# Food and Ectoparasites of Shrews of South Central Indiana with Emphasis on *Sorex fumeus* and *Sorex hoyi*

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## Introduction

Although information on shrews of Indiana was summarized by Mumford and Whitaker (1982), the pygmy shrew, *Sorex hoyi*, and smoky shrew, *Sorex fumeus*, were not discovered in Harrison County in southern Indiana (Caldwell, Smith & Whitaker, 1982) until the former work was in press. Cudmore and Whitaker (1984) used pitfall trapping to determine the distributions of these two species in the state. The two had similar ranges, occurring from Perry, Harrison and Clark counties along the Ohio River north to Monroe, Brown and Bartholomew counties (*S. hoyi* ranging into extreme SE Owen County). This is essentially the unglaciated "hill country" of south central Indiana where *S. fumeus* and *S. hoyi* occur on wooded slopes whereas *S. longirostris* inhabits bottomland woods (Whitaker & Cudmore, in preparation).

Information on food and ectoparasites of *Blarina brevicauda*, *S. cinereus* and *S. longirostris* from Indiana was summarized by Mumford and Whitaker (1982), and more data on the latter two species were presented by French (1982, 1984). Additional information on ectoparasites of these species, other than for *Sorex longirostris*, was reported from New Brunswick, Canada, by Whitaker and French (1982).

The purpose of this paper is to present information on the food and ectoparasites of shrews of south central Indiana.

## Materials and Methods

Pitfall traps (1000 ml plastic beakers) were used to collect shrews. The traps were sunk under or alongside logs in woods so that their rims were at ground level. They were placed in lines with the spacing and number dependent on the number and distribution of logs, and were left in place an average of 31 days (range 16-49). About 3 cm of water was placed in the beakers which were then checked once or twice per week.

Thirty-five localities in 21 southern Indiana counties were sampled in this fashion. Habitat relationships of these shrews will form the basis for a separate paper. However, all traps were in deep woods, ranging from Oak-Hickory to Beech-Maple forest. *Blarina* occurred throughout the area. *Sorex fumeus* and *S. hoyi* occurred on the uplands and slopes of the unglaciated hill country, whereas *Sorex cinereus* was absent from that area. *Sorex cinereus* was the only long-tailed shrew to occur in southeastern Indiana east of the unglaciated area (see Cudmore & Whitaker, 1984), whereas *S. cinereus* occurred in the bottomlands and *S. longirostris* occurred in the uplands in southwestern Indiana (west of the unglaciated hill country) (see French, 1980).

Most of the shrews for this study were collected between the fall of 1982 and June 1983. An average of 19 traps (6-40) was used per site. Shrews were taken as follows: Short-tailed Shrew, *Blarina brevicauda* (n = 299), Smoky Shrew, *Sorex fumeus* (n = 108), Pygmy Shrew, *Sorex hoyi* (n = 73), Southeastern Shrew, *Sorex longirostris* (n = 76), and Masked Shrew, *Sorex cinereus* (n= 98).

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It is well known that shrews deteriorate quickly after death, especially in warm weather. This raises the question of suitability of the shrews for research puroses when they were allowed to remain in the pitfall traps for several days. Much of the present work was done in cool weather. However, even in warm weather, many of the shrews were still suitable for study, and many were preserved as study skins. Stomach contents of many could be examined, and ectoparasites from many could be collected (Tables 1-5). The water in the beakers apparently helped to preserve the shrews by excluding air. We suspect that the parasite numbers are somewhat low, because some may have been lost in the water. Also, there is some chance for mixing of parasites between hosts, but we found little evidence of this. There were no cases of numbers of host specific species being on the wrong host. Information on foods eaten was gathered on all four shrew species, whereas information on ectoparasites was gathered only on *S. hoyi* and *S. fumeus* from this sample.

Stomachs were removed from shrews, their contents immersed in water and identified under a dissecting microscope; volumes were visually estimated. Food habits data were summarized as percent volume (percent total volume each food comprised) and percent frequency (percent of shrews having eaten each food). A one-way ANOVA with Duncan's Multiple Range Test was used to test for significant differences among food groupings using raw data and the 95% significance level. The ANOVA was conducted on transformed data (equal to the arcsine of the square root of the percentage estimate).

