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Higher Efficiency of Pitfall Traps in Capturing Three Shrew Species for Analysis of Diet and Habitat

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ABSTRACT

An investigation to evaluate relative utility of pitfall versus snap-traps for censusing several shrew species of east-central Illinois was undertaken, as well as a study to assess diet and habitat preference. Traps were set for shrews in 51 locatios in Coles and Edgar Counties, Illinois, from May 1987 to April 1988. A total of 5,880 trapnights yielded 26 *Cryptotis parva*, 24 *Blarina brevicauda* and 21 *Sorex longirostris*. Results show no significant difference in the number of each species of shrew caught. This was not determined if due to equal distribution or smallness of sample size. *Blarina* was found in the widest variety of habitats, *Cryptotis* was abundant in old fields and old field-like habitats, and *Sorex* was found primarily in wooded areas. Examination of stomach and intestinal contents demonstrated the most frequently ingested prey of all three species was beetles. Finally, this study shows the advantage of using pitfall traps rather than snap-traps whn evaluating small mammal populations.

INTRODUCTION

Six species of shrew are found in Illinois with four present in east-central Illinois (Ellis et al., 1978; Hoffmeister, 1989; Hoffmeister and Mohr, 1972). Short-tailed shrews (*Blarina* sp.) are the largest species of shrew in Illinois; it has been well studied and is considered an ubiquitous species (Blair, 1940; Getz, 1961). Least shrews (*Cryptotis parva*), found in old field and old field-like habitats, have been trapped throughout Illinois (Hoffmeister, 1989; Hoffmeister and Mohr, 1972). Although Hoffmeister (1989) reported 119 masked shrews (*Sorex cinereus*) captured in Illinois, they are restricted to the northern third of the state with the exception of two collections taken from the southern tip. Habits and habitats of the southeastern shrews (*Sorex longirostris*) and the pygmy shrews (*Sorex hoyi*) are less well understood, because only a few individuals have been captured in Illinois (Hoffmeister, 1989). This study of trapping efficiencies, species abundance, habitats, and foods of shrews in east- central Illinois was undertaken in an effort to add to the knowledge about shrews.

STUDY AREAS

Pitfall traps were set for shrews at 51 locations in Coles and Edgar Counties, Illinois, from 27 May 1987 to 9 April 1988. Habitats at the sites were grouped into three major categories: coniferous forest, deciduous forest, and non-forested areas. The coniferous forest habitats consisted of white pine (*Pinus strobus*) or scotch pine (*P. sylvestris*) plantations of different ages. The young plantations (trees $\leq$ 3 m tall) contained annual forbs and grasses characteristic of old field succession. Although these plantations were often mowed between the rows, foxtail (*Setaria* sp.) and other annuals grew around trees and along rows where mowing did not occur. In contrast, the ground cover in older plantations (trees > 3 m tall) consisted only of pine needles.

The deciduous forest category included bottomland and upland frests of various ages. Bottomland stands were characterized by silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*) and box elder (*A. negundo*). There was little ground cover, and the dense understory was predominated by stinging nettle (*Urtica gracilis*) and poison ivy (*Toxicodendron radicans*). Upland forests consisted of younger oak-hickory stands and more mature sugar maple (*A. saccharum*) forests. Both of these areas featured a dense canopy and heavy leaf litter, but the understory in younger stands was limited, while the more mature woods contained an understory of poison ivy and Virginia creeper (*Parthenocissus quinquefolia*).

A variety of non-forested habitats were also trapped including three stages of old field succession, pasture lands, drainage ditches, prairie remnants, and edge habitats. The early successional stage of old field habitat was characterized by bareground and dominated by annual vegetation. The second or grass stage, however, had good ground cover, containing blue grass (*Poa pratensis*), meadow fescue (*Festuca pratensis*), evening primrose (*Oenothera biennis*) and foxtail. The third old field stage was a brush or early forest succession stage. Trees in this stage (diameter at breast height < 4.0 cm) included American elm (*Ulmus americanus*), cherry (*Prunus serotina*), hawthorn (*Crataegus* sp.), and sassafras (*Sassafras albidum*), while the ground cover was similar to the grass stage of succession, except that it also included blackberry (*Rubus allegeniensis*), green brier (*Smilax hispida*), and multiflora rose (*Rosa multiflora*).

