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An Analysis of Mite Populations in Muskrat Houses[1]

ROBERT A. BUCKLEY[2] AND ELLIS A. HICKS[3]

Abstract. During the summers of 1960 and 1961, samples of material from muskrat houses in Goose Lake, Hamilton County, Iowa, were analyzed for their acarine content to obtain information on the factors influencing the composition of mite populations. Representatives of 18 different families or groups were obtained. Their ecology is discussed from the following relationships: (1) immediately available flora and composition of muskrat houses, (2) size of houses and occurrence of mites, (3) utility of houses and occurrence of mites, (4) sampling area of houses and occurrence of mites, and (5) the mite populations themselves.

INTRODUCTION

Houses for the muskrat, *Ondatra zibethicus* (L.), afford opportunities for studying an interesting complex of mite populations. The profuse organic material, both of plant and animal origins and in varying degrees of decay and wetness, constitutes an abundant food supply for detritus feeders. These are utilized by predaceous mites, some of which, in turn, are preyed upon by other mites.

The area chosen for study was Goose Lake, located one-half mile east of Jewell, Iowa, in Hamilton County. This lake, private-

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ly owned, covers an area of approximately 80 acres. Hunting is restricted to the fall season, and, since the lake is not open to the public, it is relatively free of disturbances from boating, fishing, hunting and bathing. These factors, together with the proximity of the area to the Iowa State University campus, constituted a desirable situation for conducting field work.

The houses chosen for sampling were distributed as shown in Fig. 1. Selection of those near the middle of the lake resulted in a degree of isolation impossible to obtain with those near the periphery. Consequently, some sites were chosen near the shoreline of the islands rather than along the outer lake shore.

Figures 2 and 3 show the distribution of vegetation in Goose Lake in the springs of 1960 and 1961 respectively. Immediately

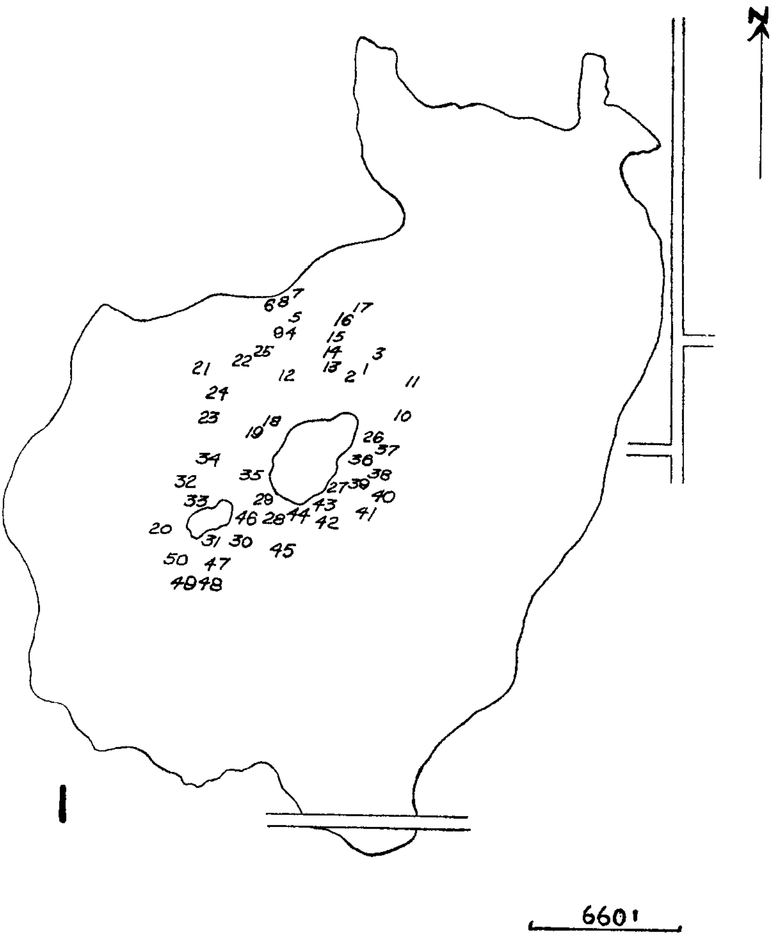

Fig. 1 Map of Goose Lake showing location of muskrat houses sampled.