Ectoparasites were collected from the fur and skin of *S. fumeus* and *S. hoyi* with the aid of a 10-70 power zoom dissecting microscope. A probe was used to manipulate the fur, and parasites were removed with watchmakers forceps, preserved in 70% ethanol, cleared and stained in Nesbitt's solution and mounted in Hoyer's solution. Ectoparasites were counted when possible, or their numbers visually estimated when numbers were large. Data on ectoparasites were presented as average number per host, based on all hosts, and percent of hosts infected. Information on ectoparasites previously collected from Indiana *S. cinereus*, *S. longirostris* and *B. brevicauda* (Mumford and Whitaker, 1982; French, 1982) was used for comparison.

## Results

### Food

Information on foods consumed by the five species is presented in Table 1, and

TABLE 1. Food of five species of shrews from south central Indiana (numbers in parentheses are subtotals for insect larvae and beetles).

| | *Blarina brevicauda* | | *Sorex fumeus* | | *Sorex longirostris* | | *Sorex cinereus* | | *Sorex* (*Microsorex*) *hoyi* | |
|---|---|---|---|---|---|---|---|---|---|---|
| n = | 150 | | 82 | | 69 | | 71 | | 63 | |
| | % vol | % freq | % vol | % freq | % vol | % freq | % vol | % freq | % vol | % freq |
| Earthworms (Annelida) | 38.9 | 48.7 | 16.1 | 23.2 | 3.8 | 4.3 | 4.1 | 8.5 | | |
| Slugs & Snails (Mollusca) | 9.3 | 12.0 | 2.1 | 3.7 | 1.2 | 1.4 | 0.2 | 1.4 | | |
| Centipedes (Chilopoda) | 3.0 | 6.0 | 15.1 | 30.4 | 5.1 | 11.6 | 3.7 | 8.5 | 1.5 | 7.9 |
| Insect larvae | | | | | | | | | | |
| Unidentified | 5.4 | 7.3 | 6.5 | 12.2 | 3.9 | 8.7 | 7.6 | 12.7 | 8.4 | 15.9 |
| Tipulid larvae | 3.7 | 5.3 | 1.6 | 2.4 | 1.4 | 1.4 | 0.2 | 1.4 | 3.2 | 4.8 |
| Dipteran larvae | 3.3 | 6.7 | 2.7 | 8.5 | 4.3 | 7.2 | 7.5 | 11.3 | 2.4 | 3.2 |
| Coleopteran larvae | 3.1 | 6.7 | 6.7 | 14.6 | 5.1 | 7.2 | 4.2 | 4.2 | 5.6 | 11.1 |
| Bibionid larvae | 2.9 | 3.3 | | | | | | | 1.6 | 1.6 |
| Lepidopteran larvae | 2.2 | 3.3 | 3.8 | 11.1 | 6.7 | 13.0 | 3.9 | 4.2 | 6.7 | 7.9 |