Pasture habitats were ungrazed stands of fescue, orchard grass (*Dactylis glomerata*) and brome grass (*Bromus inermis*). Other vegetation included foxtail, purple top (*Tridens flavus*), and goldenrod (*Solidago* sp.). All pastures were uniform and unmowed and were bordered by cultivated land or fence rows.

Drainage ditches had steep sides (2-3 m deep) and held water throughout the trapping period. The cover was thick and the vegetation was diverse. Forbs present included goldenrod, small ragweed (*Ambrosia artimisiifolia*) and giant ragweed (*A. trifida*). Reed canary grass (*Phalaris arundinacea*) was the sole grass at one location, while other areas contained Johnson (*Sorgum halepense*) and rice (*Leersia oryzoides*) grasses.

Prairie remnants were also botanically diverse. Ground cover was thick in some areas, but sparse in others. Representative vegetation included big bluestem (*Andropogon gemardi*), Queen Anne's lace (*Daucus carota*), multiflora rose, and meadow fescue.

Finally, edge habitats were classified as either fence rows or roadside edge. Fence rows were further divided and described as either wooded or grassy. Wooded fence rows had a dense canopy and thick ground cover. The herbaceous understory included brome grass, goldenrod, foxtail, poison ivy, and multiflora rose. Representative trees included slippery elm (*Ulmus rubra*), American ash (*Fraxinus americana*), hawthorn, osage orange (*Maclura pumifera*), white oak (*Quercus alba*), and shingle oak (*Q. imbricaria*). Grassy fence rows had a dense ground cover consisting of blue grass, meadow fescue, and barnyard grass (*Echinochloa crusgalli*).

Roadside edge habitats were grouped as grass, areas bordering cultivated fields, or areas bordering forest edge. Ground cover was dense in grassy roadsides, but scarce in the roadsides bordering both forest and cultivated areas. Representative vegetation found in the grass areas included meadow fescue, brier, goldenrod, and foxtail. Roadsides bordering cultivated fields contained only sparse amounts of witch grass (*Panicum capillare*) and foxtail; those bordering the forest had more cover with goldenrod, multiflora rose, poison ivy, and witch grass generally predominating.

MATERIALS AND METHODS

Shrews were collected in each habitat with pitfall traps. Pitfalls were 2420 ml plastic containers 20 cm deep, 14 cm in diameter at the top and tapering to 12 cm at the bottom. A trap line consisted of 10 pitfalls buried flush with the ground at 10 intervals. No bait was used, and lines were set for five trapnights (TN) and checked every morning. Additionally, we recorded the types of non-woody vegetation present along the trap line. All trees within a 10 m radius of the fifth pitfall trap were identified.

The standard pitfall trap lines were modified in a few instances. Four lines had pitfall traps in combination with Museum Special snap- traps baited with peanut butter. Two of these trap lines had 100 snap- traps set three per station (four at the last station) at 10 m intervals with pitfalls buried halfway between each snap-trap station. The other two lines each had 20 snap-traps set with two at each station followed by one pitfall trap halfway between the stations. These lines were also set for five trapnights. All Museum Specials were reset and rebaited as needed. Additionally, two other pitfall lines were maintained as long-term lines by adding 500 ml of isopropyl alcohol covered with 20 ml of glycerin to slow evaporation. These lines were in place for 28 trapnights and checked once a week.

All shrews were identified as described by Hall and Kelson (1959) and Hamilton and Whitaker (1979). Study skins were prepared as described by Mosby and Cowan (1969). Cranial measurements were taken using dial calipers and were carried out to 0.1 mm. The skulls and skins were deposited with the Department of Zoology, Eastern Illinois University.

Stomachs and intestines were removed from all shrews and preserved in 5% formalin. Food items were separated with the aid of a dissecting microscope, and the frequency of occurrence and volumetric displacement of each food item was recorded as described by Windell (1970). With the assistance of Michael Goodrich, Department of Zoology, Eastern Illinois University, arthropod material was identified using the criteria of Borror et al. (1976). Morisita's index (Colwell and Futuyma, 1971) was used to statistically

evaluate the amount of food overlap among the genera of shrews. All other statistical procedures followed those described by Schefler (1980).