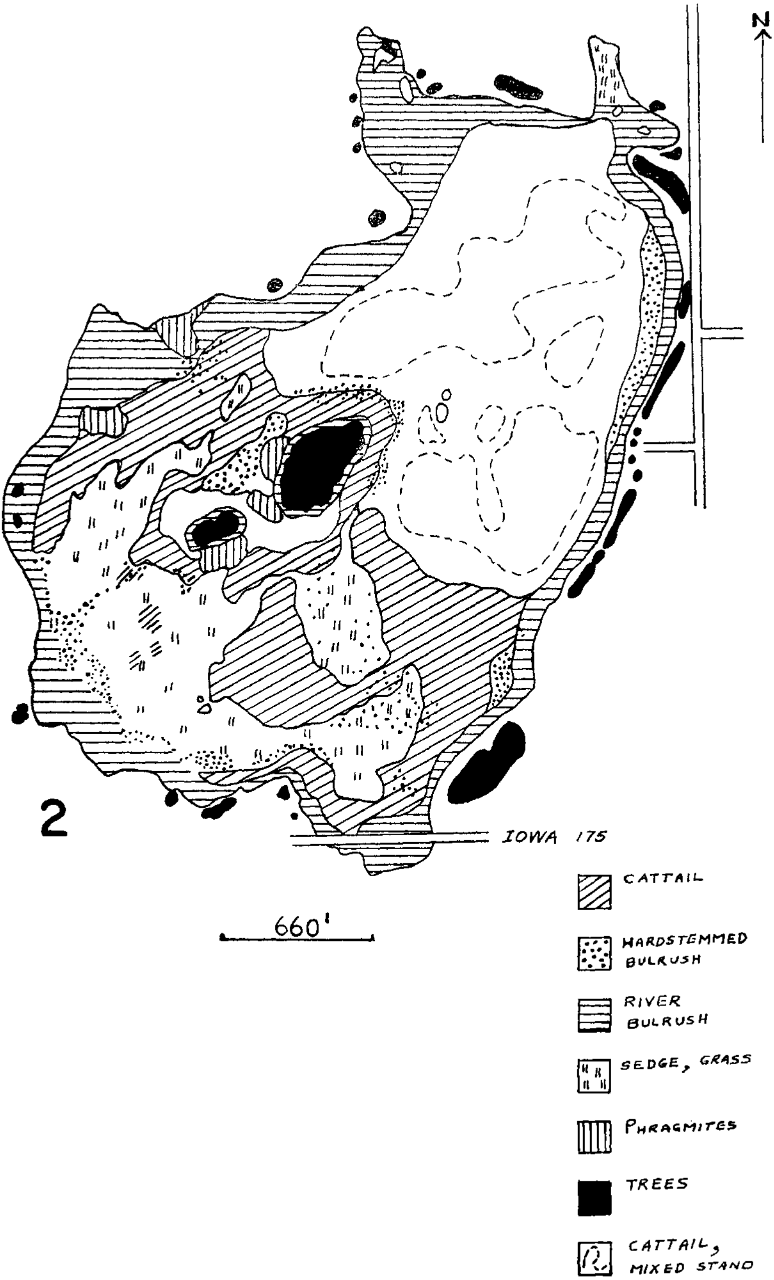

Fig. 2 Distribution of vegetation on Goose Lake, spring, 1960.

Blue joint-grass	*Calamagrostis inexpansa*
Water sedge	*Carex aquatilis*
Arrowhead	*Sagittaria cuneata*
Smartweed	*Polygonum natans*
Broad-leaved cattail	*Typha latifolia*
Common reed grass	*Phragmites communis*
Algae	several genera **and species**

