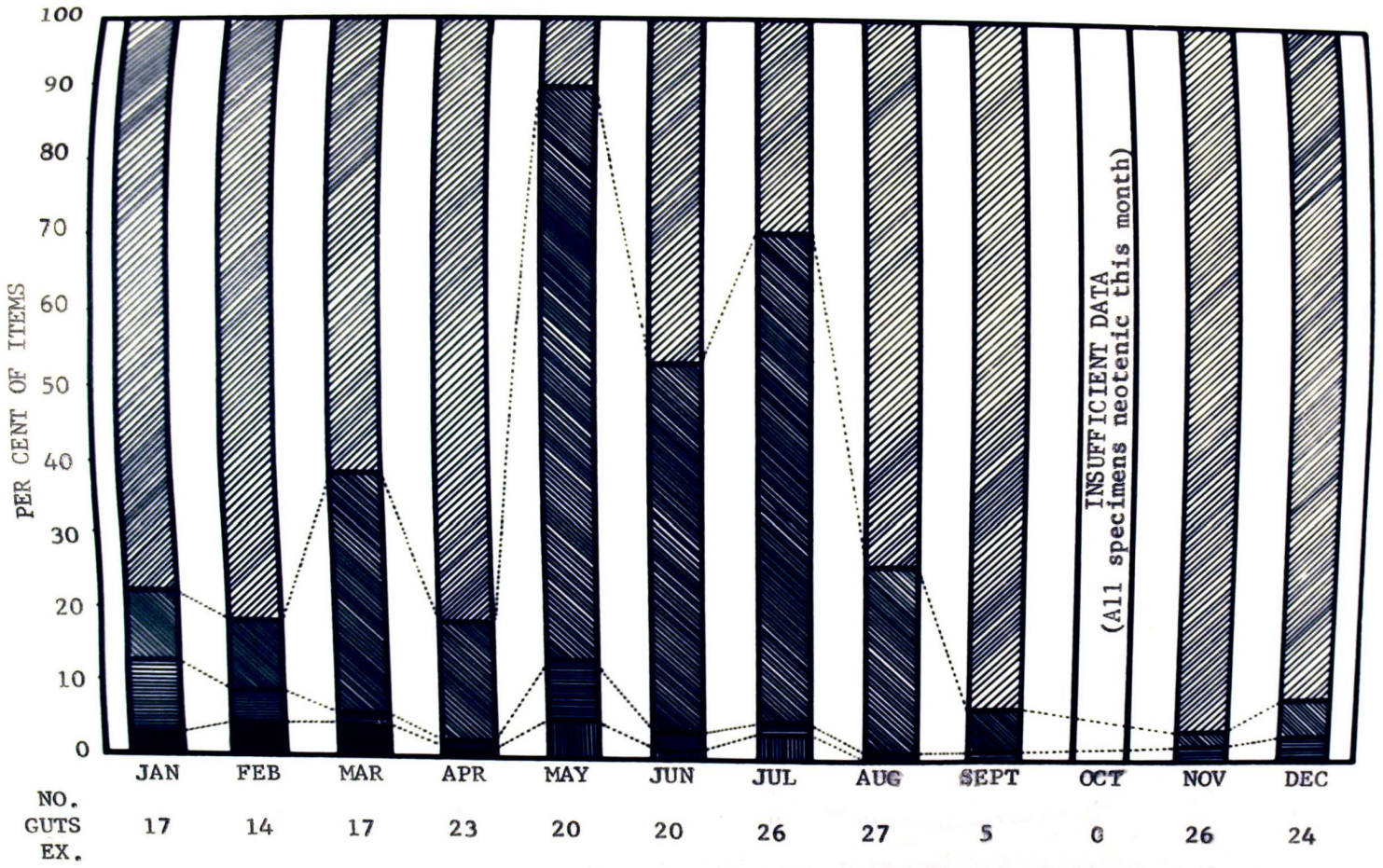

Figure 1. Dietary Items of 219 Sexually Immature Larvae of A. talpoideum, by Month

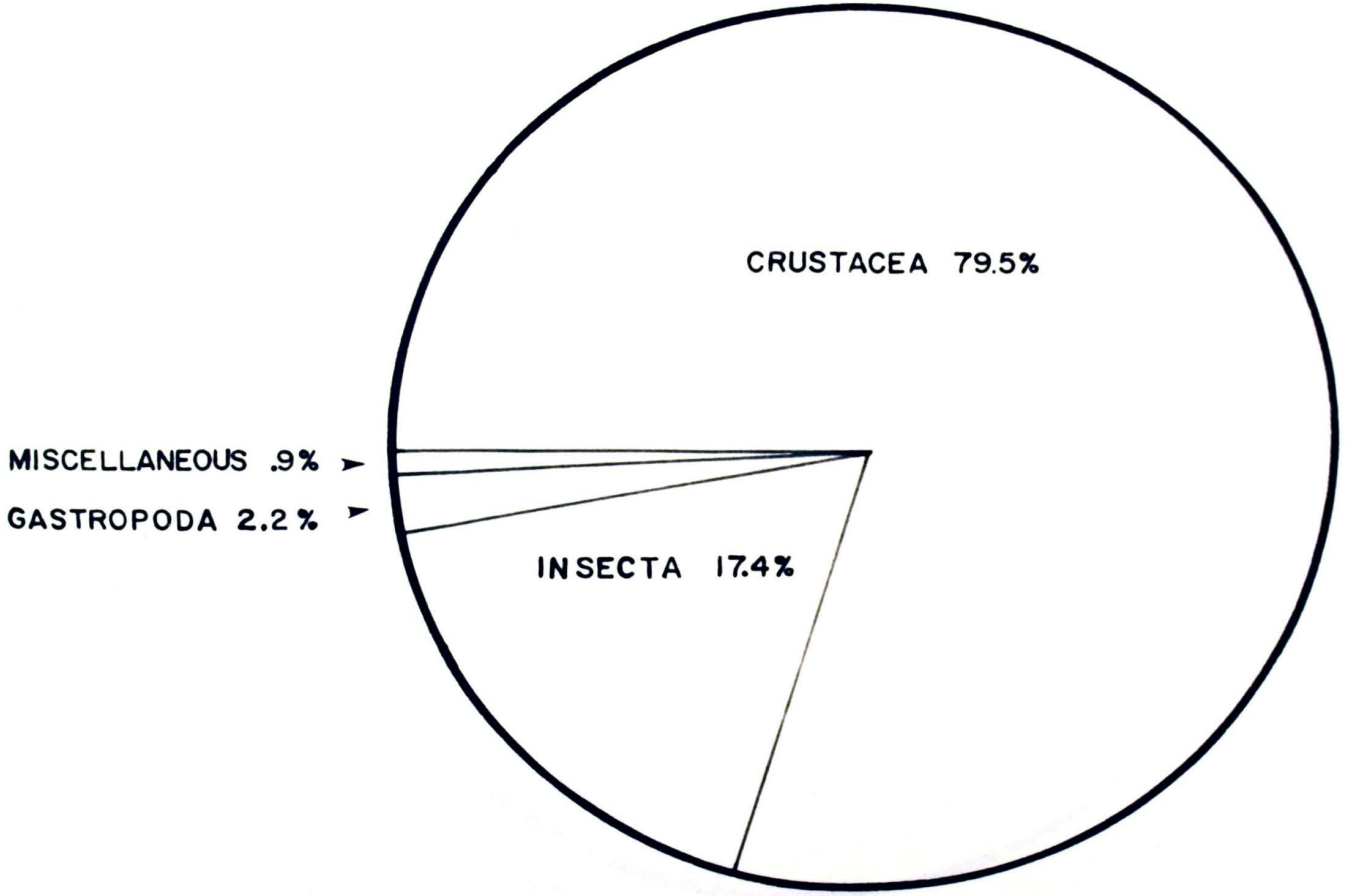

Figure 2. Dietary Items of 219 Sexually Immature Larvae of A. talpoideum, by Year

