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A study of the aspectional variations of Siphonaptera associated with the nests of the Thomas wood rat *Neotoma lepida lepida* Thomas

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A STUDY OF THE ASPECTIONAL VARIATIONS OF SIPHONAPTERA ASSOCIATED WITH THE NESTS OF THE THOMAS WOOD RAT *NEOTOMA LEPIDA LEPIDA* THOMAS[1]

J. FRANKLIN HOWELL

INTRODUCTION

The purpose of this study was to determine seasonal variations in flea populations associated with the nests of the desert wood rat *Neotoma lepida lepida* Thomas.

Faunal nest surveys are becoming increasingly important in connection with the ecology of mammalian parasites. Nest consort studies, not of seasonal nature, have been conducted in California, Oregon, and Utah concerning three species belonging to the genus *Neotoma*. Nevertheless, these nest studies were not on a yearly basis so as to show differences as analyzed from a seasonal aspect.

In addition to providing further information in the field of general flea ecology, there is the importance of such a study as it is related to plague ecology (disease-host relationships). Eskey and Haas (1939) reported the desert wood rat *(N. l. lepida)* as being plague implicated and it is known that plague implicated fleas inhabit the nest of *N. l. lepida* (Beck, Barnum, and Moore, 1953). Nothing is known about the population changes of these flease as demonstrated on a seasonal basis. This paper is presented to indicate what changes were noted from an aspectional point of view.

REVIEW OF LITERATURE

Siphonapterists have long known that flea consortes are found in the nests and on the bodies of host animals. Holland (1949) explains:

> "The number of adult fleas that may be removed from an animal is not necessarily indicative of the number belonging to it, as by far the greater proportion of them is frequently to be found in the nest. Some species rarely leave the nests at all."

Bishopp (1915) was one of the first to publish information relative to such flea associations. Rothschild and Clay (1952) in their study of bird fleas have found that certain species of fleas are associated with the nest rather than the host. The above authors give some aspectional differences related to flea populations.

With the advent of sylvatic plague surveys it became apparent that it was important to recognize the ecological factors related to the hosts and their flea consortes. Stewart and Evans (1941) have shown in their study of rodents and their burrows that there was a definite variation in populations of fleas as seen on an aspectional basis. Other workers, such as Holdenried, Evans, and Longanecker (1951),

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Longanecker and Burroughs (1952), and Burroughs (1947) have contributed information on the ecology of host-parasite relationships which includes some data relative to aspectional differences.

Eskey and Haas (1939) demonstrated that plague can be carried by wild rodent fleas and have listed many rodent fleas which may be implicated in plague epizootics. Meyer and Holdenried (1949) substantiated that transmission of plague may occur in nature. These men through their work have emphasized the importance and necessity of further ecological data concerning rodents and their parasites with regard to seasonal differences.

In his life history study of *Neotoma fuscipes* Rhoades, Vestal (1938) emphasizes the importance of nest and host consortes in connection with the ecology of the host. Walters and Roth (1950) worked out a faunal study of the nests of *Neotoma fuscipes monochroura* Rhoades in Oregon. Traub and Hoff (1951) considered the wood rat nests of prime importance in their distributional studies of fleas in New Mexico. Holland (1949) believes there is an indication that the nests serve as incubators of ectoparasites especially in arid regions. Thus the ecology of the nests of rodents is becoming increasingly important to the zoologist from a public health point of view.

DESCRIPTION OF AREA

The study area of approximately three square miles, lies three miles northeast of Jericho, Juab County, Utah, paralleling highway U.S. 6. The area has an average elevation of 5,200 feet above sea level. Physiographically the country is a rolling landscape with alternating low ridges and small valleys. The soil composition is of general sierozem and desert types (Odum, 1953). Scattered igneous and limestone rocks are characteristic of the area.

The predominant plants are the Utah juniper, *Juniperus utahensis* (Engelm.), sagebrush, *Artemisia tridentata* Nutt., and rabbitbrush, *Chrysothamus* sp. The junipers are characteristic of the low ridges while sagebrush and rabbit brush are usually confined to the valley flats. Many other shrubs and grasses occur throughout the area but are not in great abundance (Fig. 1).

NESTING HABITS

The life history and habits of some species of *Neotoma* have been worked out previously by Goldman (1910) and Richardson (1924). Others, such as Vestal (1938), have added much to the understanding of the life history of individual species. No attempt will be made in this study to give an extended discussion of the habits of *N. lepida*. Nevertheless, some important observations have been recorded and are described in brief below.