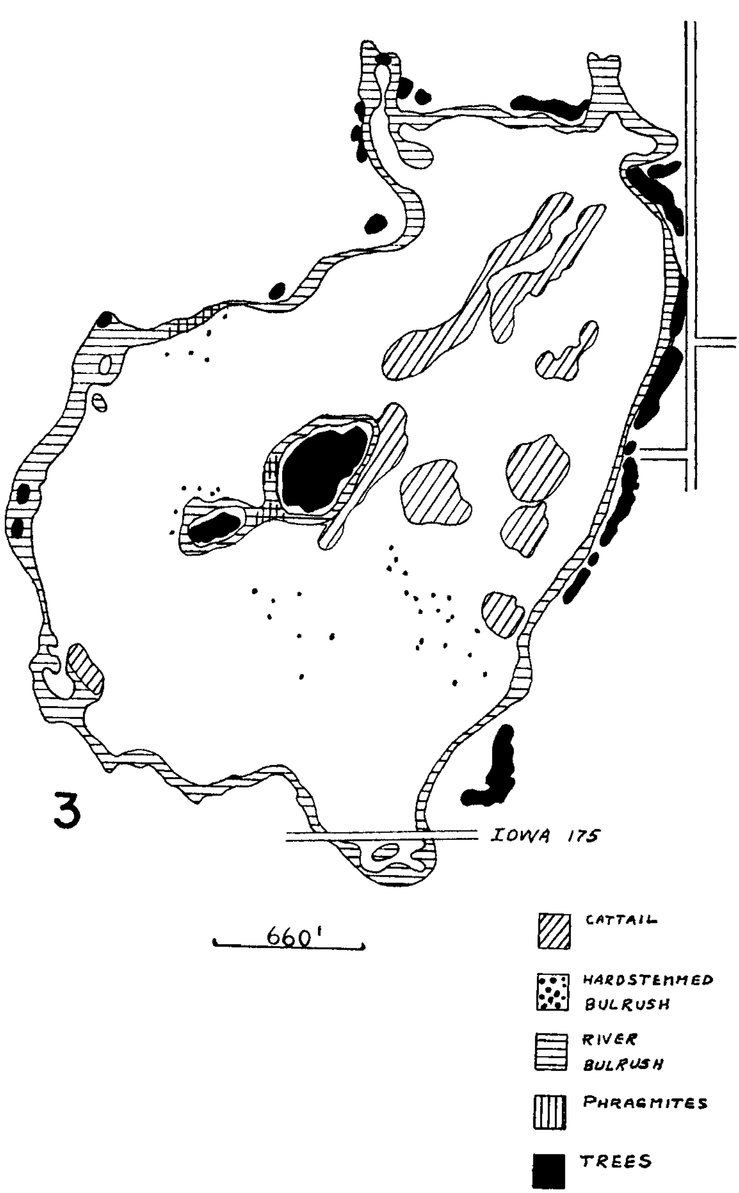

Fig. 3 Distribution of vegetation on Goose Lake, spring, 1961.

apparent is the substantial decrease in emergent vegetation from that present in 1960. According to unpublished information received from Milton W. Weller, Iowa State University, the major factor contributing to the sparse vegetation in 1961 was a high population of muskrats in 1960, using much of the vegetation for construction of houses.

Analysis of the houses revealed they were composed of the following plant materials:

Lesser duckweed	*Lemna minor*
Greater duckweed	*Spirodela polyrhiza*
Dotted wolffia	*Wolffia punctata*
Narrow-leaved cattail	*Typha angustifolia*
Large bur-reed	*Sparganium eurycarpum*
Hard-stemmed bulrush	*Scirpus acutus*
River bulrush	*Scirpus fluviatilis*

Procedures

Field. Fifty muskrat houses were chosen for sampling. Each house was marked by piercing it vertically with a three-eighths inch steel reinforcing rod 12 feet long. The rod was secured by pushing it through the muskrat house into the lake bottom. Each rod was marked by crimping around it an ordinary chicken legband at approximately two feet from the upper end of the rod. Upon each band was stamped a number serving to identify that particular muskrat house.

Initially a sample of one cubic decimeter of material was taken from each of three different regions of each muskrat house. The three regions were at waterline, at an area halfway between waterline and the top of the house, and at the top of the house.

The sampling tool consisted of a metal cylinder with a volume of one cubic decimeter. A bandsaw blade was welded on the bottom, and two three-foot lengths of strap iron were bolted onto the sides of the cylinder so that the two lengths of iron were diametrically opposed. A three-quarter inch pipe was welded across the top of the strap irons thus making a handle. It was hoped that manipulation of this tool in a way similar to use of a soil-testing apparatus would yield a comparatively undisturbed sample. Henderson (1960) used this same type of tool successfully to acquire wheat mite samples. However, the coarseness and toughness of the vegetation comprising the house precluded efficient sampling by this method. The sampling device might have been more effective if a blade with smaller teeth had been used. A reliable method of turning the device faster than is possible by hand might also have added to its efficiency.

The majority of samples were taken by removing a measured cubic decimeter by hand from the muskrat houses. The samples were placed in plastic bags for transport to the laboratory. The number and region of the muskrat house from which each sample was taken were recorded in permanent ink on a waterproof tag inserted inside the plastic bag. Size and composition of each muskrat house were also recorded at the time samples were taken.

Laboratory. To speed up analysis of the samples, each sample was mixed thoroughly in a container. One-tenth of the original sample was then placed in water and examined by the aid of a dissecting microscope. All arthropods were removed and placed in 70 per cent alcohol. Mites were then removed from the alcohol and placed in chloral hydrate clearing solution. This meticulous and time-consuming method was used in the summer of 1960. However, in 1961, samples were placed in Berlese funnels from which the arthropods were collected in 70 per cent alcohol, then cleared in chloral hydrate. After adequate clearing, the mites were mounted on microscope slides by using methyl cellulose for the lightly sclerotized specimens, and modified Hoyer's for the more heavily sclerotized ones.

ANALYSIS

The following five types of relationships were considered:

1. Immediately available flora and composition of muskrat houses.
2. Size of muskrat house and occurrence of mites.
3. Type of muskrat house and occurrence of mites.
4. Sampling areas (waterline, middle, or top) and occurrence of mites.
5. Mite populations occurring in respective houses.

The texts used for identification of specimens were Baker and Wharton (1952), and Baker et al. (1958).