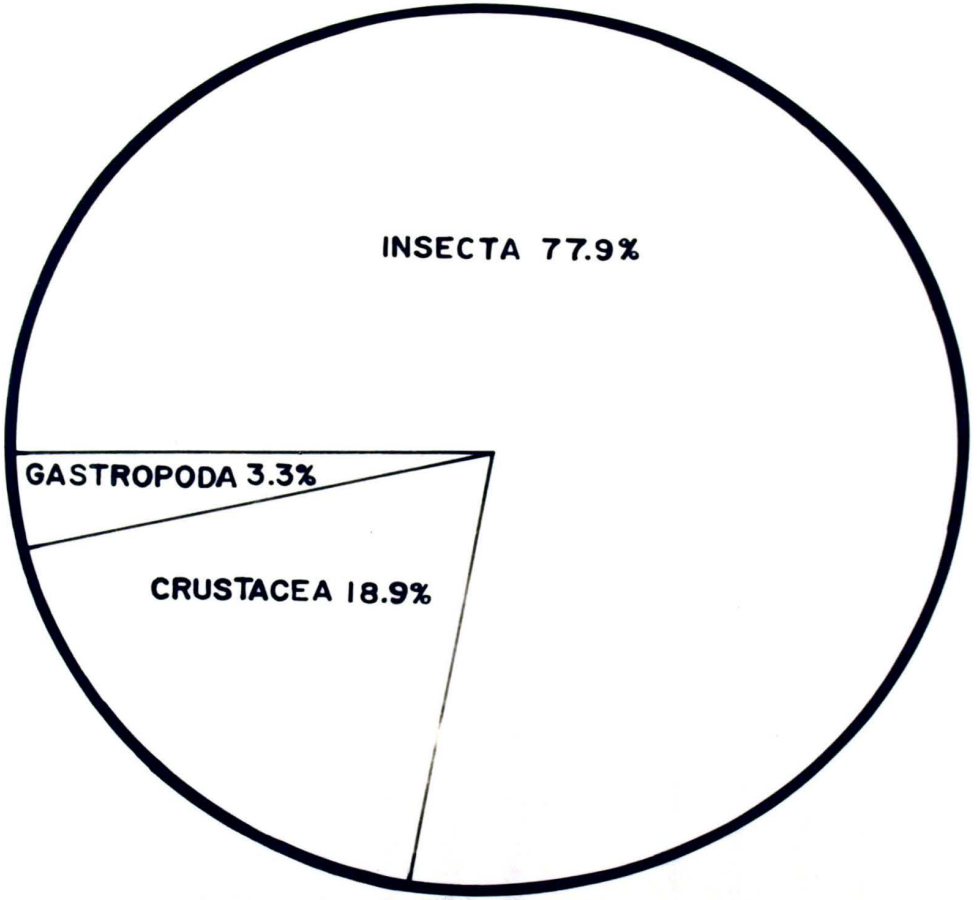

Figure 3. Dietary Items of 40 Neotenic Larvae of A. talpoideum, by Year

Dietary items of metamorphosed adults of A. talpoideum. Of the 30 metamorphosed adult A. talpoideum collected and examined from December through March, the stomachs of 16 contained invertebrate food. Eleven of those remaining contained molted skin, and three were empty. Figure 4 presents graphically the class composition of the food eaten for the year. Due to the limited sample size and collection period, the data presented in Figure 4 can not be assumed to reveal a valid picture of the food items consumed for each month of the year. During most of the year metamorphosed adults were terrestrial, and not in the pond.

Dietary items of all stages of A. talpoideum. Of the 289 specimens of A. talpoideum examined, the stomachs of 273 contained food. Those empty or with only molted skin were mostly from adults taken during the breeding season. Table IV is a monthly summary of the food items eaten, and Table V presents the same data summarized by season and year. Figures 5 and 6 present a monthly summary of the food items eaten by all stages of A. talpoideum.

Dietary items of other species of urodeles. Of the 25 A. maculatum examined (15 larvae and 10 adults), the stomachs of 21 contained invertebrate food. Of the remaining four, two were empty and two contained a few leaf fragments. A. maculatum adults were collected during their breeding season (January through February). Larvae were collected from March through May. Figure 7 summarized the dietary items consumed by adult A. maculatum for the year. The data has not been tabulated because of the small sample size. Due to the limited sample size and collection