TABLE 1.—Continued

| | *Blarina brevicauda* | | *Sorex fumeus* | | *Sorex longirostris* | | *Sorex cinereus* | | *Sorex (Microsorex) hoyi* | |
|---|---|---|---|---|---|---|---|---|---|---|
| n = | 150 | | 82 | | 69 | | 71 | | 63 | |
| | % vol | % freq | % vol | % freq | % vol | % freq | % vol | % freq | % vol | % freq |
| Scarabaeid larvae | 0.9 | 2.0 | 1.2 | 1.2 | 1.2 | 1.4 | 4.2 | 4.2 | 1.6 | 1.6 |
| Neuropteran larvae | 0.7 | 0.7 | | | | | | | | |
| Stratiomyid larvae | 0.5 | 0.7 | | | | | | | | |
| Chironomid larvae | 0.1 | 0.7 | | | 0.1 | 1.4 | 0.1 | 1.4 | | |
| Elateridae | | | | | | | 1.8 | 2.8 | | |
| *Chauliognathodes* | | | 1.6 | 2.4 | | | | | | |
| | (22.8) | | (24.1) | | (22.7) | | (29.5) | | (29.5) | |
| Beetles (Coleoptera) | | | | | | | | | | |
| Unidentified | 6.4 | 14.7 | 5.4 | 17.0 | 7.2 | 13.0 | 5.7 | 11.3 | 14.7 | 19.0 |
| Carabidae | 2.8 | 4.0 | 1.2 | 2.4 | | | 0.7 | 1.4 | 4.4 | 6.3 |
| Scarabaeidae | 0.7 | 0.7 | 3.1 | 4.9 | | | | | 0.1 | 1.6 |
| Curculionidae | — | — | | | — | — | 0.2 | 1.4 | — | — |
| Bostrichidae | — | — | | | — | — | | | 1.3 | 1.6 |
| | ( 9.9) | | (10.7) | | ( 7.2) | | ( 6.6) | | (20.5) | |
| Mast | 2.3 | 3.3 | | | 1.6 | 2.9 | 2.8 | 2.8 | 1.0 | 1.6 |
| Isopods, Isopoda | 1.9 | 2.7 | 0.6 | 3.7 | 0.3 | 1.4 | 0.3 | 4.2 | 1.5 | 1.6 |
| *Endogone* | 1.7 | 4.0 | 2.0 | 4.9 | | | | | | |
| Spider | 1.5 | 2.7 | 12.4 | 26.8 | 36.1 | 47.8 | 31.3 | 42.3 | 25.4 | 31.7 |
| Lepidopterous pupae | 1.5 | 2.0 | 1.2 | 1.2 | | | | | | |
| Mammal | 1.3 | 1.3 | | | | | | | 2.1 | 4.8 |
| Unidentified insect | 1.0 | 6.0 | | | | | | | 2.1 | 7.9 |
| Salamander | 0.7 | 0.7 | | | | | | | | |
| Hemiptera | 0.7 | 0.7 | 0.9 | 3.7 | 0.2 | 1.4 | 0.1 | 2.8 | | |
| Orthopteran eggs | 0.6 | 0.7 | | | | | | | | |
| Ants (Formicidae) | 0.6 | 2.0 | 1.2 | 2.4 | 0.9 | 1.4 | 0.4 | 1.4 | 4.5 | 6.3 |
| Moths (Lepidoptera) | 0.6 | 0.7 | 4.7 | 4.9 | | | 2.8 | 5.6 | 0.6 | 1.6 |
| Vegetation | 0.5 | 10.7 | 0.1 | 1.2 | | | | | 0.01 | 1.6 |
| Harvestmen (Phalangida) | 0.4 | 0.7 | 0.1 | 1.2 | 1.4 | 1.4 | 1.5 | 2.8 | 0.3 | 1.6 |
| Flies (Diptera) | 0.2 | 2.0 | 1.3 | 8.5 | 2.0 | 5.8 | 5.2 | 14.1 | 3.5 | 7.9 |
| Unidentified invertebrate | 0.2 | 0.7 | 2.8 | 9.8 | 8.3 | 17.4 | 2.7 | 11.3 | | |
| Unidentified fungus | 0.1 | 0.7 | | | | | | | | |
| Crickets (Gryllidae) | 0.1 | 0.7 | 2.1 | 6.1 | 2.7 | 5.8 | 2.6 | 2.8 | 3.1 | 7.9 |
| Green Pentatomidae (Stinkbugs) | 0.03 | 0.7 | 0.7 | 1.2 | 2.1 | 5.8 | 3.5 | 4.2 | | |
| Moss | | | | | | | 0.2 | 1.4 | | |
| Sciaridae | | | 1.0 | 2.4 | | | 0.1 | 1.4 | | |
| Vertebrate flesh | | | | | | | 2.1 | 2.8 | | |
| Craneflies (Tipulidae) | | | | | 1.2 | 1.4 | | | 1.6 | 1.6 |
| Lanternflies (Fulgoridae) | | | | | 0.9 | 1.4 | | | | |
| Homoptera | | | | | 0.9 | 1.4 | | | | |
| Roaches (Blattidae) | | | | | 0.5 | 1.4 | | | | |
| Leafhoppers (Cicadellidae) | | | | | 0.4 | 1.4 | | | | |
| Miridae | | | | | 0.2 | 1.4 | | | | |
| Mite | | | | | 0.03 | 1.4 | | | | |
| Hymenoptera | | | | | | | | | 1.3 | 1.6 |
| Unidentified | | | | | | | | | 1.6 | 1.6 |
| Lygaeidae | | | 0.5 | 3.7 | | | | | | |
| Aphid | | | 0.02 | 1.2 | | | | | | |
| | 99.8 | | 99.7 | | 99.7 | | 99.8 | | 100.1 | |

the major food groupings (those comprising at least 8% of the volume in any one species) in Table 2.