Relationship of Immediately Available Flora and Composition of Muskrat Houses. An approximate relationship of marsh flora and muskrat house composition has already been noted. Figures 2 and 3 show the distribution of the major types of emergent marsh vegetation. The number of muskrat houses composed of these different types of vegetation is shown in Table 1. A combination of cattail and river bulrush was the material most often used for building by muskrats. The second most used category for building was cattail alone. Figures 1 and 2 suggest that the composition of a house should be approximately the same as the immediately available vegetation. Since little new vegetation was available to the muskrats for building purposes in 1961, the houses consisted for the most part of 1960 flora. In 1961 the house materials were much more decayed and contained a greater per cent of water than in 1960.

Table 1. Relationship of immediately available flora and composition of muskrat houses.

Emergent flora	Number of houses composed of flora
Cattail and river bulrush	22
Cattail	13
River bulrush	6
Cattail and hardstem	4
River bulrush and hardstem	1
Cattail and phragmites	1
Cattail, river bulrush and hardstem	1
River bulrush and phragmites	1
Sedge	1
	50

Relationship of the Size of Muskrat Houses and Occurrence of Mites. Seven groups of mites (Table 2) were taken from 49 different samples in 1960, and 18 groups (Table 3) were taken from 50 different samples in 1961. To correlate the occurrence of these groups with the size of muskrat houses, the latter were categorized as shown in Tables 2 and 3. For each house size is tabulated the number of specimens of the respective groups taken in the samples, the total number of specimens in combined samples for respective house sizes, and the average number of specimens for each sample. Because houses were a year older in 1961, the average house size was smaller. Thus, no house with a diameter from 116″ to 157″ was sampled. Progressive decay seemed to be the major factor in reduction of house size. From the evidence provided by the 1960 study, houses with diameters of 95″-115″ and 137″-157″ had larger mite populations. Houses with diameters ranging from 95″-157″ contained higher populations of mites per unit volume than did smaller houses. The 1961 data indicate that houses with ranges of 32″-52″ and 95″-115″ contained higher mite populations.

Table 2. Relationship of the size of muskrat houses and occurrence of mites—1960

Diameter of house in inches	No. of samples per house size	No. of specimens of family or group in combined samples								Av. no. of specimens per sample
		*E	T	D	P	A	S	MN	Total	
32-52	7	4	0	0	0	0	0	0	4	.57
53-73	18	66	0	2	1	4	5	21	99	5.50
74-94	14	29	0	10	13	0	21	20	93	6.64
95-115	6	33	2	3	19	0	3	13	73	12.16
116-136	2	5	0	0	1	0	4	6	16	8.00
137-157	2	11	0	8	2	0	0	4	25	12.50
	49	148	2	23	36	4	33	64	310	

*E=Eremaeidae D=Diplogyniidae A=Acaridae MN=Mesostigmatid
T=Trombidiidae P=Parasitidae S=Stigmaeidae Nymphs

The data for both years show no correlation between house size and quantity or quality of population. It is doubtful that population variations can be explained on the basis of house size alone. Complementary influences such as the usage made of the house (to be considered in the next section) must also be included.

Relationship of the Utility of Muskrat Houses and Occurrence of Mites. Houses were categorized as active, inactive, feeder, and latrine types. The active type contained the living

Table 3. Relationship of the size of muskrat houses and occurrence of mites—1961

Diameter of house in inches	No. of samples per house size	*E	T	D	P	C	A	S	H	L	DE	ER	MN	ML	ON	OL	EY	AC	M	Total	Av. no. of specimens per sample
		No. of specimens of family or group in combined samples																			
32-52	14	193	2	7	12	1	0	10	0	0	4	9	76	21	39	11	0	0	6	391	27.93
53-73	16	51	1	1	21	1	2	18	0	1	3	4	59	13	18	6	0	2	7	208	13.00
74-94	13	36	1	5	18	3	0	9	2	0	0	10	63	8	47	23	3	0	0	228	17.54
95-115	7	241	1	2	4	0	0	13	0	0	0	6	21	17	60	16	1	0	2	384	54.86
Total	50	521	5	15	55	5	2	50	2	1	7	29	219	59	164	56	4	2	15	1211	

*E=Eremaeidae
T=Trombidiidae
D=Diplogyniidae
P=Parasitidae
C=Cheyletidae
A=Acaridae
S=Stigmaeidae
H=Hydrachnellae
L=Laelaptidae
DE=Dermanyssidae
ER=Ereynetidae
MN=Mesostigmatid Nymphs
ML=Mesostigmatid Larvae
ON=Oribatid Nymphs
OL=Oribatid Larvae
EY=Erythraeidae
AC=Aceosejidae
M=Macrochelidae

Table 5. Relationship of the type of muskrat house and sampling area to the occurrence of mites—1961