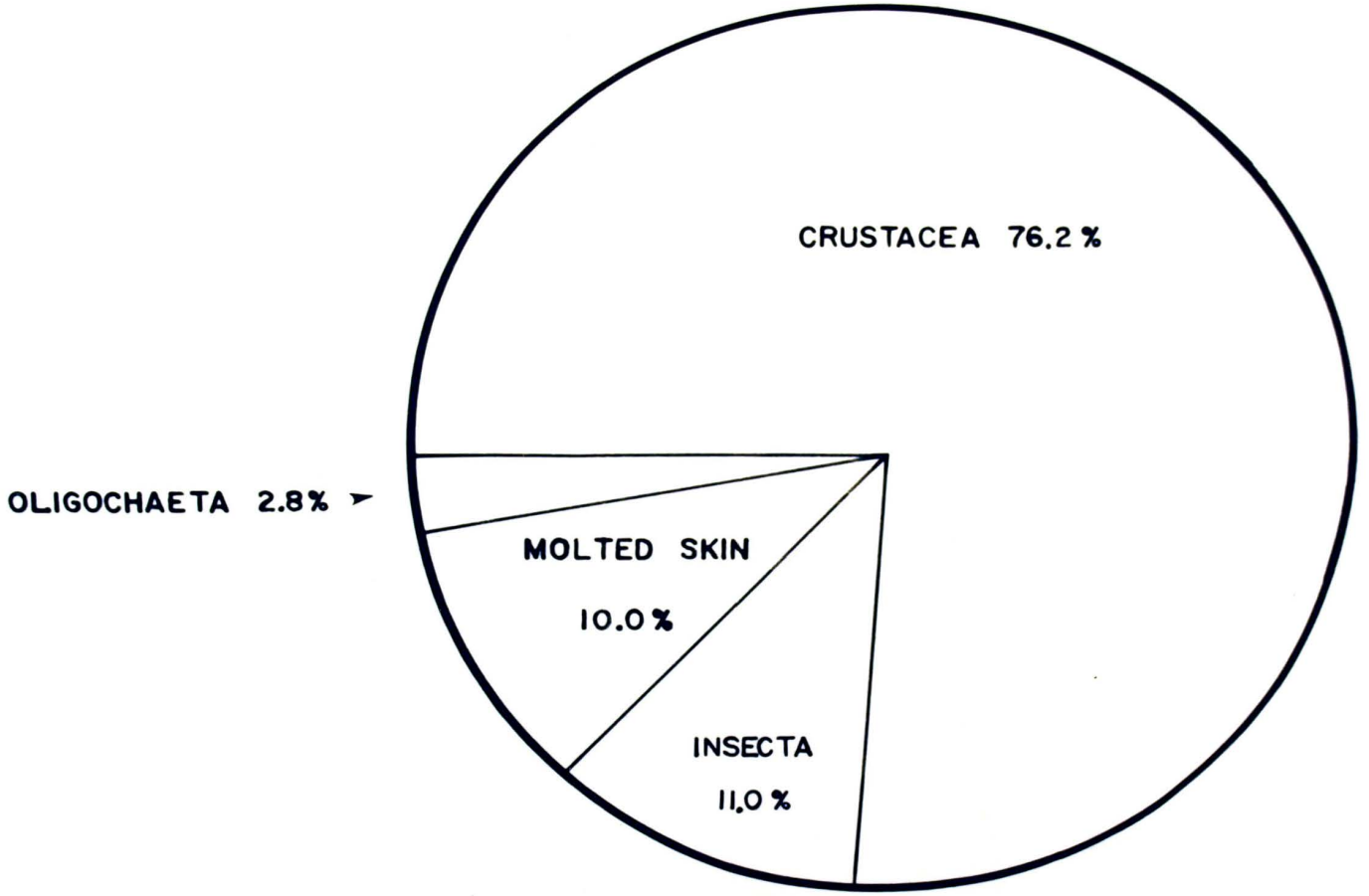

Figure 4. Dietary Items of 30 Metamorphosed Adults of A. talpoideum, December Through March

TABLE IV

DIETARY ITEMS OF ALL STAGES OF A. TALPOIDEUM, BY MONTH*

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
OPISTHOPORA	.2	...	.7	...	...	...	...	...	...	...	...	...
CLADOCERA	15.6	15.4	21.4	69.6	1.2	30.0	20.5	44.4	13.2	14.7	.3	4.2
EUCOPEPODA	...	...	...	...	...	...	5.4	...	...	...	...	.1
PODOCOPA	51.6	43.3	15.8	5.6	1.2	1.6	...	...	4.7	.3	95.7	84.5
AMPHIPODA	15.4	20.9	23.5	5.7	6.5	11.2	1.5	28.4	11.8	...	.2	3.9
SCUTIGEROMORPHA	...	...	...	...	...	...	...	...	...	...	...	...
ODONATA	.5	.5	...	.2	2.8	.5	.2	2.4	3.5	3.2	.2	.6
HEMIPTERA	...	...	1.2	.4	1.2	.5	.3	.3	...	.8	.1	...
MEGALOPTERA	...	.2	.7	.2	.8	.2	.3	.1	...	.5	...	...
COLEOPTERA	.2	2.0	12.4	.3	1.6	.2	.3	...	.2	...	2.0	.1
DIPTERA	4.0	5.3	15.8	16.7	73.0	51.7	67.0	23.7	65.9	75.3	...	3.6
CTENOBRANCHIATA	...	...	...	...	1.6	1.6	.3	...	.4	4.7	...	...
PULMONATA	9.8	3.6	1.2	1.4	5.7	1.6	1.1	.7	.2	.5	1.6	3.1
EULAMELLIBRANCHIA	...	...	...	...	4.4	1.0	3.2	...	...	...	...	...
MOLTED SKIN	...	...	...	...	...	...	...	...	...	...	...	...
EGGS (A. TALPOIDEUM)	2.7	8.9	7.3	...	...	...	...	...	...	...	...	...

*Data are shown by percentage composition by number of items for each month.

TABLE V

DIETARY ITEMS OF ALL STAGES OF A. TALPOIDEUM,
BY SEASON AND YEAR

ITEM	WINTER NO. EX. 80		SPRING NO. EX. 67		SUMMER NO. EX. 73		FALL NO. EX. 31		FREQ. OF OCCUR.	TOT. NO. OF ITEMS FOR YEAR	PCT. COMP. BY NO. OF ITEMS
	NO.	%	NO.	%	NO.	%	NO.	%			
OPISTHOPORA	1	.1	3	.1	...	...	...	...	.01	4	.03
CLADOCERA	179	9.2	1466	56.1	656	30.3	134	2.7	8.4	2435	20.9
EUCOPEPODA	1	.1	...	...	...	...	...	...	.004	1	.01
PODOCOPA	1322	67.9	179	6.9	61	2.8	3937	79.5	19.0	5499	47.1
AMPHIPODA	198	10.2	225	8.6	268	12.4	68	1.4	2.6	759	6.5
SCUTIGEROMORPHA	1	.1	...	...	...	...	...	...	.004	1	.01
ODONATA	10	.5	10	.4	21	.1	39	.8	.3	80	.7
HEMIPTERA	...	...	15	.6	7	.3	6	.1	.1	28	.2
MEGALOPTERA	1	.1	8	.3	5	.2	...	...	.1	14	.1
COLEOPTERA	10	.5	69	2.6	5	.2	1	.02	.3	85	.7
DIPTERA	79	4.1	575	22.1	1071	49.5	702	14.6	8.4	2427	20.8
CTENOBRANCHIATA	...	...	4	.2	10	.5	...	...	.05	14	.1
PULMONATA	92	4.7	46	1.8	23	1.1	67	1.4	.8	228	2.0
EULAMELLIBRANCHIA	...	...	11	.4	36	1.7	...	...	.2	47	.4
MOLTED SKIN	3	.2	2	.1	...	...	...	...	.02	5	.04
EGGS (A. TALPOIDEUM)	49	2.5	...	...	...	...	...	...	.2	49	.4