TABLE 2. Major food groups of southern Indiana shrews (% volumes). Lines connect values not differing significantly at $P \leq .05$ (ANOVA + Duncan's Multiple Range Tests).

| | *Blarina brevicauda* | *Sorex fumeus* | *Sorex longirostris* | *Sorex cinereus* | *Sorex (Microsorex) hoyi* |
|---|---|---|---|---|---|
| n = | 150 | 82 | 69 | 71 | 63 |
| Earthworm | 38.9 | 16.1 | 3.8 | 4.1 | — |
| Insect larvae | 22.8 | 24.2 | 22.9 | 29.5 | 29.4 |
| Beetles | 9.9 | 10.7 | 7.2 | 6.6 | 20.4 |
| Slugs & Snails | 9.3 | 2.1 | 1.2 | 0.2 | — |
| Spider | 1.5 | 12.4 | 36.1 | 31.3 | 25.4 |
| Centipede | 3.0 | 15.1 | 5.1 | 3.7 | 1.5 |

The most important foods of *Blarina brevicauda* listed by order of decreasing percent volume were earthworms, insect larvae, beetles, and slugs and snails. These items comprised 80.9% of the total volume of food in the sample. The five most important foods of smoky shrews were insect larvae, earthworms, centipedes, spiders, and beetle adults. Adult moths were consumed more (4.7% volume, 4.9% frequency) than in any other shrew species. The primary foods of the masked shrew were spiders, insect larvae, beetle adults, and flies, while for *Sorex longirostris* and *S. cinereus*, they were spiders and insect larvae, followed by beetle adults and centipedes. The primary foods of the pygmy shrew were insect larvae, spiders and beetle adults. Adult beetles ranked much higher than in either of the other two small shrew species and ants (Formicidae) were consumed more (4.5% of the volume) than in any other species.

There were significant differences in the amounts of earthworms eaten by the various species ($F = 28.708$, $df = 4$). *Blarina* ate significantly more earthworms than any other species. *Sorex fumeus* ate significantly less earthworms than *Blarina* but significantly more than the other shrews. *Blarina* ate significantly more slugs and snails than any of the other four species ($F = 5.702$, $df = 4$), but there were no significant differences among any of the other species. There were no significant differences among the five species in the amount of insect larvae eaten ($F = 0.636$, $df = 4$). Pygmy shrews consumed significantly greater amounts of adult beetles than any other species ($F = 2.920$, $df = 4$). *Sorex longirostris*, *S. cinereus* and *S. hoyi* did not differ significantly from each other in the amount of spiders eaten, but each consumed significantly more spiders than did *S. fumeus* or *Blarina*, and *S. fumeus* ate significantly more spiders than did *Blarina* ($F = 20.223$, $df = 4$). Centipedes were eaten in significantly greater amounts by *S. fumeus* ($F = 67.835$) than by any other species; there were no significant differences among the other species.

The shrews included in this study were of four distinct size classes. The largest, the short-tailed shrew, which averages about 17.0 (Mumford & Whitaker, 1982), then the smoky shrew, at about 7.2 (our data, $n = 87$, range 4.7-10.7, $SD = 1.46$). The masked shrew and southeastern shrew are the closest in size, averaging about 3.7 and 3.1 grams respectively (Mumford & Whitaker, 1982), whereas the pygmy shrew *S. hoyi* is the smallest and generally weighs about 2.2-6 grams (Long, 1974). The Indiana pygmy shrews are the smallest known pygmy shrews, however. Our specimens averaged about 2.1 grams ($n = 65$, $SD = 0.4$, $SE = 0.049$).

Ectoparasites

Data are presented here on ectoparasites of *Sorex fumeus* and *Sorex hoyi* from Indiana (Tables 3-5). Data on ectoparasites of *B. brevicauda*, *S. cinereus* and *S. longirostris* by Whitaker and Mumford (1972), and on *S. cinereus* and *S. longirostris* by French (1982), from Indiana will be used for comparison.