House	Type of area of muskrat house	*E	T	D	P	C	A	S	H	L	DE	ER	MN	ML	ON	OL	EY	AC	M	Total
Active	Waterline	44	0	9	4	2	2	9	0	0	0	3	48	7	8	3	0	0	0	139
	Middle	72	2	0	8	1	0	10	0	0	1	8	45	12	3	0	1	0	0	163
	Top	142	0	1	5	0	0	12	0	1	2	3	15	14	52	19	0	0	2	268
																				570
Inactive	Waterline	36	0	1	2	1	0	1	2	0	0	2	11	3	11	4	0	2	1	77
	Middle	61	2	0	13	1	0	0	0	0	2	5	24	7	51	11	2	0	5	184
	Top	154	0	2	3	0	0	4	0	0	0	1	23	8	36	17	0	0	5	253
																				514
Feeder	Waterline	2	1	0	0	0	0	0	0	0	0	0	6	1	2	0	1	0	1	14
	Middle	4	0	0	9	0	0	3	0	0	0	4	23	1	0	0	0	0	0	44
	Top	1	0	0	6	0	0	5	0	0	1	1	10	5	0	1	0	0	0	30
																				88
Latrine	Waterline	0	0	2	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	7
	Middle	5	0	0	4	0	0	4	0	0	0	2	5	0	0	0	0	0	1	21
	Top	0	0	0	0	0	0	2	0	0	0	0	8	1	0	0	0	0	0	11
																				39
TOTAL		521	5	15	55	5	2	50	2	1	7	29	219	59	164	56	4	2	15	1211

*E=Eremaeidae
T=Trombidiidae
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EY=Erythraeidae
AC=Aceosejidae
M=Macrochelidae

quarters of the muskrat. The inactive house was not used by muskrats for any purpose. The feeder was used as a temporary storage place for food and as a feeding area. The latrine type was used as a defecation site.

In 1960 the active type of house had a much greater mite population than the other types (Table 4). This probably was caused by the presence of muskrats and the addition of new organic materials. One could expect a new inactive type to have a rather sparse mite population, not only because of the relative freshness of the vegetation comprising it, but also from lack of new and varied organic additions. However, houses no longer used by muskrats may commonly be used by birds for perching, preening, and nesting sites; thus, the habitat for mites may be more or less changed. Frequently, feeder and latrine houses are older structures with the bulk of their mass submerged, thus offering substantially less of an actual environment to accommodate large or diversified mite populations.

Table 4. Relationship of the type of muskrat house and the sampling area to the occurrence of mites—1960

House	Type of area of muskrat house	*E	T	D	P	A	S	MN	Total
Active	Waterline	79	2	13	1	0	0	9	104
	Middle	13	0	9	22	0	24	10	78
	Top	18	0	1	8	0	7	33	67
									249
Inactive	Waterline	9	0	0	0	4	0	2	15
	Middle	0	0	0	0	0	0	0	0
	Top	1	0	0	1	0	0	0	2
									17
Feeder	Waterline	19	0	0	2	0	0	2	23
	Middle	1	0	0	0	0	0	0	1
	Top	4	0	0	2	0	2	8	16
									40
	Waterline	3	0	0	0	0	0	0	3
Latrine	Middle	0	0	0	0	0	0	0	0
	Top	1	0	0	0	0	0	0	1
									4
	TOTAL	148	2	23	36	4	33	64	310

*E=Eremaeidae
T=Trombidiidae
D=Diplogyniidae
P=Parasitidae
A=Acaridae
S=Stigmaeidae
MN=Mesostigmatid Nymphs

The houses sampled in 1961 (Table 5) had noticeably large populations in both active and inactive types, their per cent of the total population being 47 and 42 respectively. The latter figure is especially surprising and tends to discount the singular importance of muskrat occupancy in its effect upon mite population. One must include, also, the size of the emergent portion of the house as well as the age and state of decomposition of the contents as complementary factors. The "contaminative" effect of birds is well illustrated here by the occurrence of *Ornithonyssus sylviarum* (C. & F.) and *Pellonyssus passeri* (C. & Y.), both dermanyssids parasitic on birds, in active and inactive houses.

Relationship of the Sampling Area of the Muskrat House and Occurrence of Mites. Table 6 lists families of mites represented in samples taken from the three sampling areas. From these data the following observations are made for 1960:

1. Waterline samples were dominated by Eremaeidae.
2. Middle samples were dominated by Stigmaeidae and Parasitidae.
3. Top samples were dominated by mesostigmatid nymphs and Eremaeidae.
4. Eremaeidae and Diplogyniidae were most numerous in waterline samples.
5. Parasitidae and Stigmaeidae were most numerous in middle and in top samples.
6. Mesostigmatid nymphs were most numerous in top samples.