RESULTS

Fifty-one areas were trapped from 27 May 1987 to 14 December 1987 and from 4 April 1988 to 9 April 1988, resulting in a total of 5,880 trapnights (Table 1). Ten species in nine genera were represented in the 109 mammals caught, with a trap success of 0.0190 mammals/TN. Seventy-one (65.1%) of the 109 mammals were shrews belonging to one of three genera, *Blarina brevicauda* (n=24), *Cryptotis parva* (n=26) and *Sorex longirostris* (n=21). There was no significant difference in the number of each species of shrews captured (x^2=0.535,df=2,0.90>p>0.75). Other mammals trapped in either pitfalls or Museum Specials included 17 *Microtus ochrogaster*, one *M. pennsylvanicus*, 11 *Peromyscus leucopus*, four *Zapus hudsonicus*, two *Mus musculus*, two *Synaptomys cooperi*, and one *Tamias striatus*.

While snap-traps accounted for 2,100 trapnights of this effort, only two of the 71 shrews trapped (both *Blarina*) were taken in snap- traps. Trap analysis demonstrated the superior effectiveness of pitfalls versus snap-traps for capturing shrews (x^2=63.2,df=1,p<0.005).

Fifteen different habitats were trapped (Table 1). Overall, coniferous forest yielded the lowest percentage of shrews (15.5%) followed by deciduous stands (22.5%) and non-forested areas (62.0%). The difference in the number of shrews captured in these general types of habitats was statistically significant (x^2=36.055,df=2,p<0.005).

The only habitat which supported all three species was upland deciduous forest. Although no single area contained all three species, two species were captured in eight habitats, with seven of these eight having *B. brevicauda* in combination with one of the other species. *Cryptotis parva* and *S. longirostris* were found together only in young coniferous plantations. Of the four habitats from which only one shrew species was collected, three were stages of old field succession.

Stomach and intestinal contents from 26 *C. parva*, 21 *S. longirostris* and 23 *B. brevicauda* were examined (Table 2). Total volume of intestinal samples were over four times larger than stomach contents (1.05 ml in stomachs, 4.25 ml in intestines). Intestinal contents contained higher volumes of undigestible hard material such as chitinous exoskeletons and bone fragments. In contrast, stomach samples contained undigested soft foods which were absent or unrecognizable in the intestine. For example, annelids represented 41.8% of the total stomach volume, but the digested annelid bodies were not identifiable in the intestine. Wings of dipterans, lepidopterans and hemipterans were also found only in stomachs. Although combining stomach and intestinal contents can potentially bias results toward less digestible items, this procedure was chosen beause of the very low total volume from stomach samples relative to intestinal samples.

As can be seen in Table 2, *B. brevicauda* had more categories of food present than did *C. parva* or *S. longirostris*. Animal remains, rather than plant material, was dominant in the shrews with undifferentiated soft tissue (UST) being present in both the greatest frequency of occurrence and percent total volume. Beetles were the most frequently ingested prey making up 11.3%, 16.3% and 18.6% of the total volume for *S.*

longirostris, *B. brevicauda*, and *C. parva*, respectively. This was followed by mammals in *S. longirostris*, annelids in *B. brevicauda* and chilopods and arachnids in *C. parva*. Ingested in lesser frequencies, but represented in all three genera, were Diptera, Hymenoptera, and plant material. Morisita's index also showed a strong overlap of foods for the three shrews (*Blarina-Cryptotis*=99.7%, *Blarina-Sorex*=99.9%, *Sorex-Cryptotis*=99.6%). Mammal remains were present in 14 of the shrews trapped, but the percent total volume was low. Both bone fragments and hair were present, but total volumes were small because hair was usually not present in measurable amounts.