During the present study, a total of 9 taxa of ectoparasites was found on 9 of 10 southeastern shrews examined. Ectoparasites were ($\bar{x}$, % infested in parentheses) *Orycteroxenus soricis* ($\bar{x}$ = 14.1, 40.0% infested), *Bakerdania* sp. (1.6, 30.0), *Protomyobia indianensis* (1.3, 40.0), *Amorphacarus hengererorum* (1.3, 20.0), and the following with one individual each (0.1, 10.0): *Androlaelaps fahrenholzi*, *Pygmephorus hastatus*, *Cyrtolaelaps* sp., *Proctolaelaps* sp., and one *histiostomatid*. These limited data are similar to previous Indiana information from this host (French, 1982; Whitaker and Mumford, 1972). It would be desirable to obtain additional data for *Blarina* and *S. longirostris* for south central Indiana.

*Sorex* (*Microsorex*) *hoyi*

An estimated 11,554 ectoparasites ($\bar{x}$ = 340/individual) were recovered from a sample of 34 pygmy shrews (Table 3). Thirty-two (94.1%) of the shrews yielded ectoparasites.

TABLE 3. Ectoparasites and other associates of 34 Pygmy Shrews, *Sorex* (*Microsorex*) *hoyi*, from south central Indiana.

| | Number | | Number infested | |
|---|---|---|---|---|
| | N | x | N | % |
| *Orycteroxenus soricis* | 11522 | 338.9 | 30 | 88.2 |
| *Pygmephorus whitakeri* | 8 | 0.2 | 5 | 14.7 |
| *Comatacarus americanus* | 7 | 0.2 | 2 | 5.9 |
| *Euschoengastia jamesoni* | 3 | 0.1 | 2 | 5.9 |
| *Pygmephorus proctorae* | 3 | 0.1 | 3 | 8.8 |
| *Pygmephorus spinosus* | 3 | 0.1 | 2 | 5.9 |
| *Pygmephorus moreohorridus* | 2 | 0.1 | 1 | 2.9 |
| *Bakerdania* sp. | 2 | 0.1 | 1 | 2.9 |
| *Cyrtolaelaps* sp. | 2 | 0.1 | 1 | 2.9 |
| *Xenoryctes nudus* | 1 | 0.03 | 1 | 2.9 |
| Histiostomatidae | 1 | 0.03 | 1 | 2.9 |
| | 11554 | | | |

Only 1 species of mite, the hypopus stage of *Orycteroxenus soricis*, phoretic rather than parasitic, was very common on pygmy shrews. It was found on 30 (88.2%) of the 34 individuals examined (Table 4). Numbers ranging from 1 to an estimated 1000 individuals were found per shrew.

Twenty individuals of *Pygmephorus* were taken, representing 4 species, and 2 species of chiggers, *Euschoengastia jamesoni* (3 individuals) and *Comatacarus americanus* (7 individuals) were taken. The latter species had not previously been recorded from Indiana. The only other forms taken were 1 or 2 individuals of *Bakerdania*, *Cyrtolaelaps*, Histiostomatidae, and *Xenoryctes nudus*.

*Sorex fumeus*

Seventy-one smoky shrews were examined for ectoparasites, of which 67 (94.4%) harbored a total of 4810 ($\bar{x}$ = 68/individual) parasites or other associates (Table 4). Most

TABLE 4. Ectoparasites of the Smoky Shrew, *Sorex fumeus*, from south central Indiana (n = 71).