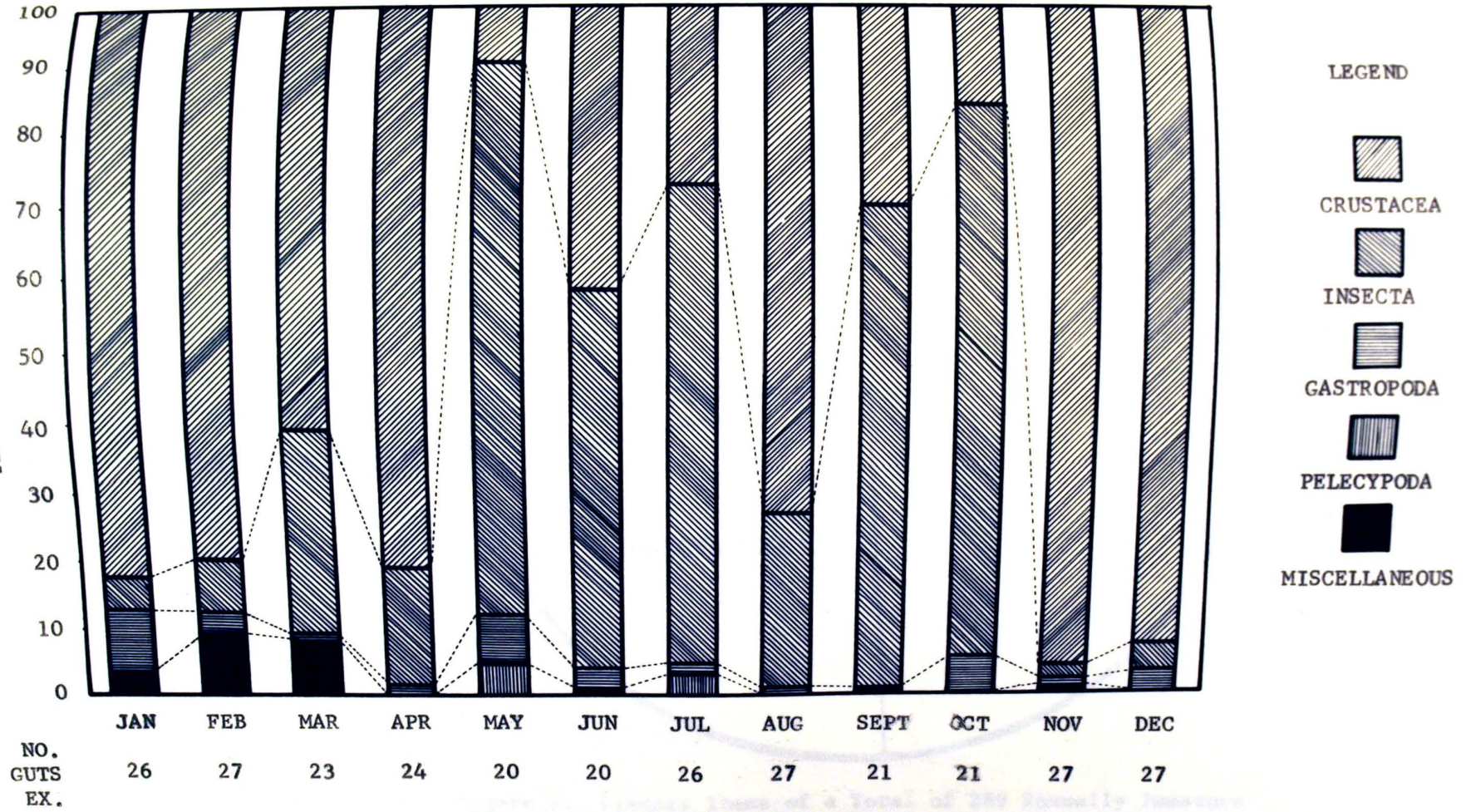

Figure 5. Dietary Items of a Total of 289 Sexually Immature and Neotenic Larvae, and Adult A. talpoideum, by Month

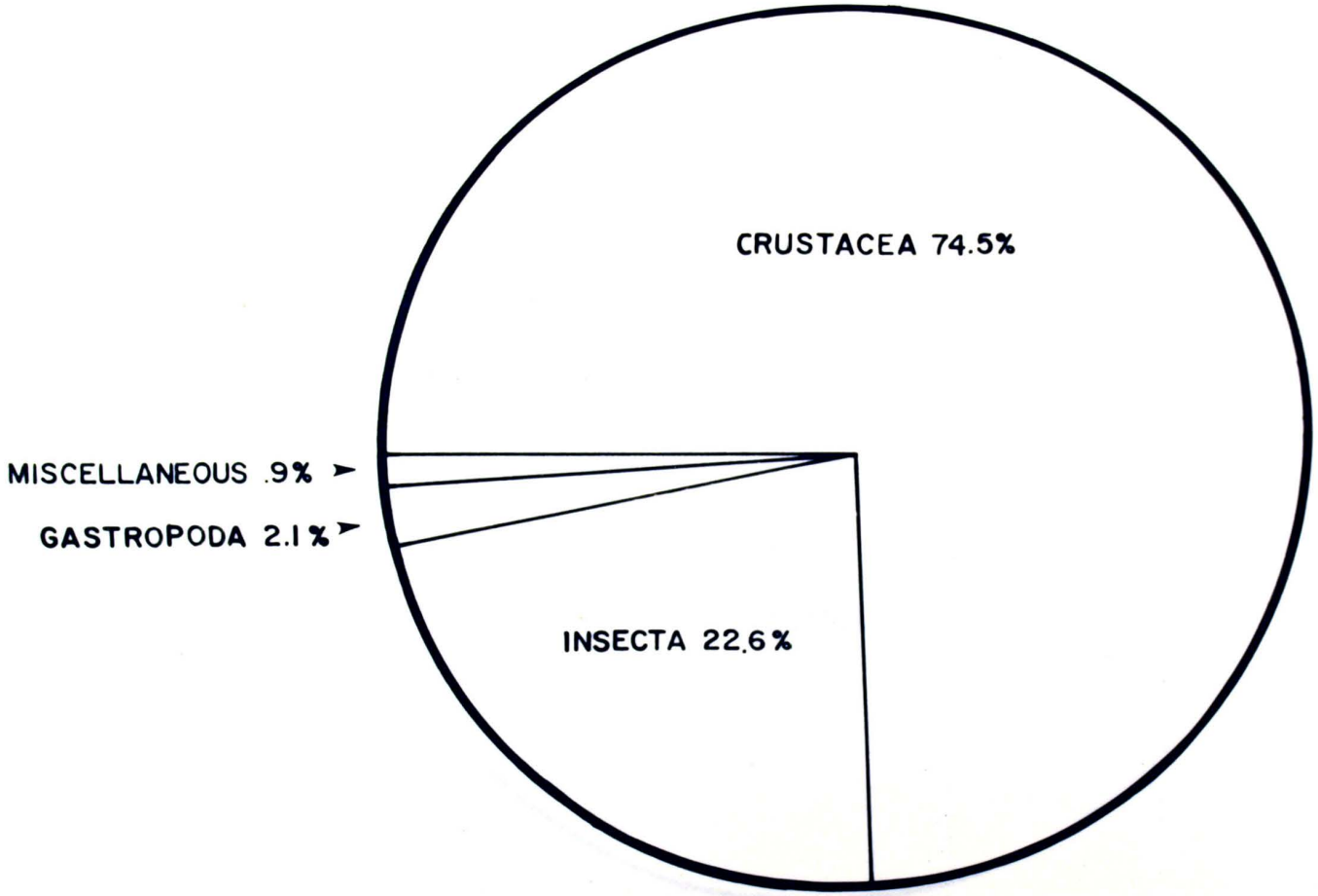

Figure 6. Dietary Items of a Total of 289 Sexually Immature and Neotenic Larvae and Adult A. talpoideum, by Year