Table 6. Relationship of the sampling area of the muskrat house and occurrence of mites—1960

Family	Number of specimens taken from sampling areas			
	Waterline	Middle	Top	Total
Eremaeidae	110	14	24	148
Trombidiidae	2	0	0	2
Diplogyniidae	13	9	1	23
Parasitidae	3	22	11	36
Acaridae	4	0	0	4
Stigmaeidae	0	24	9	33
Mesostigmatid nymphs	13	10	41	64
Total	145	79	86	310

Reference to Table 7 suggests the following relationships for 1961:

1. Waterline samples were dominated by Eremaeide and mesostigmatid nymphs.
2. Middle samples were dominated by Eremaeidae and mesostigmatid nymphs.
3. Top samples were dominated by Eremaeidae and oribatid nymphs.
4. Eremaeidae were most numerous in top samples.
5. Parasitidae were most numerous in middle samples.
6. Stigmaeidae were most numerous in top samples.
7. Ereynetidae were most numerous in middle samples.
8. Mesostigmatid nymphs were most numerous in middle samples, although they were all represented at waterline and top.
9. Mesostigmatid larvae were most numerous in top samples, although they were well represented at both middle and waterline.

10. Oribatid nymphs were most numerous in top samples, with substantial yet decreasing frequency in middle and waterline samples.
11. Oribatid larvae were most numerous in top samples.

Table 7. Relationship of the sampling area of the muskrat house and occurrence of mites—1961

Family	Number of specimens taken from sampling areas			
	Waterline	Middle	Top	Total
Eremaeidae	82	142	297	521
Trombidiidae	1	4	0	5
Diplogyniidae	12	0	3	15
Parasitidae	7	34	14	55
Cheyletidae	3	2	0	5
Acaridae	2	0	0	2
Stigmaeidae	10	17	23	50
Hydrachnellae	2	0	0	2
Laelaptidae	0	0	1	1
Dermanyssidae	1	3	3	7
Ereynetidae	5	19	5	29
Mesostigmatid nymphs	66	97	56	219
Mesostigmatid larvae	11	20	28	59
Oribatid nymphs	22	54	88	164
Oribatid larvae	8	11	37	56
Erythraeidae	1	3	0	4
Aceosejidae	2	0	0	4
Macrochelidae	2	6	7	15
Total	237	412	562	1211

Relationship of Mite Populations Occurring in Muskrat Houses. A measure of the degree of co-occurrence of mite families may arbitrarily be categorized as high, some, and low or none. A high co-occurrence is represented by a ratio (in the form of a proper fraction) of the two populations being compared and having a value of 75 per cent or more. For example, in Table 8, the co-occurrence of Parasitidae and Stigmaeidae in the middle area is expressed as 22/24, which falls within the high category. A low or none category is indicated by a ratio of less than 50 per cent, and those groups with some co-occurrence are represented by a ratio from 50 to 74 per cent. Tables 8 and 9 list the degrees of co-occurrence of the several groups with each other. The symbols "H", "S", and "L" represent high, some, and low or none categories respectively.

Reference to co-occurrence values in Table 8 suggests the following relationships:

1. *Waterline.* Predominantly low co-occurrence is indicated for most groups, explained partially by the fact that Eremaeidae comprise 76 per cent of the whole mite population taken at waterline. Some co-occurrence is represented by the Trombidiidae-Parasitidae and Trombidiidae-Acaridae populations; however, in both instances only a few specimens are involved. High co-occurrences are represented by the Diplogyniidae-mesostigmatid nymph and Parasitidae-Acaridae comparisons.

2. *Middle.* Some co-occurrence is characteristic of Eremaeidae in this area, this category being descriptive of their relation-

ship to Diplogyniidae, Parasitidae, Stigmaeidae, and mesostigmatid nymphs. High co-occurrences are indicated by the Diplogyniidae-mesostigmatid nymph and Parasitidae-Stigmaeidae ratios.

Table 8. Relationship of mite populations occurring in muskrat houses—1960

Specimens per family by respective sampling areas		*E	T	D	P	A	S	MN
				In comparison with				
Eremaeidae								
Waterline	110		2L	13L	3L	4L	0	13L
Middle	14		0	9S	22S	0	24S	10S
Top	24		0	1L	11L	0	9L	41S
Trombidiidae								
Waterline	2			13L	3S	4S	0	13L
Middle	0			9	22	0	24	10
Top	0			1	11	0	9	41
Diplogyniidae								
Waterline	13				3L	4L	0	13H
Middle	9				22L	0	24L	10H
Top	1				11L	0	9L	41L
Parasitidae								
Waterline	3					4H	0	13L
Middle	22					0	24H	10L
Top	11					0	9H	41L
Acaridae								
Waterline	4						0	13L
Middle	0						24	10
Top	0						9	41
Stigmaeidae								
Waterline	0							13
Middle	24							10L
Top	9							41L

*E=Eremaeidae
T=Trombidiidae
D=Diplogyniidae
P=Parasitidae
A=Acaridae
S=Stigmaeidae
MN=Mesostigmatid Nymphs

3. *Top.* Co-occurrences in this area are predominantly low, the only exceptions being the "some" ratio of Eremaeidae-mesostigmatid nymphs and the high ratio of Parasitidae-Stigmaeidae.