DISCUSSION AND SUMMARY

Standard lines of snap-traps set for a given length of time were long considered to provide a sample of small mammal populations (Dice, 1941). Snap-traps alone, however, will not provide a representative sample of all species. Pitfall traps reduce this bias (Brown, 1967; MacLeod and Lethiecq, 1963; Rose, 1980; Spencer and Pettus, 1966; Tuttle, 1964). Because this was not a study of all small mammals, but specifically of shrews, pitfall trapping was emphasized. The results of this study suggests that pitfall traps were successful, because more *S. longirostris* were collected in this study (Table 1) than have been previously reported in earlier studies done in Illinois (Clapp, 1985; Hoffmeister, 1989; Hoffmeister and Mohr, 1972). *Sorex longirostris* has a distribution ranging approximately over the southern half of Illinois (Hamilton and Whitaker, 1979; Hoffmeister, 1989). The total number of these shrews previously collected within Illinois consists of 66 specimens taken from 12 counties, two of wich were trapped in Coles County (Clapp, 1985; Hoffmeister, 1989; Hoffmeister and Mohr, 1972). In this study, 21 *S. longirostris* were collected in Coles County exclusively using pitfall traps (Table 1). In fact, the pitfall captures of *S. longirostris* were not statistically different from those of *B. brevicauda* and *C. parva*.

This investigation also confirms previous reports about the habitat of *Blarina brevicauda*. This larger shrew is generally recognized as an ubiquitous species (Blair, 1940; Choate, 1972; Getz, 1961; Hoffmeister and Mohr, 1972; Wrigley et al., 1979). Getz (1961) and Wrigley et al. (1979) stated that the type of vegetation and cover had no influence upon local distribution of *B. brevicauda*, and, within Illinois, *B. brevicauda* has been reported to inhabit forest floors, forest edges, meadows near woods, and swampy, brushy habitats (Hoffmeister and Mohr, 1972). As stated previously, data from this study show similar results.

In contrast to the well-studied *B. brevicauda*, however, habitat requirements and distribution of *C. parva* and *S. longirostris* are less well described (perhaps due, at least in part, to fewer numbers of these species being collected). *Sorex longirostris* has been found in forest and old fields in Indiana (Rose, 1980) and in fence rows, deciduous forest, old field and open field habitats in Tennessee (Tuttle, 1964). We found *S. longirostris* to be primarily associated with forest habitats: bottomland deciduous forest, roadside edge bordering a forest, and wooded fence rows. Two specimens were also found in a young coniferous plantation which was located near a deciduous stand. Most habitats in which these shrews were reported tended to be moist, and, at least in Illinois, the southeastern shrew seems to avoid drier habitats such as old field, pasture and prairie remnants.

Cryptotis parva has been reported to occupy a diverse range of habitats (Clapp, 1985; Hoffmeister, 1989; Hoffmeister and Mohr, 1972), but is primarily associated with upland

old fields (Andrews, 1974; Rose and McKean, 1980). It was not surprising, therefore, that *C. parva* was collected, in this study, in habitats that were old field or similar to old field (Table 1). Nine specimens were collected in a young coniferous plantation. However, the vegetation between pine tree rows and within mowed rows of these plantations consisted of grasses and annual weeds much like old fields. This vegetational overlap is also evident in the grassy fence rows and grassy roadside edge habitats.

Blarina brevicauda has often been reported in association with other species (Dueser and Shugart, 1978), and in this study, it was collected with both *C. parva* and *S. longirostris*. This is not surprising given the broad habitat base of *B. brevicauda* and the fact that shrews have shown a sympatric coexistence of up to six species (Spencer and Pettus, 1966; Wrigley et al., 1979) without apparent adverse effects of niche overlap (Getz, 1961). Niche separation plays a significant role in small mammals distribution (Dueser and Shugart, 1978) and, therefore, use of different habitats reduces competition (Zegers and Ha, 1981). However, the two smaller shrews were trapped together only in a young coniferous plantation and upland deciduous forest (Table 1), suggesting that smaller shrews may have a greater niche overlap with each other than either of them do with the larger *Blarina*. The 99% dietary overlap of the three shrews found in this study suggests significant niche overlap, but it is quite possible that there is less overlap of foods than these data indicate. For example, beetles, which are the largest order of insect (Boror et al., 1976), were the most frequently ingested prey. Hence, each species of shrew could be feeding upon different taxa, and because shrews chew their food finely (Hamilton, 1930), distinguishing within lower taxonomic levels would be more difficult from analysis of stomach and intestinal contents.