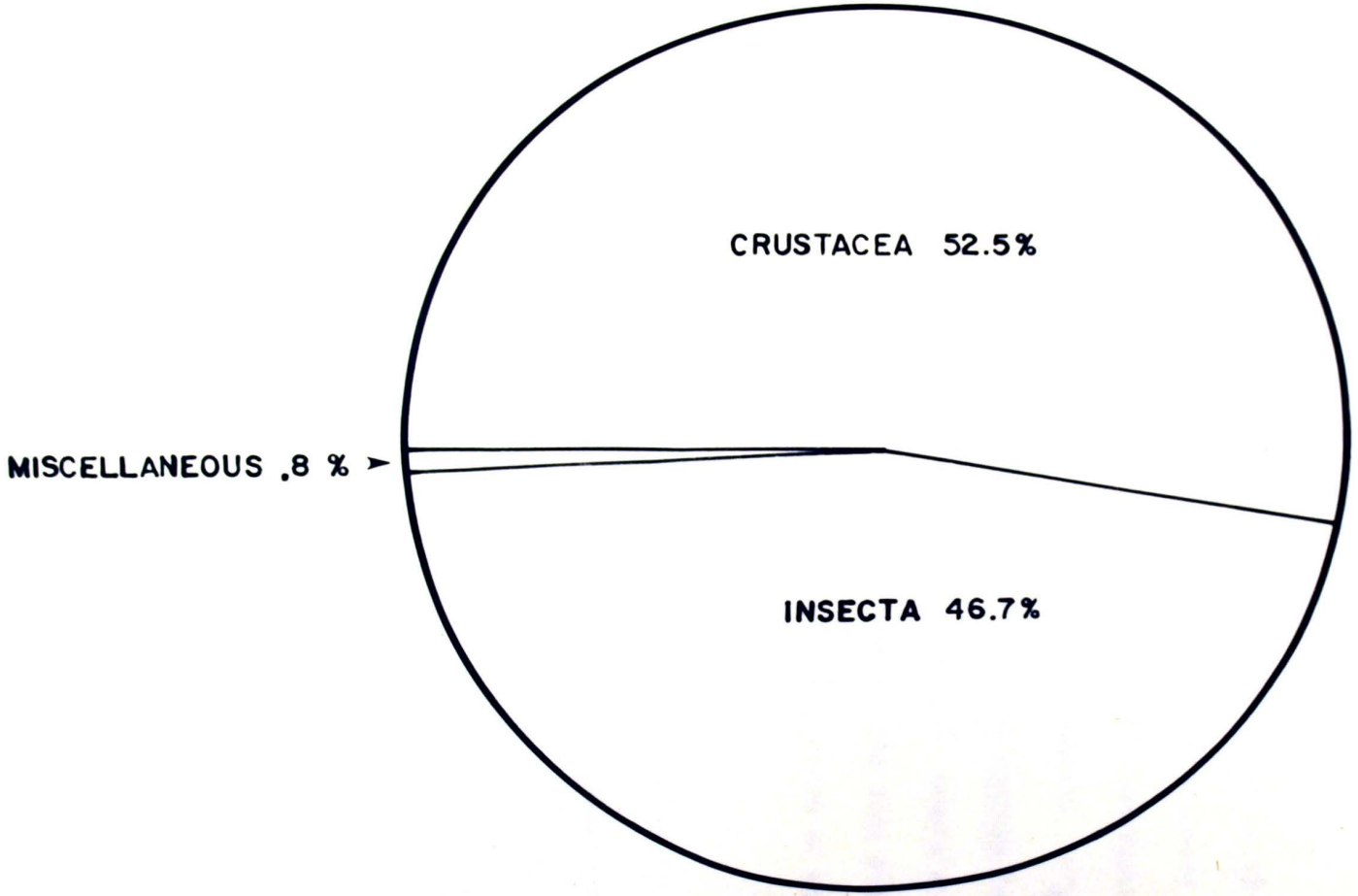

Figure 7. Dietary Items of 25 A. maculatum (15 Larvae and 10 Adults)

period, the data presented in Figure 7 can not be assumed to reveal a valid picture of the dietary composition of A. maculatum for the year. During most of the year A. maculatum adults were terrestrial, and not in the pond.

Of the 25 N. viridescens examined, the stomachs of 18 contained invertebrate food, one contained molted skin, and six were empty. The empty stomachs and the one with molted skin were from specimens collected during the breeding season (December through January). Figure 8 summarizes the dietary items consumed by adult N. viridescens for the year. Data have not been tabulated because of the small sample size. Due to the limited sample size and collection period, the data presented in Figure 8 can not be assumed to reveal a valid picture of the dietary composition of N. viridescens for the year.

Relative length of different dietary items. Table VI shows the relative lengths of the different food items eaten by all stages of A. talpoideum.

