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## An Analysis of Mite Populations in Muskrat Houses

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## An Analysis of Mite Populations in Muskrat Houses<sup>1</sup>

ROBERT A. BUCKLEY<sup>2</sup> AND ELLIS A. HICKS<sup>3</sup>

*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

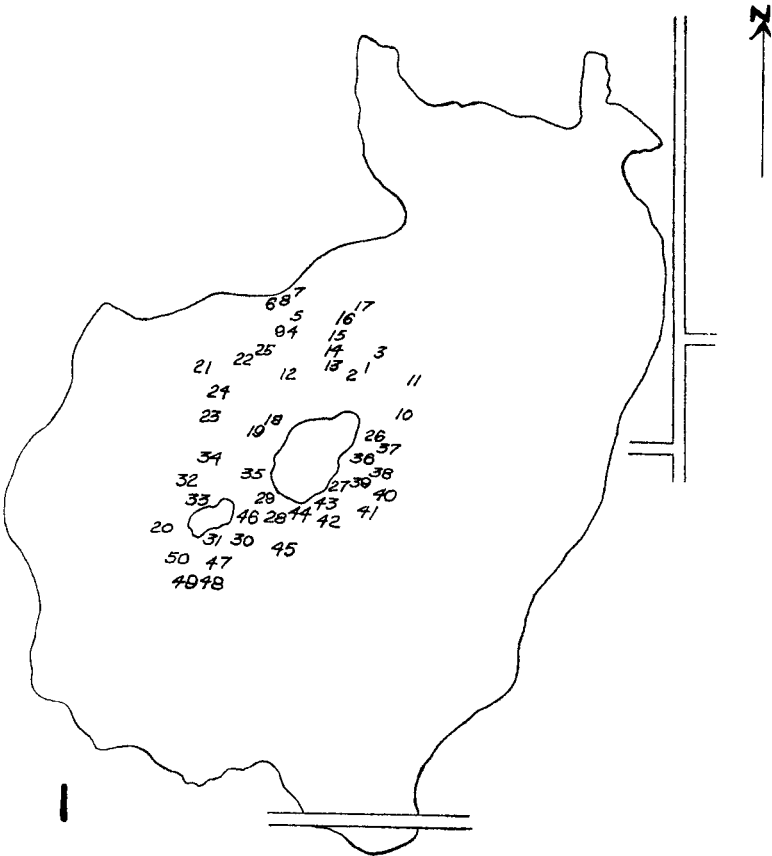


Fig. 1 Map of Goose Lake showing location of muskrat houses sampled.