According to Richardson (1924), immdiately upon weaning the rat constructs a house.* The house is built from any available materials within the immediate environs. The house of *N. lepida* is

*The use of the term "house" follows the designation as applied by Vestal (1938).

made up of about 95 per cent sticks of various size, primarily juniper sticks, but thorny vegetation, bits of cactus, bones, stones, leaves, and almost anything else they can carry may be used.

An occupied house may be recognized at a glance, owing to its well kept appearance and the presence of slight repairs and additions (Goldman, 1910). Vestal (1938) in his study on *N. fuscipes* states that the rat continually adds to its house throughout the year. During the October collections in the present study it was observed that several of the houses exhibited a complete new layer of material deposited on the exterior of the house. Apparently building activity increases in preparation for the winter months.

The house, depending upon age, will vary in size from two feet in diameter and six inches in depth to seven feet in diameter and five feet in depth. The house in some way is usually associated with a juniper tree. The tree aids construction, provides protection, and is a source of food (Fig. 2).

Houses have from one to a half dozen entrances to burrows which run both above and below the surface of the ground (Fig. 3). Often during summer months, the nest may be seen from one of these entrances. To reach a nest all outer construction as described above must first be removed. An effort was made to collect only nests from houses which displayed habitance.

The term "nest" refers only to the finer materials forming the actual bed for the animal (Vestal, 1938). It is typically an oval pocket recessed into the wall or floor of the nest chamber (Fig. 3). Usually it is constructed of shredded bark but whenever possible fur, hair, and other soft material is used. In the laboratory a captive rat readily substituted cotton in preference to bark. As to size, a teacup will easily fit into the cavity of the usual nest.

Vestal (1938) indicates the presence of one or more chambers in the house of *N. fuscipes*. Observations made during this study indicate the presence of only one chamber in the house of *N. lepida;* the nest chamber. A few houses contained two nests but the consortes extracted indicated that only one nest was in regular use. Often each of the two nests were in separate chambers but it seems apparent that one chamber was abandoned. The nest chamber is characterized by cuttings and excreta (Fig. 3). This chamber lies on a foundation of heavy sticks which are held together by accumulated deposits of excreta.

Not only does the rat add to his house during the year but changes are observed in the nest according to the season. During the late spring and summer months the nest is not oval as stated, but more of a saucer shape. As the season progresses the nest is reconstructed and again assumes an oval shape.

METHODS AND MATERIALS

Field Equipment.—The equipment used to collect the nests consisted of a pick-ax, heavy leather gloves, and large paper bags. The pick-ax was used to facilitate the tearing apart of the house in order

to obtain access to the nest. Heavy leather gloves were very useful when the house or nest contained thorns or other materials that might cause skin abrasions.

Each nest that was collected was placed in a paper bag, the top of which was sealed to prevent the escape of consortes. Six to eleven nests were collected each month from February, 1954 to January, 1955.* Only those nests showing evidence of occupancy were collected, this being statistically important both quantitatively and qualitatively.

Laboratory Methods.— In the laboratory, each nest was placed into a modified Berlese funnel and left for a twenty-four hour period. The consortes were collected in a catch-bottle containing 70 per cent ethyl alcohol, which was fitted to the base of the funnel. Sorting of the organisms was done by use of a medicine dropper under a dissection microscope.

The fleas were immediately processed and identified. All other consortes from each nest were segregated into various taxonomic groups, properly labeled, and preserved as separate units. This keeping of all consortes was done to facilitate further study, if desired, as it might relate to this project.

Flea Mounting Techniques.—The techniques used are:

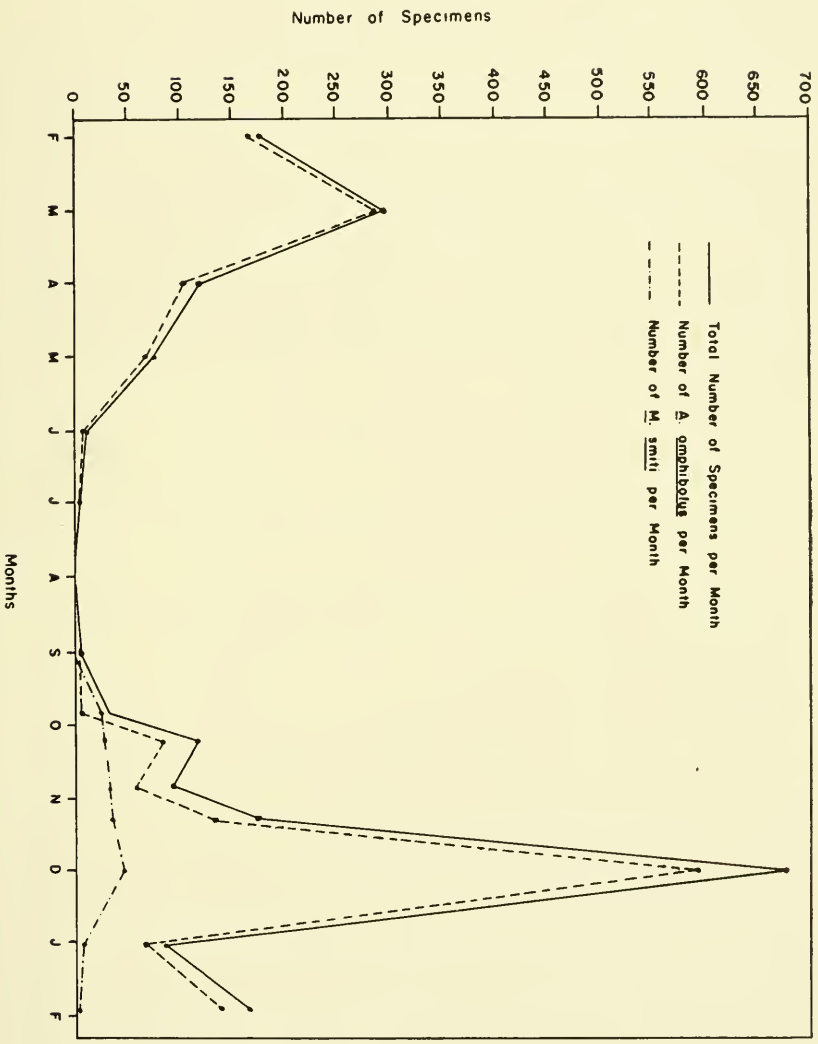
1. NaOH (five per cent) Remains in solution until cleared (24-72 hrs.)
2. Water (12 hrs.)
3. 50 per cent acid ROH (2 hrs.)
4. 70 per cent ROH (2 hrs.)
5. 85 per cent ROH (2 hrs.)
6. 95 per cent ROH (2 hrs.)
7. 100 per cent ROH (2 hrs.)
8. Oil of Wintergreen (12 hrs.)
9. Mount on microslide in clarite.

DISCUSSION

In 1939, Eskey and Haas indicated the importance of burrow openings and excavated nests in connection with flea populations. Since 1939 two detailed studies have been made concerning those species of fleas found in rodent burrows and also of the species found upon the host. The first, by Stewart and Evans (1941), establishes definite seasonal variations among those fleas in the burrow and on the host. The second, by Holdenried, Evans, and Longanecker (1951), was a continuation of the first and covered a five-year period (1940 to 1945). Both of the above studies were in agreement regarding the flea populations.

A number of species of nest and burrow inhabiting fleas have been implicated with plague transmission (Eskey and Haas, 1939). Therefore, from the standpoint of plague-vector relationship, it is

*During the summer months when no fleas were found extra nests were collected to test the validity of the sampling. Otherwise the sample was constant throughout the study. (See data sheet.)


Number of Specimens
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
F
M
A
M
J
J
A
S
O
N
D
J
F
Months
Total Number of Specimens per Month
Number of A. amphibolus per Month
Number of M. smiti per Month

important to recognize kinds of consortes located in nests and burrows of host organisms.

Hampton (1940) published an account showing the presence of plague organisms in *N. l. lepida.* With *N. l. lepida* implicated as a host animal for both the disease organism and the vector it was deemed important to observe population variations of implicated vectors as found in the nests of the host.

Beginning February 6, 1954, nest collections of the desert wood rat *(N. l. lepida)* were begun and extended over a period of twelve months, ending January 24, 1955. All collections were made in the Jericho area as stated. The 98 nests collected contained an average of twenty plus fleas per nest giving a total of 2023 specimens. Although there were only two predominant species (*Megarthroglassus smiti** and *Anomiopsylla amphibolus* Wagner), eleven species were identified from the collections.

