uses occurring in narrow valley locations in the case of pasture and small cropped areas, and a quarry typical of the Holston Formation also appears in the upper part of the example.

The largest area of solution on the Copper Ridge overthrust sheet straddles the boundary between the Concord and Meadow quadrangles. State Highway 95 bisects the area (see Figure 5). Although the land use pattern is seemingly complex, it is because of the large number of residences along this major feeder route to nearby Lenoir City, three miles north across Fort Loudon Dam. In this area, karst areas are characteristically hay lands included within pasture surrounded by woodland. Possibly because of their status as relatively preferable agriculture lands within this dominantly non-agricultural locale, field boundaries commonly follow depression limits, at least in the case of the large depressions.

The only significant karst depression on floodplain is on the ancestral floodplain of the Tellico River south of the historical site of Fort Loudon (see Figure 6). This entire floodplain is in cropland and a lake was in evidence at the time of photography within the limits of the large depression interpreted as a swallow hole. Woodlands occupy the low bluffs on either side of the floodplain, and cropland again appears on the benches approximately 100 feet above the floodplain, along with some hay and pasture land. Field boundaries in this example are severely influenced by the breaks in slope at the edges of the floodplain and the benches. The cross-sction line trends across the floodplain and lateral benches.

A section of the central extent of Knox Group rocks was chosen for closer inspection of the effects of faulting on land use/Karst relationships. It lies in the north-central part of the Madisonville quandrangle (see Figure 7). Although certain land use combinations pertain to this example, it is the alignment along the fault zone that best characterizes this type, with a stairstep effect in decreasing elevation toward the northeast imparted along this trace. Although mostly cropland appears along the cross-section lines in Figure 7, other depressions in the area show pasture along wetter stream bottoms, and woodlands are found occupying the steeper-walled depressions. Field boundary decisions appear to be completely unaffected by solutional activity.

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LITERATURE CITED

Berry, B. J. L. 1962. *Sampling, Coding, and Storing Flood Plain Data*. Agricultural Handbook No. 237, USDA. 24 p.

Freeman, T. W. 1961. *A Hundred Years of Geography*. Aldine Publishing Co., Chicago. 74 p.

Griffin, John I. 1962. *Statistics, Methods, and Applications*. Holt, Rhinehart and Winston, New York. p. 188-189.

Hardeman, W. D. 1966. *Geologic Map of Tennessee (East Central Sheet)*. State of Tennessee, Division of Geology, Nashville.

Harvey, D. 1970. *Explanation in Geography*. St. Martin's Press, New York. 313 p.

King, L. J. 1969. *Statistical Analysis in Geography*. Prentice-Hall, Inc., Englewood Cliffs, N.J. 81 p.

Malott, C. A. 1939. "Karst Valleys," *Bulletin of the Geological Society of America*, 50: 1984 p.

Nunnally, N. R. and R. E. Witmer, 1970a. *A Land Use Interpretation Experiment*. Technical Report 69-5, USGS.

_____. 1970b. "Remote Sensing for Land Use Studies," *Photogrammetric Engineering*. 36: 449-453.

Saarinen, T. F., 1969. *Perception of Environment*. Commission on College Geography Resource Paper No. 5, Association of American Geographers, Washington, D.C. p. 3-4.

Thornbury, W. D. 1969. *Principles of Geomorphology*, 2nd. ed. John Wiley and Sons, Inc., New York. 311 p.

_____. 1965. *Regional Geomorphology of the United States*. John Wiley and Sons, Inc., New York. 609 p.

Witmer, Richard E. 1970. *Tellico Test Site Land Use Map*. Technical Report 69-4, USGS GEOGAP Program, Contract 14-08-0001-12009.

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A SURVEY OF THE MICROTINE AND ZAPODID RODENTS OF WEST TENNESSEE

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ABSTRACT

A total of 235 specimens of the subfamily Microtinae and the family Zapodidae were examined and collected from West Tennessee. *Microtus pinetorum* was collected readily throughout the study area. *M. ochrogaster* was absent from the southern tier of counties. *Ondatra zibethicus* was found throughout the study area. *Zapus hudsonius* was infrequently collected and found only in the northern half.

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INTRODUCTION

In western Tennessee, the mammals of the rodent groups Microtinae and Zapodidae are poorly known. Therefore, a study was initiated to learn more about

these rodents in that area of Tennessee between the Mississippi and Tennessee rivers. Rhoads (1896) gave no evidence of *Synaptomys cooperi*, *Microtus ochrogaster*, or *Zapus hudsonius* in this area. However, he reported that *Fiber* (=*Ondatra*) *zibethicus* and *Microtus pinetorum* were found. In a more comprehensive work on Tennessee mammals, Kellogg (1939) reported that Perrygo and Lindbach collected a "small series" of *Microtus ochrogaster* near Reelfoot Lake in 1937. He also reported *Pitymys* (=*Microtus*) *pinetorum* in Obion and Fayette counties and stated that *Ondatra zibethicus* had been taken in Fayette County, Shelby County, and the Reelfoot Lake area. Calhoun (1941) caught two prairie voles and a jumping mouse at the Reelfoot Lake Biological Station. Goodpaster and Hoffmeister (1952) reported catching 17 prairie voles, a "large number" of pine voles, one jumping mouse, and observed muskrat houses and dens in the vicinity of Reelfoot Lake.