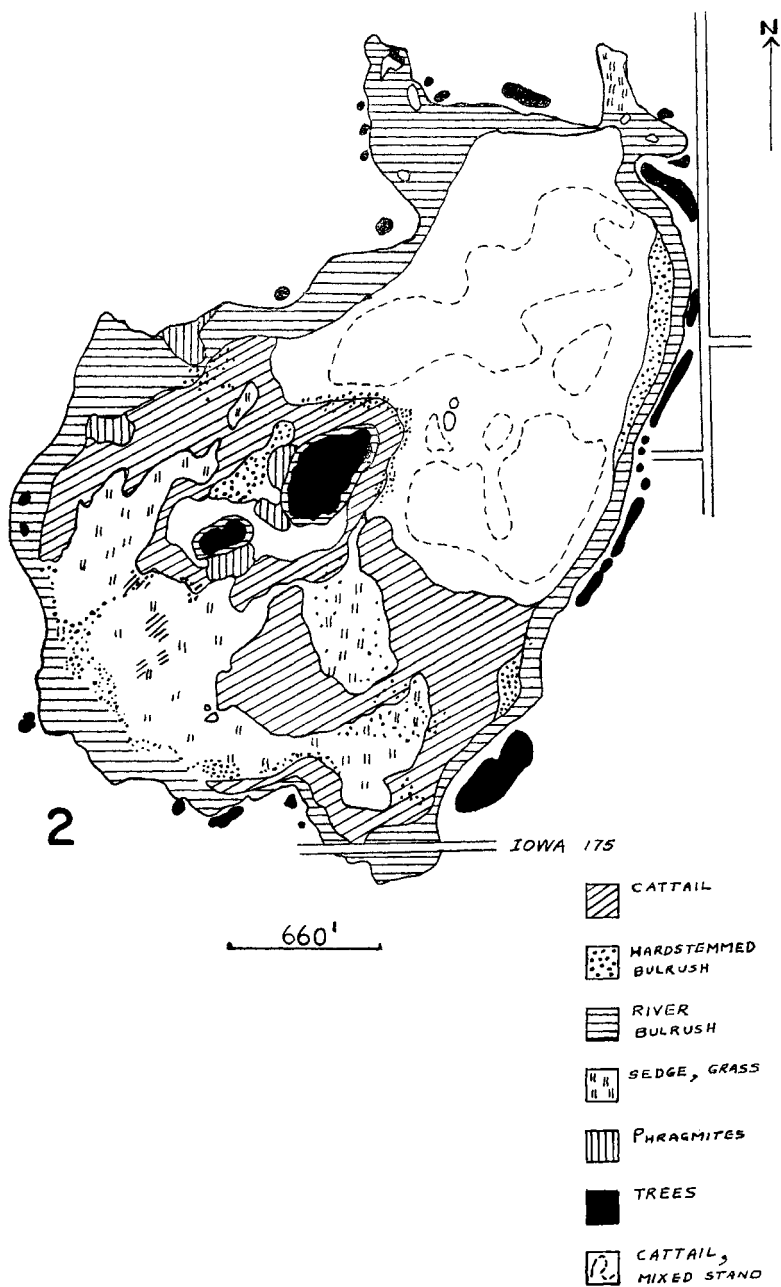


Fig. 2 Distribution of vegetation on Goose Lake, spring, 1960.

Blue joint-grass  
 Water sedge  
 Arrowhead  
 Smartweed  
 Broad-leaved cattail  
 Common reed grass  
 Algae

*Calamagrostis inexpansa*  
*Carex aquatilis*  
*Sagittaria cuneata*  
*Polygonum natans*  
*Typha latifolia*  
*Phragmites communis*  
 several genera and species

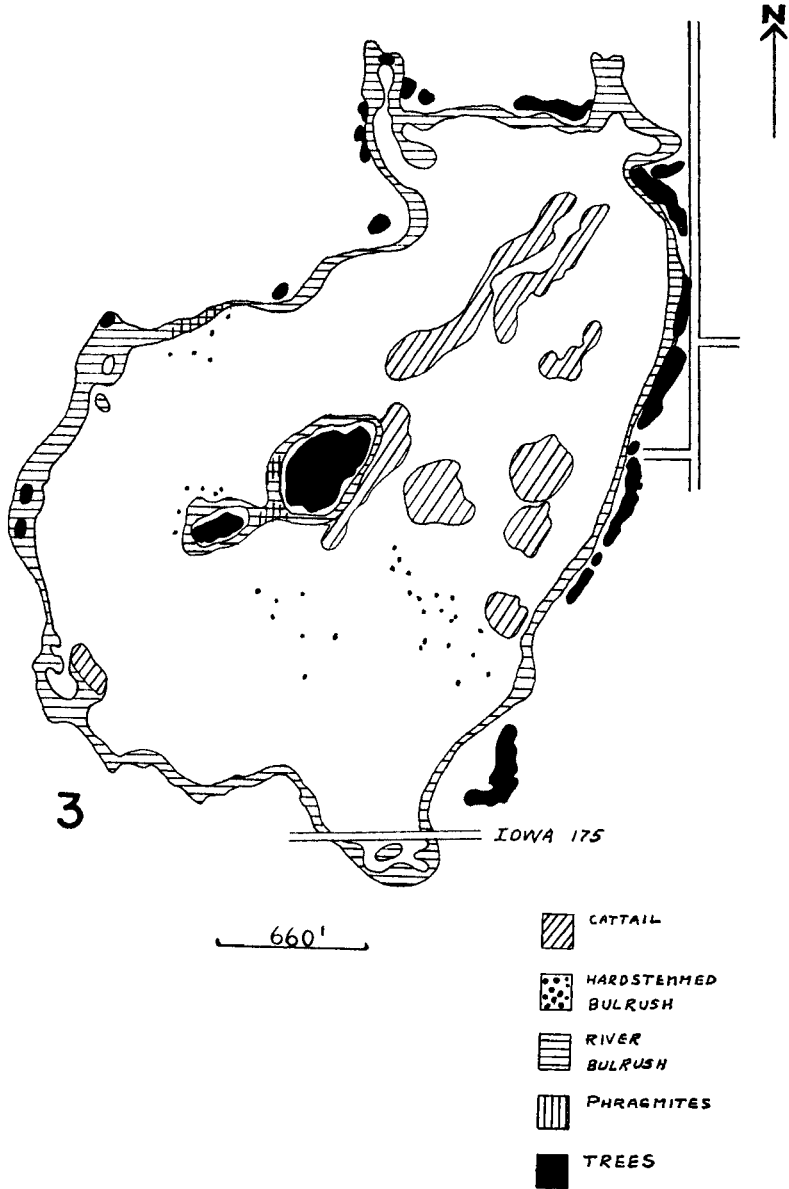


Fig. 3 Distribution of vegetation on Goose Lake, spring, 1961.