| | Parasites | | Hosts infested | |
|---|---|---|---|---|
| | Number | Av #/host | No. | Percent |
| *Amorphacarus hengererorum* | 2568 | 36.2 | 17 | 23.9 |
| *Euschoengastia whitakeri* | 939 | 13.2 | 27 | 38.0 |
| *Orycteroxenus soricis* | 533 | 7.5 | 11 | 15.5 |
| *Xenoryctes nudus* | 275 | 3.9 | 11 | 15.5 |
| *Euschoengastia jamesoni* | 167 | 2.4 | 29 | 40.8 |
| *Protomyobia brevisetosa* | 68 | 1.0 | 12 | 16.9 |
| *Bakerdania* sp. | 43 | 0.6 | 16 | 22.5 |
| *Cyrtolaelaps* sp. | 27 | 0.4 | 18 | 25.4 |
| Histiostomatidae | 27 | 0.4 | 19 | 26.8 |
| *Neotrombicula cavicola* | 24 | 0.3 | 4 | 5.6 |
| *Xenoryctes latiporus* | 18 | 0.3 | 6 | 8.5 |
| *Pygmephorus hastatus* | 17 | 0.2 | 10 | 14.1 |
| *Pygmephorus rackae* | 13 | 0.2 | 8 | 11.3 |
| *Pygmephorus whitakeri* | 12 | 0.2 | 6 | 8.5 |
| *Dermacentor variabilis* | 11 | 0.2 | 2 | 2.8 |
| *Echinonyssus blarinae* | 11 | 0.2 | 8 | 11.3 |
| *Echinonyssus talpae* | 9 | 0.1 | 3 | 4.2 |
| *Doratopsylla blarinae* | 7 | 0.1 | 5 | 7.0 |
| *Proctolaelaps* sp. | 6 | 0.1 | 5 | 7.0 |
| *Androlaelaps fahrenholzi* | 5 | 0.1 | 5 | 7.0 |
| *Pygmephorus horridus* | 4 | 0.1 | 4 | 5.6 |
| *Pygmephorus brevicaudae* | 3 | 0.04 | 3 | 4.2 |
| *Pygmephorus spinosus* | 3 | 0.04 | 1 | 1.4 |
| *Euryparasitus* sp. | 3 | 0.04 | 3 | 4.2 |
| *Pygmephorus hamiltoni* | 2 | 0.03 | 2 | 2.8 |
| *Pygmephorus equitrichosus* | 2 | 0.03 | 1 | 1.4 |
| *Eucheyletia bishoppi* | 2 | 0.03 | 2 | 2.8 |
| *Leptinus americanus* | 2 | 0.03 | 2 | 2.8 |
| *Glycyphagus hypudaei* | 1 | 0.01 | 1 | 1.4 |
| *Pygmephorus lutterloughae* | 1 | 0.01 | 1 | 1.4 |
| *Pygmephorus faini* | 1 | 0.01 | 1 | 1.4 |

abundant was the myobiid mite, *Amorphacarus hengererorum*, followed by the chigger, *Euschoengastia whitakeri*, the glycyphagid hypopi *Orycteroxenus soricis* and *Xenoryctes nudus*, and another chigger, *Euschoengastia jamesoni*. Thirty-one ecoparasite taxa were recovered from *S. fumeus*.

Four species of chiggers were found on *S. fumeus*, but *Euschoengastia whitakeri* and *E. Jamesoni* were the most abundant species. *Euschoengastia whitakeri* was discovered during this study and has recently been described as new (Wrenn, 1984). *E. Jamesoni* and *N. cavicola* had not been previously taken from Indiana.

Glycyphagid hypopi were prominent on *S. fumeus* although they were not as abundant as on *S. hoyi*. The most abundant species was *Orycteroxenus soricis* with an estimated total of 533 individuals, 500 on one animal. *Xenoryctes nudus* and *X. latiporus* were also often taken, and collectively, were taken on more individuals (14) than was *O. soricis*.

The sixth most abundant form on *S. fumeus* was the myobiid mite, *Protomyobia brevisetosa*. It is restricted to *S. fumeus* in the east but is widespread on *Sorex* in the western United States. Mites of the family Pygmephoridae (*Bakerdania* and *Pygmephorus*) were common. *Bakerdania* sp. probably included several species. *Pygmephorus* was represented by 11 species. Two species of *Echinonyssus* were taken: *E. talpae*, of several species of shrews, and *E. blarinae*, usually found on *Blarina*. A few fleas, 7 individuals

of *Doratopsylla blarinae* and 1 of *Ctenophthalmus pseudagyrtes*, were taken, as were 2 individuals of the beetle parasite, *Leptinus americanus*.

Eight species of ectoparasites were taken from Indiana for the first time during this study. They consist of four chiggers, *Euschoengastia whitakeri* from *S. fumeus*, *E. jamesoni* from *Sorex fumeus* and *S. hoyi*, *Neotrombicula cavicola* from *S. fumeus*, and *Comatacarus americanus* from *S. hoyi*; the glycyphagid mite *Xenorcytes nudus* and the myobiid mite *Protomyobia brevisetosa* from *S. fumeus*; and *Pygmephorus lutterloughae* from *S. fumeus* and *P. proctorae* from *S. hoyi*.