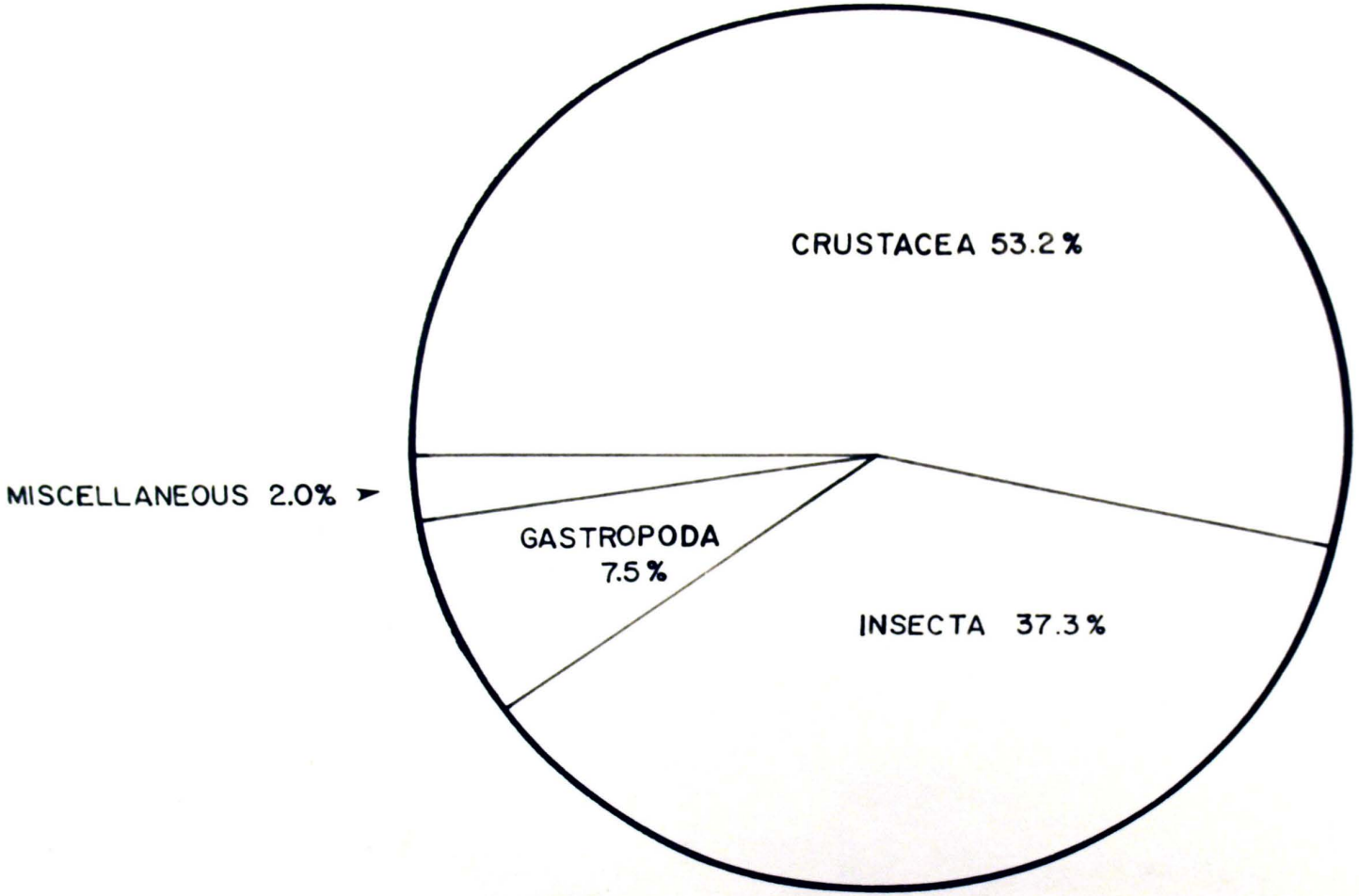

Figure 8. Dietary Items of 25 Adult N. viridescens

TABLE VI

RELATIVE MEAN LENGTH OF DIFFERENT FOOD ITEMS EATEN BY ALL STAGES OF A. TALPOIDEUM

Item	Millimeter(s)
Cypricercus	1
Cyclops	1
Daphnia	2
Ferrissia	3
Gyraulus	3
Amnicola	4
Gammarus	5
Buenoa	6
Chaoborus	8
Musculium	9
Culex	9
Hesperocorixa	10
Coptotomus	10
Tendipes	11
Sialis	11
Acilius	12
Plathemis	12
Belostoma	12
Dineutus	28
Corydalus	35
Tipula	36
Lumbricus	45

CHAPTER IV

DISCUSSION AND CONCLUSIONS

Food habits of sexually immature larvae of A. talpoideum. Crustaceans comprised 79.5 per cent of the yearly total of food items found in the 219 immature larvae. These organisms occurred in 38 per cent of the stomachs examined. The order Cladocera comprised 21.9 per cent of the total items for the year and occurred in 10.6 per cent of the stomachs examined. This order was represented by the following genera: Daphnia, Ceriodaphnia, and Simocephalus. One specimen examined contained a copepod (Eucopepoda) of the genus Cyclops. The order Podocopa (seed shrimps) comprised 51.3 per cent of the total food items eaten for the year and was represented in 24.8 per cent of the stomachs. These organisms comprised a greater proportion of the total diet in the fall (93.5 per cent) and winter (68 per cent) than in spring (6.7 per cent) and summer (6.8 per cent). This shift is correlated with a decrease in availability and consumption of insects in the fall and winter as illustrated in Figure 1, page 15. Although larger invertebrates were available, the Mole Salamander larvae fed mostly upon the smaller and more abundant seed shrimps. Cypricercus, averaging about 1 mm. in length, was the smallest invertebrate detected in stomachs (Table VI, page 27). Data from this study do not indicate any distinct predilection for certain prey species by the larvae, but the more motile invertebrates were ingested more frequently than the less motile ones. The availability and motility of Cypricercus, at all depths, rather than just at the surface as in the case of Culex, may account partially for its

frequency as a prey species. Mole Salamander larvae are definitely not primarily surface feeders as data do not reveal surface-dwelling invertebrates to constitute a significant part of the diet. When the pond became extremely turbid the diet of the sexually immature larvae did not change appreciably although a slight increase in the frequency of small crustaceans such as Cypricercus was observed. This suggests that vision is not the only means by which Mole Salamander larvae locate prey. Possibly the olfactory receptors and/or lateral line system function in this capacity. Mole Salamander larvae placed in an aquarium with the lights turned off were observed to continually swallow water. It is therefore speculated that larvae use their gill rakers to seine seed shrimps and other small organisms from the water during periods of high turbidity and/or darkness. Since some of the stomachs contained only seed shrimps, the possibility that their ingestion is accidental or coincidental to the ingestion of larger forms seems remote.

The food insects were almost exclusively larval or nymphal forms of aquatic species and unless otherwise indicated in the following discussion, this may be assumed.

Insects comprised 17.4 per cent of the yearly total of food items of the immature larvae (Figure 2, page 16). These organisms occurred in 8.4 per cent of the stomachs examined.

The order Odonata (dragonflies) comprised 0.5 per cent of the total items eaten for the year, and occurred in 0.3 per cent of the stomachs examined. Genera found included Plathemis and Celithemis. Forty-six of the 55 dragonflies found in the stomachs were taken from salamanders

captured in the spring, summer, and fall. During these seasons the dragonflies were still available, but with cold weather they moved deeper into the mud and leaf litter where they assumedly were inaccessible to the salamander larvae.

The order Hemiptera comprised 0.2 per cent of the yearly total of food items of the immature larvae. These organisms occurred in 0.1 per cent of the stomachs examined. Twenty-two of the twenty-five hemipterans eaten were from salamanders collected in spring and summer when these items were most abundant (Table III, page 14). No hemipterans were found in the stomachs of specimens collected in winter even though they were available. The most common genera were Hesperocorixa and Buenoa, in that order. Buenoa was found only in salamanders collected in summer when this hemipteran was most abundant and two of the four taken from stomachs were immature. The fact that notonectids "sting" sharply with their mouth parts may explain why they are not a common item in the diet of the salamanders in spite of their abundance.

The order Megaloptera comprised 0.1 per cent of the yearly total of food items and occurred in 0.1 per cent of the stomachs examined. Thirteen of the 15 megalopterans found in stomachs were Corydalus. These insect larvae were preyed upon mainly in the spring and summer when they were more abundant in the leaf litter. One specimen of Sialis was taken from a stomach in the spring. Both Corydalus and Sialis larvae lie buried under leaves, the latter often in mud, thus preventing their being preyed upon heavily.

The order Coleoptera comprised 0.7 per cent of the yearly total of food items, and occurred in 0.3 per cent of the stomachs examined.

Acilius and Coptotomus larvae were most frequently eaten by salamanders in the spring. Only three specimens of Dineutus (one adult and two larvae) were found in stomachs.

The Diptera (true flies) were the most commonly eaten insects. These organisms comprised 15.8 per cent of the yearly total of food items and occurred in 7.6 per cent of the stomachs. In order of dominance, Chaoborus, Tendipes, Culex, and Tipula were the invertebrates most often preyed upon. Most of these were taken by salamanders during spring and summer. Chaoborus (common phantom midge) was a much more common food item than Culex which was found in stomachs mainly from spring and summer. The former exhibits a jerky, lashing, swimming movement which is thought to attract the attention of the Mole Salamander larvae. According to Pennak (1953), Chaoborus exhibits pronounced daily migratory movements, being confined to the bottom waters during the day and migrating to the surface at night. Data indicate that the bottom water is the primary feeding zone of the Mole Salamander larvae and that they spend little time feeding on Culex at the surface. The fact that Chaoborus remains on the bottom during daylight hours and constitutes a substantial part of the diet suggests that the Mole Salamander larva is at least partially a diurnal feeder. Tendipedid larvae were found in stomachs principally during spring and summer but occurred much more frequently in the diet than Chaoborus during winter and fall. Tendipes larvae were available in relatively large numbers during all seasons, and were found to be very active in the leaf litter and feeding zone of the salamander larvae. Tipula larvae composed only a small portion of the total dipteran diet and

were found in stomachs during every season except fall. They inhabited both leaf litter and mud but were never found to be available in significant numbers.