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       | <i>Lemna minor</i>            |
| Greater duckweed      | <i>Spirodela polyrrhiza</i>   |
| Dotted wolffia        | <i>Wolffia punctata</i>       |
| Narrow-leaved cattail | <i>Typha angustifolia</i>     |
| Large bur-reed        | <i>Sagittarium eurycarpum</i> |
| Hard-stemmed bulrush  | <i>Scirpus acutus</i>         |
| River bulrush         | <i>Scirpus fluviatilis</i>    |

#### 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 leg-band 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 sam-

ple 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                               |
| 53-73                       | 18                            | 66  | 0 | 2  | 1                       | 4 | 5  | 21 | 99                              |
| 74-94                       | 14                            | 29  | 0 | 10 | 13                      | 0 | 21 | 20 | 93                              |
| 95-115                      | 6                             | 33  | 2 | 3  | 19                      | 0 | 3  | 13 | 73                              |
| 116-136                     | 2                             | 5   | 0 | 0  | 1                       | 0 | 4  | 6  | 16                              |
| 137-157                     | 2                             | 11  | 0 | 8  | 2                       | 0 | 0  | 4  | 25                              |
|                             | 49                            | 148   | 2 | 23 | 36                      | 4 | 33 | 64 | 310                             |
| *E=Eremaeidae               | D=Diplogyniidae               | A=Acaridae  |   |    | MN=Mesostigmatid Nymphs |   |    |    |                                 |
| T=Trombididae               | P=Parasitidae                 | S=Stigmaciidae  |   |    |                         |   |    |    |                                 |

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 | No. of specimens of family or group in combined samples |   |    |    |   |   |    |   |   |    |    |     |    |     |    |    |    |    | Total | Av. no. of specimens per sample |
|-----------------------------|-------------------------------|---|---|----|----|---|---|----|---|---|----|----|-----|----|-----|----|----|----|----|-------|---------------------------------|
|                             |                               | *E  | T | D  | P  | C | A | S  | H | L | DE | ER | MN  | ML | ON  | OL | EY | AC | M  |       |                                 |
| 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      A=Acaridae      ER=Ereynetidae      EY=Erythraeidae  
 T=Trombidiidae    S=Stigmaeidae    MN=Mesostigmatid Nymphs    AC=Aceosejidae  
 D=Diplogyniidae    H=Hydrachnellae    ML=Mesostigmatid Larvae      M=Macrochelidae  
 P=Parasitidae      L=Laelaptidae      ON=Oribatid Nymphs  
 C=Cheyletidae      DE=Dermanyssidae    OL=Oribatid Larvae

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

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    |
| Latrine  | Waterline                     | 5   | 0 | 0  | 0  | 0 | 0  | 0  | 5     |
|          | 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=Trombididae  
D=Diplogynidae  
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 dermanysoids 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   |
| Trombididae          | 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 Eremaeidae 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. Ereyetidae 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 water-line 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 |        |     | Total |
|----------------------|---|--------|-----|-------|
|                      | Waterline                                     | Middle | Top |       |
| 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     |
| Dermapnyssidae       | 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  | In comparison with |     |    |     | MN  |
|---|-----|----|----|--------------------|-----|----|-----|-----|
|   |     |    |    | D                  | P   | A  | S   |     |
| <b>Eremaeidae</b>                                 |     |    |    |                    |     |    |     |     |
| Waterline   | 110 |    | 2L | 13L                | 3L  | 4L | 0   | 13L |
| Middle  | 14  |    | 0  | 9S                 | 22S | 0  | 24S | 10S |
| Top   | 24  |    | 0  | 1L                 | 11L | 0  | 9L  | 41S |
| <b>Trombidiidae</b>                               |     |    |    |                    |     |    |     |     |
| Waterline   | 2   |    |    | 13L                | 3S  | 4S | 0   | 13L |
| Middle  | 0   |    |    | 9                  | 22  | 0  | 24  | 10  |
| Top   | 0   |    |    | 1                  | 11  | 0  | 9   | 41  |
| <b>Diplogyniidae</b>                              |     |    |    |                    |     |    |     |     |
| Waterline   | 13  |    |    |                    | 3L  | 4L | 0   | 13H |
| Middle  | 9   |    |    |                    | 22L | 0  | 24L | 10H |
| Top   | 1   |    |    |                    | 11L | 0  | 9L  | 41L |
| <b>Parasitidae</b>                                |     |    |    |                    |     |    |     |     |
| Waterline   | 3   |    |    |                    |     | 4H | 0   | 13L |
| Middle  | 22  |    |    |                    |     | 0  | 24H | 10L |
| Top   | 11  |    |    |                    |     | 0  | 9H  | 41L |
| <b>Acaridae</b>                                   |     |    |    |                    |     |    |     |     |
| Waterline   | 4   |    |    |                    |     |    | 0   | 13L |
| Middle  | 0   |    |    |                    |     |    | 24  | 10  |
| Top   | 0   |    |    |                    |     |    | 9   | 41  |
| <b>Stigmaeidae</b>                                |     |    |    |                    |     |    |     |     |
| 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-occurrence. 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, Ereyne-tidae with 5 per cent, and Stigmaeidae with 4 per cent. Of these major representations, high co-occurrences include Stigmaeidae-Ereyne-tidae, Stigmaeidae-mesostigmatid larvae, Ereyne-tidae-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 eremauids. The same explanation can be applied to populations of oribatid 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 | In comparison with |     |     |     |     |    |    | M  |
|---|-----|----|-----|-----|----|----|-----|----|----|----|--------------------|-----|-----|-----|-----|----|----|----|
|   |     |    |     |     |    |    |     |    |    |    | ER                 | MN  | ML  | ON  | OL  | FY | AC |    |
| <b>Eremaeidae</b>                                 |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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 |
| <b>Trombididae</b>                                |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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  |
| <b>Diplogyniidae</b>                              |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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 |
| <b>Parasitidae</b>                                |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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 |
| <b>Cheyletidae</b>                                |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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  |
| <b>Acaridae</b>                                   |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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  |
| <b>Stigmaeidae</b>                                |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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 |
| <b>Hydrachnellae</b>                              |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| Waterline   | 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  |
| <b>Laelaptidae</b>                                |     |    |     |     |    |    |     |    |    |    |                    |     |     |     |     |    |    |    |
| 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)