The 17 most abundant species of ectoparasites (those occurring at rates of at least 0.3/shrew on any one species) are listed in Table 5. Only one species, *Orycteroxenus soricis*, occurred on all five hosts. *Androlaelaps fahrenholzi* occurred on four of the shrew species and was a major species on two, whereas *Xenoryctes nudus* occurred on four but was a major parasite on only one. *Amorphacarus hengererorum* was a major parasite on all three on which it occurred.

A simple coefficient was developed to assess similarities and differences between the parasite communities. Complete or 100% similarity would mean that all 17 parasites

TABLE 5. Major species of ectoparasites of shrews of Indiana (those occurring at rates of at least 0.3/individual of any one host species, expressed as Av. #/individual). (Data for *Sorex cinereus* and *S. longirostris* are from French, 1982; those from *Blarina* are from Whitaker & Mumford, 1972.)

| | | Sorex | | | | Number of Shrew Species | |
|---|---|---|---|---|---|---|---|
| | *Blarina* | *fumeus* | *cinereus* | *longi-rostris* | *hoyi* | on which it occurs | on which it occurs as major species |
| n = | 92 | 71 | 58 | 41 | 34 | | |
| Fleas | | | | | | | |
| *Ctenophthalmus pseudagyrtes* | 0.3 | 0.01 | 0.07 | — | — | 3 | 1 |
| *Corrodopsylla curvata* | | | 0.7 | — | | 1 | 1 |
| Myobiid Mites | | | | | | | |
| *Amorphacarus hengererorum* | — | 36.2 | 0.9 | 5.2 | — | 3 | 3 |
| *Protomyobia brevisetosa* | — | 1.0 | | | — | 1 | 1 |
| *P. indianensis* | — | — | — | 1.4 | — | 1 | 1 |
| *P. claparedei* | — | — | 1.8 | — | — | 1 | 1 |
| Trombiculid Mites (Chiggers) | | | | | | | |
| *Euschoengastia whitakeri* | — | 13.2 | | | — | 1 | 1 |
| *E. jamesoni* | | 2.4 | | | 0.1 | 1 | 1 |
| *Neotrombicula cavicola* | — | 0.3 | | | — | 1 | 1 |
| Glycyphagid mites | | | | | | | |
| *Orycteroxenus soricis* | 13.5 | 7.5 | 162.6 | 59.1 | 338.9 | 5 | 5 |
| *Xenoryctes nudus* | — | 3.9 | 0.1 | 0.1 | 0.03 | 4 | 1 |
| *X. latiporus* | — | 0.3 | 0.03 | 0.1 | — | 3 | 1 |
| *Glycyphagus hypudaei* | | | 0.1 | 1.2 | | 2 | 1 |
| Laelapid mites | | | | | | | |
| *Androlaelaps fahrenholzi* | 0.7 | 0.1 | 0.1 | 0.3 | | 4 | 2 |
| *Myonyssus jamesoni* | 0.3 | — | | | | 1 | 1 |
| *Haemogamasus liponyssoides* | 0.3 | 0.01 | 0.05 | — | | 3 | 1 |
| Listrophorid mites | | | | | | | |
| *Asiochirus blarinae* | 28.4 | — | | | — | 1 | 1 |
| | | | | | | 36 | 24 |

would occur as major forms on all five shrew species. In that case the total in the last column of Table 5 would be 85. Zero similarity would be indicated by a one in every row for a total of 17. The similarity coefficient was calculated as $((T - 17)/68) \times 100$ would be 100% when t = 85 and zero when t = 17. (Complete similarity would actually, of course, require that the numbers per host not differ significantly also, but that factor was ignored here.)

The similarity coefficient for major parasites in the shrews under study here was only 10.3%; for simple occurrence the similar value was 27.9%. These values indicate rather dissimilar parasite communities on the five species of shrews.