Results of the analysis of stomach and intestinal contents suggest that animal matter is the dominant food item for the shrews, with beetles making up the greatest volume of ingested prey. While plant material also was present in all three species of shrews, the amount measured suggests that it was a secondary consequence of foraging for insects. This wide array of possible foods allows the shrews to inhabit a variety of habitats.

Finally, shrews were not collected at some locations that appeared to be suitable habitats. Isolation of habitats may restrict the movement of shrews (Adams and Geis, 1983) and may explain the absence of shrews in several habitats. For example, drainage ditches possessed suitable food, cover and water, yet no shrews were collected in this habitat. This may be due to a lack of access to these habitats from areas which contain shrews. Studies on movements of shrews and their microhabitat requirements need to be evaluated more thoroughly to determine reasons for the absence of shrews in suitable habitats.

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Table 1: Habitat subdivisions and shrew captures

HABITAT	N	n	TN	*Bb*	*Cp*	*Sl*	TOTAL	SHREWS/TN
Coniferous Forest								
A.< 3m tall	4	65	1155*	0	9	2	11	0.0095
B.> 3m tall	1	10	50	0	0	0	0	0.0000
Deciduous Forest								
A.Bottomland	3	30	160	4	0	7	11	0.0688
B.Upland	11	132	2765**	3	1	1	5	0.0018
Non-Forest								
A.Pasture	5	50	250	2	1	0	3	0.0120
B.Old Field								
1.Annuals	2	20	100	0	1	0	1	0.0100
2.Grass	2	20	100	0	9	0	9	0.0900
3.Brush	2	20	100	1	0	0	1	0.0100
C.Drainage Ditch	4	40	200	0	0	0	0	0.0000
D.Prairie Remnant	4	40	200	0	0	0	0	0.0000
E.Fence Row								
1.Wooded	5	50	300	8	0	7	15	0.0500
2.Grass	2	40	200	4	2	0	6	0.0300
F.Roadside								
1.Forest edge	1	10	50	2	0	4	6	0.1200
2.Cultivated edge	1	10	50	0	0	0	0	0.0000
3.Grass	4	40	200	0	3	0	3	0.0150
TOTAL	51	577	5880	24	26	21	71	

N = number of traplines per habitat
n = number of pitfall traps per habitat
TN = number of trapnights
Bb = *Blarina brevicauda*
Cp = *Cryptotis parva*
Sl = *Sorex longirostris*
* = some lines were set for long-term, thus the large TN total
** = TN includes 2000 snap nights

Table 2: Analysis of stomach and intestine samples

FOODS	*Blarina*		*Cryptotis*		*Sorex*	
	Freq	Vol(%)	Freq	Vol(%)	Freq	Vol(%)
Animal Material	60	99.4	51	100.0	48	98.6
Arthropoda						
Chilopoda	2	2.8	1	4.1	0	-
Insecta						
Coleoptera	13	16.3	11	18.6	9	11.3
Orthoptera						
Blattidae	1	1.1	0	-	0	-
Hymenoptera						
Formicidae	4	0.6	1	1.0	1	1.4
Diptera	1	+	1	+	2	+
Hemiptera	0	-	1	+	0	-
Homoptera	0	-	3	+	0	-
Lepidoptera						
Adult	1	+	0	-	0	-
Larval	1	0.3	0	-	0	-
Unidentified	6	0.6	2	+	8	1.4
Arachnida						
Spiders	1	+	1	4.1	4	1.4
Annelida						
Oligochaeta	2	7.5	1	1.0	0	-
Chordata						
Mammalia	5	3.0	4	1.0	3	7.0
UST	23	67.4	25	70.1	21	76.1
Plant Material	6	+	5	+	2	1.4
Inorganic Material	4	0.6	0	-	4	+
TOTAL	70	100.2	56	99.9	54	100.0

Freq = frequency of occurrence (# of observations of this)
Vol = percent total volume
+ = denotes a trace in the sample
- = denotes that it was absent
UST = undifferentiated soft tissue