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| Specimens per family by respective sampling areas | °E | T | D | P | C | A | S | H | L | DE | In comparison with |     |     | ON  | OL  | EY | AC | M  |
|---|----|---|---|---|---|---|---|---|---|----|--------------------|-----|-----|-----|-----|----|----|----|
|   |    |   |   |   |   |   |   |   |   |    | ER                 | MN  | ML  |     |     |    |    |    |
| <b>Dermanyssidae</b>                              |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| 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 |
| <b>Ereynetidae</b>                                |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 5  |   |   |   |   |   |   |   |   |    |                    | 66L | 11L | 22L | 8S  | 1L | 2L | 2L |
| Middle  | 19 |   |   |   |   |   |   |   |   |    |                    | 97L | 20H | 54L | 11S | 3L | 0  | 6L |
| Top   | 5  |   |   |   |   |   |   |   |   |    |                    | 56L | 23L | 88L | 37L | 0  | 0  | 7S |
| <b>Mesostigmatid Nymphs</b>                       |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 66 |   |   |   |   |   |   |   |   |    |                    |     | 11L | 22L | 8L  | 1L | 2L | 2L |
| Middle  | 97 |   |   |   |   |   |   |   |   |    |                    |     | 20L | 54S | 11L | 3L | 0  | 6L |
| Top   | 56 |   |   |   |   |   |   |   |   |    |                    |     | 28S | 88S | 37S | 0  | 0  | 7L |
| <b>Mesostigmatid Larvae</b>                       |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 11 |   |   |   |   |   |   |   |   |    |                    |     |     | 22S | 8S  | 1L | 2L | 2L |
| Middle  | 20 |   |   |   |   |   |   |   |   |    |                    |     |     | 54L | 11S | 3L | 0  | 6L |
| Top   | 28 |   |   |   |   |   |   |   |   |    |                    |     |     | 88L | 37H | 0  | 0  | 7L |
| <b>Oribatid Nymphs</b>                            |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 22 |   |   |   |   |   |   |   |   |    |                    |     |     |     | 8L  | 1L | 2L | 2L |
| Middle  | 54 |   |   |   |   |   |   |   |   |    |                    |     |     |     | 11L | 3L | 0  | 6L |
| Top   | 88 |   |   |   |   |   |   |   |   |    |                    |     |     |     | 37L | 0  | 0  | 7L |
| <b>Oribatid Larvae</b>                            |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 8  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     | 1L | 2L | 2L |
| Middle  | 11 |   |   |   |   |   |   |   |   |    |                    |     |     |     |     | 3L | 0  | 6S |
| Top   | 37 |   |   |   |   |   |   |   |   |    |                    |     |     |     |     | 0  | 0  | 7L |
| <b>Erythraeidae</b>                               |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 1  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    | 2S | 2S |
| Middle  | 3  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    | 0  | 6S |
| Top   | 0  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    | 0  | 7  |
| <b>Aceosejidae</b>                                |    |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    |    |
| Waterline   | 2  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    | 2H |
| Middle  | 0  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    | 6  |
| Top   | 0  |   |   |   |   |   |   |   |   |    |                    |     |     |     |     |    |    | 7  |

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°E=Eremaeidae  
T=Trombidiiidae  
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 stigmatids. 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, Stigmatidae, Laelaptidae, Ereyneidae, 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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