Because of the scanty information available on the eremaeids, their preponderant occurrence at waterline can not be explained. These mites are described typically as terrestrial, vegetarian, and negatively phototaxic. This specific environment accommodated the last two characteristics but not the first. It is somewhat surprising to find Diplogyniidae most numerous at waterline unless this indicates a commensal relationship with beetles. These mites are known to occur on beetles and other arthropods. Parasitidae and Stigmaeidae would be expected to occupy a drier habitat as indicated by these findings. Since the mesostigmatid nymphs represent a complex of several families, they could be expected to occur in all three habitats.

From the co-occurrence values given in Table 9 are derived the following interpretations:

1. *Waterline.* Here, again, the Eremaeidae are most numerous, comprising 35 per cent of the total specimens taken at

waterline as compared with 76 per cent for 1960. Mesostigmatid nymphs, comprising 28 per cent of the total, are the next most numerous group at waterline. Oribatid nymphs with 9 per cent, Diplogyniidae with 5 per cent, mesostigmatid larvae with 5 per cent, and Stigmaeidae with 4 per cent complete the most populous groups in this sampling for 1961. Consequently, we find a high co-occurrence of the following groups: Eremaeidae-mesostigmatid nymphs, Diplogyniidae-Stigmaeidae, Diplogyniidae-mesostigmatid larvae, and Stigmaeidae-mesostigmatid larvae. Although high co-occurrence values are present for several other groups, their representation is so small that they are believed to have no particular significance. For example, one each adult dermanyssid and adult erythraeid were taken at waterline, giving a perfect high co-occurence. However, this value is of doubtful significance since the former is a parasite of vertebrates; the latter, free-living.

2. *Middle.* The Eremaeidae are again dominant, comprising 34 per cent. They are followed by mesostigmatid nymphs with 24 per cent, oribatid nymphs with 13 per cent, Parasitidae with 8 per cent, mesostigmatid larvae with 5 per cent, Ereynetidae with 5 per cent, and Stigmaeidae with 4 per cent. Of these major representations, high co-occurrences include Stigmaeidae-Ereynetidae, Stigmaeidae-mesostigmatid larvae, Ereynetidae-mesostigmatid larvae.

3. *Top.* Eremaeidae with 53 per cent of the population are the dominant group, followed by oribatid nymphs with 16 per cent, mesostigmatid nymphs with 10 per cent, oribatid larvae with 7 per cent, mesostigmatid larvae with 5 per cent, and Stigmaeidae with 4 per cent. The eremaeid population is so large that it is precluded from high co-occurrence relationships with other groups. High values involve immature forms and result from Stigmaeidae-mesostigmatid larvae and oribatid larvae-mesostigmatid larvae ratios.

Data for 1961 show that eremaeid populations increased from waterline to middle to top in contrast to the almost sequential inverse relationship of 1960. Since the houses marked and sampled in 1960 were also sampled in 1961, considerable change through weathering and decay of the contents could be expected in a year. Decay would be most rapid at waterline, thus affording a more suitable habitat than in the middle or top regions. But with these changes continuing through the year and eventually spreading throughout the emergent portion of the house, the middle and top portions became better habitats for eremaeids. The same explanation can be applied to populations of orbatid nymphs and larvae for 1961.