Gastropods comprised 2.2 per cent of the yearly total of food items and occurred in 1.1 per cent of the stomachs. The order Pulmonata comprised 2.1 per cent of the gastropods eaten. The genera included were Gyraulus and Ferrissia, the former being eaten more frequently and appearing in larger numbers than the latter. Both inhabited the leaf litter and were fed upon by the salamander larvae during all seasons. Order Ctenobranchiata comprised 0.1 per cent of the yearly total of food items, and occurred in 0.1 per cent of the stomachs examined. Amnicola was the only genus found, and it was taken from stomachs during all seasons except winter. This species inhabited the leaf litter but was never found to be abundant.

Class Pelecypoda, order Eulamellibranchia, genus Musculium (fingernail clams), comprised 0.4 per cent of the yearly total of food items and occurred in 0.2 per cent of the stomachs examined. Musculium was an inhabitant of the leaf litter and was only found in the stomachs during spring and summer. The data do not suggest why these organisms were eaten only during summer except that the fingernail clams were much more abundant then.

Class Oligochaeta, order Opisthopora, genus Lumbricus comprised 0.01 per cent of the yearly total of food items, and occurred in 0.01 per cent of the stomachs. At 45 mm. (Table VI, page 27) this was the longest food item taken from the stomachs. Although earthworms were found quite frequently both in the water and along the margins of the

pond, Lumbricus was found in only one stomach, this taken in winter.

Class Chilopoda, order Scutigeromorpha, comprised 0.01 per cent of the yearly total of food items, and occurred in 0.01 per cent of the stomachs. Centipedes were commonly seen in the water after a hard rain had risen the water over logs and other debris.

Molted salamander skins, presumably their own, were found in the stomachs during winter and spring. Of the 219 larval Mole Salamanders examined, only five contained molted skins.

Mole Salamander eggs were frequently eaten by sexually immature larvae during winter and spring (breeding season). They comprised 0.4 per cent of the yearly total of food items and occurred in 0.2 per cent of the stomachs examined for the year. I suspect that chemoreception is used to identify the eggs as food.

Various materials were found in the stomachs which contained molted skins. Apparently the larvae ingested a few fragments of bark, sand, leaves, and Spirogyra incidental to the ingestion of the molted skin.

Food habits of neotenic larvae of A. talpoideum. Class Insecta comprised 77.9 per cent of the yearly total of food items found in the 40 neotenic larvae. Order Diptera, which contributed 74.0 per cent of the yearly total of food items, was the most important single group. In order of importance, the genera included were Chaoborus, and Culex, together contributing 68.1 per cent of the yearly total of food items. From August through March, Chaoborus were more abundant as potential food items than Culex, which appeared during March. As in the instance

of the immature larvae, the fact that Chaoborus was found in and near the benthic leaf litter during daylight hours may explain why it was preyed upon more than the surface-dwelling Culex. Tendipes (midges) comprised 5.9 per cent of the organisms eaten during the year.

The neotenic larvae included more insects in their diet than crustaceans even when the former were less abundant. Neotenic forms apparently restricted their movements and feeding more to the benthic leaf litter than did the immature larvae. Their burrowing habits are more pronounced than are those of the other stages of A. talpoideum in the pond. During cold weather they often feed under the leaf litter where insects burrow. The limited sample size and collection period make it inadvisable to assign relative preferences for various food items eaten by the neotenic forms although there seems to be a correlation between items consumed and their distribution in the pond relative to the regions frequented by the salamanders.

The class Crustacea comprised 18.9 per cent of the yearly total of food items consumed by the neotenic larvae. Order Cladocera (water fleas) appeared in 55.0 per cent of the stomachs examined and comprised 12.6 per cent of the yearly total of food items consumed. In order of decreasing frequency of occurrence, represented were Daphnia, Ceriodaphnia, and Simocephalus. Order Podocopa (seed shrimps) comprised 4.9 per cent of the yearly total of items consumed, and occurred in 17.5 per cent of the 40 stomachs examined. In order of decreasing frequency of occurrence the genera represented were Cypricercus and Candona. As I have suggested in the instance of the immature larvae, the majority of the crustaceans were probably ingested by swallowing

water and forcing it through the gill rakers, thereby straining out these minute food items. Order Amphipoda, genus Gammarus, comprised 1.4 per cent of the yearly total of food items consumed and occurred in 10 per cent of the stomachs examined.

Class Gastropoda comprised 3.3 per cent of the yearly total of food items consumed. Order Ctenobranchiata, genus Amnicola, contributed most of the gastropods, comprising 2.3 per cent of the items eaten. The food availability survey revealed this genus to be more abundant during all seasons than any other genus of snails. Order Pulmonata, genera Ferrissia and Gyraulus, comprised approximately 1 per cent of the diet.

Miscellaneous materials were found in only three of the 40 neotenic specimens examined.

No evidence of egg eating was found in neotenic larvae.

Food habits of metamorphosed adults of A. talpoideum. The most common food items of the 30 metamorphosed adult Mole Salamanders are represented in Figure 4 (page 19).

Class Crustacea comprised 76.2 per cent of the yearly total of food items and occurred in 66.3 per cent of the stomachs examined. Order Podocopa constituted 55.1 per cent of the total food items. Twenty-six per cent of the stomachs examined contained the seed shrimp Cypricercus. The finding of Cypricercus in stomachs always with other food items and never in great numbers suggests accidental ingestion. Since visibility was adversely affected by the turbidity of the pond, it is possible that olfactory receptors play a role in locating prey.

Order Amphipoda comprised 13.8 per cent of the crustaceans eaten. Gammarus was found to be quite abundant in the leaf litter at all seasons. Order Cladocera comprised 7.3 per cent of the yearly total of food items, and occurred in 6.7 per cent of the stomachs examined. In order of decreasing frequency of occurrence, the genera included were Daphnia, Ceriodaphnia, and Simocephalus.

Insects comprised 11.0 per cent of the yearly total of the yearly total of food items, and were represented in 30.0 per cent of the stomachs examined. Order Odonata, genus Plathemis, a dragonfly nymph, occurred most frequently. Order Coleoptera comprised 2.8 per cent of the yearly total of food items eaten with larval Acilius and Dineutus being most frequently eaten in that order. Dipterans comprised 2.8 per cent of the yearly total of food items eaten with larval Chaoborus, Tendipes, and Tipula being eaten in the same proportion. Order Hemiptera, genus Hesperocorixa, and Megaloptera, genus Corydalus each comprised one per cent of the yearly total of items.

Order Opisthopora comprised 2.8 per cent of the yearly total of food items, occurring in 6.7 per cent of the stomachs examined. Lumbricus was abundant as potential food during every season except winter. The occurrence of the earthworm more commonly in the stomachs of adult than in larval salamanders suggest that it was eaten while the adults were undergoing a terrestrial existence prior to their appearance in the breeding pond.

Molted skin comprised 10.1 per cent of the total of food items eaten and occurred in 36.7 per cent of the stomachs examined, suggesting

that the metamorphosed adult Mole Salamanders molt shortly after entering the breeding pond.