The ectoparasites occurring at rates of 1.0 or more per host are lited below. They are:

| | |
|---|---|
| *B. brevicauda*: | *Asiochirus blarina*, *Orycteroxenus soricis* |
| *S. fumeus*: | *Amorphacarus hengererorum*, *Euschoengastia whitakeri*, *O. soricis*, *Xenoryctes nudus* |
| *S. cinereus*: | *O. soricis*, *Protomyobia claparedei* |
| *S. longirostris*: | *O. soricis*, *A. hengererorum*, *Protomyobia indianensis*, *Glycyphagus hypudaei* |
| *S. hoyi*: | *O. soricis* |

The commonest species is *Orycteroxenus soricis*, which is the most abundant form in the three smallest shrews, second in *Blarina* and third in *S. fumeus*. It was the only species occurring at a rate over 1.0 in *S. hoyi*. *Amorphacarus hengererorum* was most abundant in *S. fumeus* and second in abundance in *S. longirostris*. All other species occurred on one host only.

The species of shrews of the hill country of south central Indiana, when they occur together, eat many of the same foods but differ considerably in proportions and harbor rather different ectoparasite communities.

## Discussion

The five species of shrews under consideration show patterns of variation in size and in food habits, and also of ecological and geographical replacement, all of which should reduce competition and allow them to live in the same general region. *Blarina* is the largest of the species and occurs throughout the area but, unlike the other species, feeds heavily on earthworms. It differed the most in food habits from any other species. *Sorex cinereus* is very similar in size and food habits to *Sorex longirostris* but does not occur in the unglaciated region. Of the three species other than *Blarina* that live in the unglaciated region, the largest and smallest live on the slopes and in the ravines and eat quite different foods (more beetles and spiders in *S. hoyi*, more earthworms and centipedes in *S. fumeus*) whereas *Sorex longirostris* occupies the flatlands.

The foods of the three smallest species, *S. cinereus*, *S. longirostris* and *S. hoyi*, are very similar, but the three are separated in southern Indiana geographically and/or ecologically. French (1984) found *Sorex cinereus* in the bottomlands and *S. longirostris* in the uplands in SW Indiana (west of the unglaciated area). We found *Sorex fumeus* and *S. hoyi* on the uplands, *S. longirostris* on the bottomlands in the unglaciated area. It seems highly likely that this geographical/ecological separation has been highly influenced if not caused by competitive exclusion.

There were pronounced differences between the ectoparasite communities of the shrews under study here. We believe these differences in great part reflect differing habits and habitats of the hosts. Data on chiggers, in particular, support this logic. Chiggers are basically non-host specific. Many of them do occur on one or few hosts, not because of host specificity as we usually think of it (inability to tolerate conditions on other hosts) but because they live in a situation where it is unlikely that different hosts will pick them

up. For this reason, they could be termed habitat specific (Loomis, 1956). Thus, if two species of shrews spend much time in the same place and under the same conditions, their chigger communities should be quite similar. However, *S. hoyi* had few chiggers, whereas *S. fumeus* had many. In addition, the most abundant chigger of *S. hoyi* was *Comatacarus americana* (seven individuals taken at two sites), whereas this species was not found on *S. fumeus*. The most abundant chigger on *S. fumeus* was *Euschoengastia whitakeri* ($\bar{x}$ = 13.2), but this chigger did not occur on any other host. *Euschoengastia jamesoni* was found at a rate of 2.4 on *S. fumeus*, and 0.1 on *S. hoyi* but was not found on any other host. Likewise, *Comatacarus* occurred only on *S. hoyi*, and *Neotrombicula cavicola* only on *S. fumeus*. The ectoparasites of *S. hoyi* seem to show a depauperate fauna, although the chigger, *Comatacarus americana*, was found only on this species and on no other in Indiana. This may indicate some ecological specialization of this shrew.

Mites of the family Pygmephoridae (*Pygmephorus* and *Bakerdania*) are often common on insectivores, but are not host specific (Smiley & Whitaker, 1978; Whitaker, French & Smiley, 1982). Eleven species of *Pygmephorus* were taken on *Sorex fumeus*, and four on *S. hoyi* during the present work. Three of the four taken on *S. hoyi* were also taken on *S. fumeus*. Few species of *Bakerdania* have been described from North America to date, but Mahunka and Whitaker are currently in the process of describing a number of species.

**Acknowledgments**

We thank William H. Kern and Barbara A. Brown of Indiana State University and Larry Allsop and Rick Pearcy of Crosley State Fish and Wildlife Area for their generous help with the field work. Mr. Milton Firestone of the Indiana State University Computer Center helped with the statistical analysis.

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