Table 9. Relationship of mite populations occurring in muskrat houses—1961

Specimens per family by respective sampling areas	°E	T	D	P	C	A	S	H	I	DE	ER	In comparison with MN	ML	ON	OL	FY	AC	M
Eremaeidae																		
Waterline	82	1L	12L	7L	3L	2L	10L	2L	0	1L	5L	66H	11L	22L	8L	1L	2L	2L
Middle	142	4L	0	34L	2L	0	17L	0	0	3L	19L	97S	20L	54L	11L	3L	0	6L
Top	297	0	3L	14L	0	0	23L	0	1L	3L	5L	56L	28L	88L	37L	0	0	7L
Trombidiidae																		
Waterline	1		12L	7L	3L	2S	10L	2S	0	1H	5L	66L	11L	22L	8L	1H	2S	2S
Middle	4		0	34L	2S	0	17L	0	0	3H	19L	97L	20L	54L	11L	3H	0	6S
Top	0		3	14	0	0	28	0	1	3	5	56	28	88	37	0	0	7
Diplogyniidae																		
Waterline	12			7S	3L	2L	10H	2L	0	1L	5L	66L	11H	22S	8S	1L	2L	2L
Middle	0			34	2	0	17	0	0	3	19	97	20	54	11	3	0	6
Top	3			14L	0	0	23L	0	1L	3H	5S	56L	28L	88L	37L	0	0	7L
Parasitidae																		
Waterline	7				3L	2L	10S	2L	0	1L	5S	66L	11S	22L	8H	1L	2L	2L
Middle	34				2L	0	17S	0	0	3L	19S	97L	20S	54S	11L	3L	0	6L
Top	14				0	0	23S	0	1L	3L	5L	56L	28S	88L	37L	0	0	7S
Cheyletidae																		
Waterline	3					2S	10L	2S	0	1L	5S	66L	11L	22L	8L	1L	2S	2S
Middle	2					0	17L	0	0	3S	19L	97L	20L	54L	11L	3S	0	6L
Top	0					0	23	0	1	3	5	56	28	88	37	0	0	7
Acaridae																		
Waterline	2						10L	2H	0	1S	5L	66L	11L	22L	8L	1S	2H	2H
Middle	0						17	0	0	3	19	97	20	54	11	3	0	6
Top	0						23	0	1	3	5	56	28	88	37	0	0	7
Stigmaeidae																		
Waterline	10							2L	0	1L	5S	66L	11H	22L	8H	1L	2L	2L
Middle	17							0	0	3L	19H	97L	20H	54L	11S	3L	0	6L
Top	23							0	1L	3L	5L	56L	28H	88L	37S	0	0	7L
Hydrachnellae																		
Wateline	2								0	1S	5L	66L	11L	22L	8L	1S	2H	2H
Middle	0								0	3	19	97	20	54	11	3	0	6
Top	0								1	3	5	56	28	88	37	0	0	7
Laelaptidae																		
Waterline	0									1	5	66	11	22	8	1	2	2
Middle	0									3	19	97	20	54	11	3	0	6
Top	1									3L	5L	56L	28L	88L	37L	0	0	7L

(Continued)

Specimens per family by respective sampling areas		°E	T	D	P	C	A	S	H	L	DE	ER	In comparison with MN	ML	ON	OL	EY	AC	M
Dermanyssidae																			
Waterline	1											5L	66L	11L	22L	8L	1H	2S	2S
Middle	3											19L	97L	20L	54L	11L	3H	0	6S
Top	3											5S	56L	28L	88L	37L	0	0	7L
Ereynetidae																			
Waterline	5												66L	11L	22L	8S	1L	2L	2L
Middle	19												97L	20H	54L	11S	3L	0	6L
Top	5												56L	28L	88L	37L	0	0	7S
Mesostigmatid Nymphs																			
Waterline	66													11L	22L	8L	1L	2L	2L
Middle	97													20L	54S	11L	3L	0	6L
Top	56													28S	88S	37S	0	0	7L
Mesostigmatid Larvae																			
Waterline	11														22S	8S	1L	2L	2L
Middle	20														54L	11S	3L	0	6L
Top	28														88L	37H	0	0	7L
Oribatid Nymphs																			
Waterline	22															8L	1L	2L	2L
Middle	54															11L	3L	0	6L
Top	88															37L	0	0	7L
Oribatid Larvae																			
Waterline	8																1L	2L	2L
Middle	11																3L	0	6S
Top	37																0	0	7L
Erythraeidae																			
Waterline	1																	2S	2S
Middle	3																	0	6S
Top	0																	0	7
Aceosejidae																			
Waterline	2																		2H
Middle	0																		6
Top	0																		7

°E=Eremaeidae
T=Trombidiidae
D=Diplogyniidae
P=Parasitidae
C=Cheyletidae
A=Acaridae
S=Stigmaeidae
H=Hydrachnellae
L=Laelaptidae
DE=Dermanyssidae
ER=Ereynetidae
MN=Mesostigmatid Nymphs
ML=Mesostigmatid Larvae
ON=Oribatid Nymphs
OL=Oribatid Larvae
EY=Erythraeidae
AC=Aceosejidae
M=Macrochelidae

The adult eremaeids. because of their good passive defense by extensive armoring, probably suffer but minor decimation from the predators such as cheyletids and stigmaeids. Moisture content undoubtedly is an important, even controlling, factor for some of the groups. Hydrachnellae, being literally water mites, would be expected to occur at waterline rather than in greater numbers in either of the other two regions. Some acarids, although not classified as water mites, are likely to be more successful if surrounded by a film of water. From a knowledge of general habits, one should expect Trombidiidae, Diplogyniidae, Parasitidae, Cheyletidae, Stigmaeidae, Laelaptidae, Ereynetidae, Erythraeidae, Aceosejidae, Macrochelidae, and immature mesostigmatids and oribatids to prosper in moist but not saturated environment. The occurrence of some, such as Aceosejidae, is unexplainable.

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