They are:

Monopsyllus wagneri wagneri (Baker)
Monosyllus sp. **
Anomiopsylla amphibolus Wagner
Epitedia stanfordi Traub
Orchopeas sexdentatus agilis (Rothschild)
Orchopeas leucopus (Baker)
Atyphloceras echis Jordan and Rothschild
Thrassis gladiolis caducus (Jordan)
Meringis parkeri Jordan
Megarthroglossus smiti *
Malaraeus euphorbi (Rothschild)

Various species of fleas demonstrate greater or lesser host specificity. It is also known that some interchange in fleas constantly occurs between various hosts in nature. Such fleas not commonly found upon any given host may be identified as accidental or occasional parasites. In a study involving several months of observation it would be expected that a certain number of occasional or accidental flea parasites would be found associated with a given species of host. Likewise there would be found other species which would be quite host specific. With reference to the species in this study, it seems to be entirely evident that *A. amphibolus* is restrictive in host association to *N. l. lepida* and related species. Other authors have also found this to be the case (Hubbard, 1947; Holland, 1949). Not much is known about the new species *Megarthroglossus smiti* but it too seems to be restricted to *N. l. lepida* from data gathered to date. *M. w. wagneri* and *E. stanfordi* on the other hand are listed by most authors as being "mouse" fleas, most commonly found associated with species of the genus *Peromyscus.* Since the above two rodents live in close association in this area, occasionally finding an accidental host relationship can easily be understood.

*Eustorgio Mendez at Berkeley, California has recently completed an unpublished monograph of the genus *Megarthroglossus.* Specimens of this genus were sent to him for examination. He classified them as a new species which he named *M. smiti.*

**All specimens not identified to species were females. Specimens of this sex are sometimes difficult to accurately place to species in the absence of males.

Population trends for all species in this study are described in Fig. 5. Analysis of this graph indicates very definite seasonal differences. The late spring and early fall months show sparse population, the summer months showing no appreciable numbers of individuals as contrasted to the very high population density during the late fall and winter months.

The present study indicates that certain species appear seasonally predominant. *M. smiti* is predominant early, being the first flea to appear in the fall (September), leveling off in numbers during the winter and almost completely disappearing by late winter (February). *A. amphibolus* occurs in greatest numbers during late fall, winter, and spring, the peak coming between December and March (Fig. 5). The drop in population during January cannot be fully explained at present. The fact that no adult fleas of any species were found in the nests during the period from June to September is of special interest. This study and the study of Traub and Hoff (1951) are in agreement regarding summer populations. The ecological factors influencing the decrease in summer populations are unknown. *E. stanfordi* seems to be evenly distributed throughout the fall, winter, and spring. All other species related to this study have an irregular appearance.

Beck, Barnum, and Moore (1953) made a comparative nest consort study of *N. l. lepida* and *N. cinerea* (Ord) during the months of October and November of 1952. A comparison of their studies and those made by the author with regard to comparative seasonal populations is interesting. For the same period of time in both studies there was a close similarity in genera and species collected. Not only are the species similar but in many cases the number of specimens of a particular species are similar (Table I).

The species which do not follow the same population pattern in the two studies are *M. w. wagneri*, *M. euphorbi*, and *E. wemmanni*. *E. wemmanni* is represented by only one specimen and would seem insignificant to the study comparison. *M. w. wagneri* and *M. euphorbi* occurs frequently in the 1952 collections. are absent or nearly absent in the 1954 collections (Table I). Both species are commonly found on deer mice *(Peromyscus)* although they often are of accidental occurrence on many other species of rodents. Hubbard (1948) lists *Peromyscus* and *Neotoma* as common hosts of these two fleas. The association of the two rodents and their fleas would indicate a close relationship in this particular ecological situation. Thus, the study of Beck, Barnum, and Moore serves as a quantitative and qualitative check for the specific period compared.

ECONOMIC AND MEDICAL IMPORTANCE

Fleas are a definite menace to the health of man and animals, either as an entomophobia or as direct vectors of diseases. They are of wide distribution, numerous, and very definitely of parasitic habit in the adult stage. In the Rocky Mountain region, fleas are believed

to be common vectors of plague, tularemia, and typhus fever (Stark, 1948). Stewart and Evans (1941) said:

> "Because of the difference in seasonal distribution of fleas, collections should be correlated with those times of year when species capable of transmitting the infection are abundant. It is quite possible that many of those areas heretofore recorded as being free from plague infection have been placed in this category because they were surveyed at a time when efficient vectors had been largely replaced by species which are either very poor vectors or incapable of transmitting plague."