Miscellaneous materials such as bark, sand, leaf fragments, and Spirogyra were found in the stomachs containing the molted skins, suggesting that these items had been only accidently ingested while adherent to the molted skin.

The stomachs of three of the 30 adult specimens examined were completely empty. The data indicate that the metamorphosed adult Mole Salamander feeds sparingly if at all while in the breeding pond. Almost half of the stomachs of such forms examined contained only molted skins or were completely empty.

No evidence of egg eating by adult Mole Salamanders was found.

Ontogenetic changes in the food habits of A. talpoideum. The 40 neotenic larvae examined differed in their food habits from the sexually immature and metamorphosed adults in that the neotenic forms fed chiefly on insects during periods in which the latter two groups ate primarily crustaceans. Correlated with this difference in food is an apparent difference in feeding behavior. Data in regard to food consumption suggest the neotenic forms burrowed and fed deeper in the leaf litter and mud where the insects were found principally during cold weather.

An examination of the stomachs of 30 metamorphosed adult Mole Salamanders revealed that they fed chiefly on crustaceans, as did the sexually immature larva taken during the same months. No mollusks were found in the stomachs of adults as in stomachs of sexually immature and neotenic larvae.

Competition for food between urodelan inhabitants of the pond. This discussion of competition between the various urodelan species found in the pond is restricted to that period during which all were present in the pond, i.e., late fall and winter months during the breeding season. Figure 7 presents the data pertaining to the food items taken from the stomachs of the Spotted Salamander (A. maculatum) adults, and Figure 8 presents similar data for the Newt (N. viridescens).

In order of decreasing abundancies, the species of salamander present in the pond during the breeding season were A. talpoideum, A. maculatum, N. viridescens, and A. tigrinum. As indicated by Tables V and VI, and Figures 7 and 8, there was intense food competition between the three most common urodelan inhabitants of the pond during the breeding season. The stomach of the one A. tigrinum larva examined contained food items very similar to those of the Mole Salamander and therefore suggested food competition. Although competition for food is usually greater within than between taxa, N. viridescens was found to feed on essentially the same organisms as the three Ambystoma species, and in nearly the same proportions. Approximately 67.0 per cent of the Mole Salamanders' diet was crustaceans during the breeding season. The corresponding figure for the Spotted Salamanders was 52.5 per cent, for the Newts 53.2 per cent. Gastropods comprised approximately 2.1 per cent of the Mole Salamanders' diet, 1.0 per cent of the Spotted Salamanders', and 7.5 per cent of the Newts'. An examination of the orders, families, and genera of prey involved revealed that all four urodelan inhabitants fed upon the same species of invertebrates.

Correlation between food availability and food utilization. Some of the invertebrates presented in Table I (page 11) as being present in the pond were not readily available to salamanders due to their burrowing or hibernating habits. However, such invertebrates appeared more frequently in the stomachs of neotenic larvae than in other forms of A. talpoideum. Generally the data suggest that the Mole Salamander feeds on those organisms that are most available and abundant. The only invertebrates which were present occasionally and did not contribute to the diet of the salamanders were Collembola (springtails) and Blattaria (cockroaches). These organisms were frequently seen in the water after a hard rain had risen the water over logs and other debris.

Factors affecting choice of prey. It is apparent from this study that the sexually immature larva and metamorphosed adult A. talpoideum fed generally upon the most abundant and readily available food items. The notable exception was observed in the neotenic forms which ate fewer crustaceans than insects even when the former were more abundant.

All food items, regardless of size, were swallowed whole. The items consumed were usually less than 15 mm x 8 mm (Table VI, page 27).

Apparently the activity and mobility of the food item affects to some degree whether or not it is preyed upon. I observed that movement by a potential prey would stimulate the salamander and it would begin to stalk its prey. The salamanders lateral line system could function in this capacity. Chemoreception possibly is involved before the salamander lunges and snaps at the prey.

Distribution of invertebrates within the pond seemed to influence whether or not they were eaten. The Mole Salamander is not a surface feeder. Most of the food items were taken within one foot of the bottom. Some invertebrates exhibit daily vertical migrations in the pond, moving into and out of the salamanders' feeding zone. The Mole Salamander showed aggressive tendencies toward prey during periods of high light intensity. When placed in a lighted aquarium, they appeared to watch small guppies (Gambusia) and insects move, stalk them slowly or wait for them to come into range, then lunge and snap violently. When the light was turned off the salamanders would lie quietly on the bottom and gulp water. Dineen (1955) found that light intensity controlled to some extent what the Tiger Salamander fed upon.

Mole Salamander larvae are capable of seining small food items such as Cypricercus by use of their gill rakers. I believe this seining occurs mainly during darkness and/or when the water is turbid. During periods of higher light intensity (daylight and moonlight), and when visibility is good, the animal feeds upon the larger invertebrates in the pond.

CHAPTER V

SUMMARY

Data for this study were obtained by examining the stomachs of 289 Mole Salamanders (including 219 sexually immature larvae, 40 neotenic larvae and 30 metamorphosed adults), 25 Spotted Salamanders (15 larvae and 10 adults), and 25 adult Newts. All were collected from the same shallow, permanent, rain-fed woodland pond, located approximately eight miles northeast of Clarksville, Tennessee.

Specimens were collected during daylight by dip net, drift trap, seine, casting net, and dredge net, between November 1, 1966 and October 31, 1967. The stomachs were injected in the field with 10 per cent formalin to arrest digestion. The contents were later preserved in 90 per cent ethanol and identified and counted with the use of a dissecting microscope.

The important findings of this study are listed as follows:

1. The major food items of an aquatic population of Mole Salamanders were determined.
2. No conspicuous dietary changes occurred from one ontogenetic stage to another with the exception that neotenic forms consumed principally insects during periods when the other stages of A. talpoideum were feeding primarily upon crustaceans.
3. The Mole Salamander consumed mostly those organisms that were available and most numerous in its feeding zone, i.e., the water within about a foot of the bottom and among the benthic leaf litter. There were instances of poor or negative correlation between food availability and utilization. Notably Buenoa and Hesperocorixa, though normally abundant in the pond, were only rarely eaten by the salamanders. The former can inflict a painful bite.
4. No evidence of predilection was detected.
5. The data indicate that the Mole Salamander fed sparingly on surface dwelling invertebrates when the salamanders came to

the surface to take in air. Neotenic forms apparently burrowed more than the sexually immature and metamorphosed adult forms and took their food principally from within the leaf litter.

6. Sexually immature and metamorphosed adult Mole Salamanders fed chiefly upon crustaceans, insects and gastropods, in that order. Adult forms fed sparingly or not at all while in the breeding pond.
7. Neotenic larvae of A. talpoideum fed chiefly upon insects, crustaceans, and gastropods, in that order.
8. Mole Salamander larvae were capable or seining small invertebrates from the water by use of their gill rakers.
9. Data strongly indicate that during periods of high turbidity and darkness, Mole Salamander larvae fed principally by seining food items from the water. All three stages of A. talpoideum fed upon the larger invertebrates during periods of illumination.
10. The major food items were present in the pond throughout the year, but their abundance and distribution within the pond varied with the season.
11. Competition for food between the common urodelan inhabitants of the pond did occur.

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