TABLE I

A COMPARISON OF THE FLEA POPULATION OF 1954 AND 1952 IN THE NESTS OF THE DESERT PACK RAT

SPECIES	Oct. 13, to Nov. 17, 1952	Oct. 8, to Nov. 12, 1954
	No. of Specimens	No. of Specimens
Anomiopsylla amphibolus	206	270
Orchopeas sexdentatus	6	1
Malaraeus euphorbi	45	2
Monopsyllus w. wagneri	18	0
Atyphloceras echis	5	2
*Megarthroglossus smiti**	34	97
Epitedia wemmanni	1	0
Epitedia stanfordi	34	8
Meringis parkeri	1	0

Fleas implicated with plague in the Western United States have been listed by Eskey and Haas (1939). A list of plague implicated fleas for Utah is found in the reports of studies conducted by Allred (1951) and Beck (1955). Of the fleas listed for Utah in the above reports, the following species have been found as consortes in the nests of *N. l. lepida* in this study:

Monosyllus w. wagneri
Orchopeas sexdentatus
Thrassis sp.

M. w. wagneri and *O. sexdentatus* are listed as potential vectors of plague, e.g. in the laboratory they experimentally transmit plague. *Thrassis* sp. is listed as a capable vector of plague, e.g. they are known to transmit plague in nature (Allred, 1951). The genus *Thrassis* is listed because several of the species of this genus outside of Utah have been proven plague positive (Allred, 1951). These same species do occur in Utah.

**Megarthroglossus d. divisus* collected in the 1952 study is synonomous with *M. smiti*.

This report has attempted to facilitate a better understanding of the problem of seasonal variations of flea populations. It has established data which can be used to accurately identify the seasonal variations in flea populations for such consortes in the nests of *N. l. lepida* in central Utah. Whether this data will be valid within other areas of the state is not known. Such information when applied to vectors of disease adds much to the understanding of ecological factors related to these vectors as has been mentioned above for plague. The same can be said for general disease ecology.

CONCLUSIONS

From the 2023 specimens of fleas collected over a twelve month period near Jericho, Juab County, Utah, two definite seasonal variations in populations have been found. The entire flea population analyzed statistically on a year's basis, indicated a relatively low population existed from May through September, while October through April displayed a comparatively high population of fleas.

The most abundantly collected species of flea which was taken was *A. amphibolus*. This is a flea which is not usually found in any great numbers on the body of the host animal, but occurs in abundance in the host nests at certain seasons of the year. Of the total number (1726) taken the peak population was reached in December. They gradually begin to thin out and completely disappear in July. They begin to reappear in late September.

A comparison of data between this study and one made by Beck, Barnum, and Moore for the months of October and November shows many points in common. The species listing and population figures are much in agreement.

With reference to the economic importance of this study it has been pointed out that of the eleven species, two *(O. sexdentatus* and *M. w. wagneri)* are defined by Eskey and Haas (1939) as being potential vectors while certain species of *Thrassis* are listed as being capable vectors of plague.

This study indicates that it is especially important to make year round collections in order to establish accurate distributional records for any locality. It is quite apparent that a single or several collections made in the summer months with respect to species found in this study would not have accurate representation from a distributional point of view. It likewise emphasizes the need for seasonal observations to gain a proper perspective in population index.

This study has revealed that the greater population of fleas found in the nests are not particularly implicated with plague. However, it is believed that some of these species of fleas are involved with other diseases as vectors, such as typhus and tularemia.

The general examination of all other consortes of the nests seems to show responses to reasonal variations as determined by the population index. Some of these consortes were: mites, soft-bodied ticks, hard-bodied ticks, spiders, pseudoscorpions, and other arthropods.

FIG. 4

Date Collected	*Anomiopsylla amphibolus*	*Monopsyllus wagneri wagneri*	*Epitedia stanfordi*	*Monopsyllus* sp.	*Orchopeas leucopus*	*Orchopeas sexdentatus agilis*	*Atyphloceras echis*	*Thrassis gladiolus caduceus*	*Meringis parkeri*	*Megarthroglossus smiti*	*Malareus euphorbi*	B.Y.U. Field Number Project X	Total Number Collected
Feb. 6, 1954	168	1	8									3817	177
March 13	293		1					1				3820	295
April 11	105	6	5			1			1			3828	119
May 8	69	1	3							2		3834	75
June 9	9	1										3838	10
July 8	4											3855	4
August 10												3885	
September 3	2											3916	2
September 29	4									27		3917	31
October 8	82		3				2			29		3918	116
October 29	54		3	2		1				33		3919	93
November 12	134	6	2							35	2	3920	174
December 2	595	2	22		7		7			46		3927	679
Jan. 7, 1955	68		5				2	1		8		3934	84
January 24	139		5			1	16			2		3935	163

Record of Specimens Collected

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Fig. 1. Study area, a typical sagebrush-juniper community.

Fig. 2. The woodrat house.

Fig. 3. Cutaway of woodrat house showing the position of nest (scalpel) and burrows.