Methods

This study is based upon the examination of 235 specimens of which 45 are housed in the University of Illinois Museum of Natural History (UIMNH), six in the museum of the University of Tennessee at Martin (UTM), and the remainder were collected by the authors and other students and were incorporated into the Memphis State University Museum of Zoology.

Field collections by the authors took place from late March 1968 through late October 1968. Approximately 21,200 trap-nights were worked during this study. The specimens were prepared as standard study skins. Besides the normal skin measurements, the following cranial measurements were taken in millimeters:

CONDYLOBASAL—from the anterior edge of the alveoli of the incisors to the posterior edge of the occipital condyle.

BASILAR LENGTH—from the posterior edge of the alveoli of the incisors to the anterior edge of the foramen magnum.

ZYGOMATIC BREADTH—the greatest width across the zygomata.

MOLAR LENGTH—from the anterior edge of the alveoli of M1 to the posterior edge of M3.

INTERORBITAL BREADTH—the least width between the orbits across the dorsal surface of the skull.

Results

Family: Cricetidae
Subfamily: Microtinae
Microtus ochrogaster ochrogaster (Wagner)
Prairie Vole

Distribution in West Tennessee.—Found to be common throughout West Tennessee except for the southern tier of counties (see Figure 1).

Measurements.—Selected measurements of 56 adult specimens are given in Table 1.

TABLE 1: *Measurements of Microtus ochrogaster ochrogaster*

MALE

	Total Length	Tail Length	Hindfoot Length	Ear Length	N
Mean	136.0	32.5	18.3	12.8	32
Maximum	164.0	39.0	20.0	18.0	
Minimum	121.0	26.0	16.0	11.0	
Standard Deviation	11.5	3.4	1.0	1.8	

FEMALE

	Total Length	Tail Length	Hindfoot Length	Ear Length	N
Mean	135.3	32.0	18.0	12.9	22
Maximum	155.0	39.0	19.0	19.0	
Minimum	121.0	25.0	16.0	11.0	
Standard Deviation	10.2	3.8	0.9	2.2	

MALE AND FEMALE

	Condylobsal Length	Basilar Length	Zygomatic Breadth	Interorbital Breadth	Molar Length	N
Mean	26.0	23.1	14.6	4.1	6.0	35
Maximum	28.7	25.5	16.4	4.4	6.9	
Minimum	23.3	20.4	12.9	3.7	4.3	
Standard Deviation	1.5	1.3	1.0	0.2	0.5	

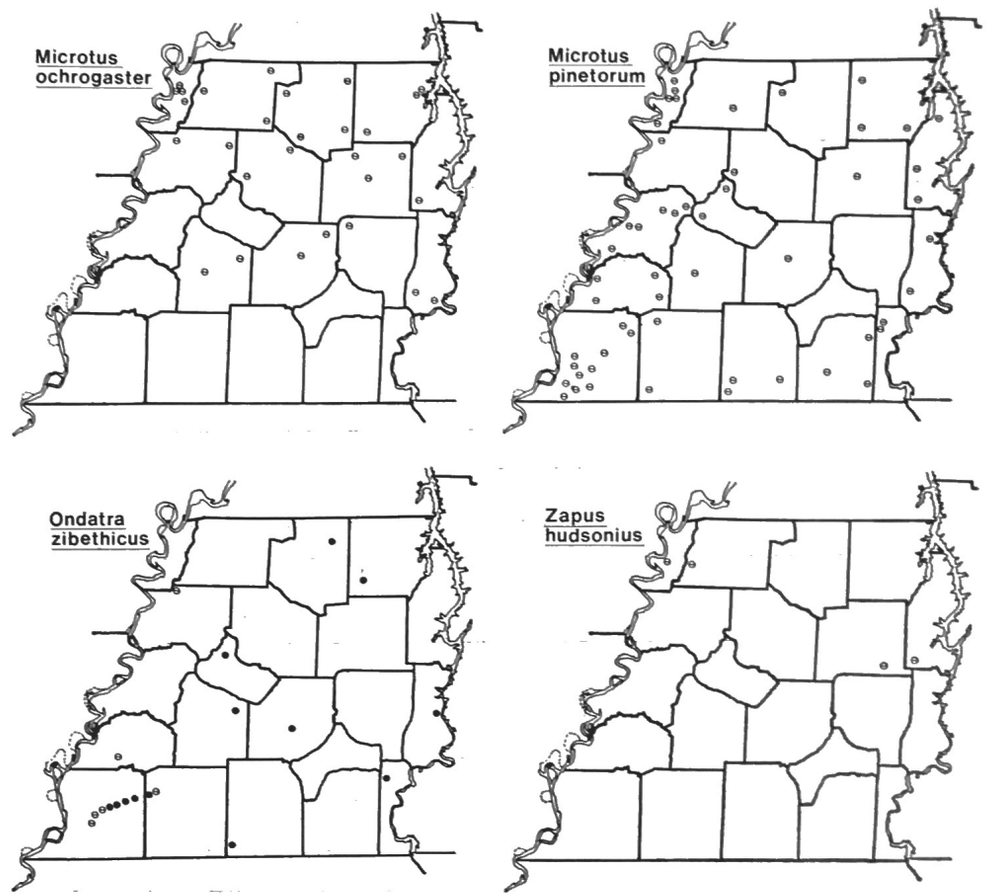

FIG. 1. *Records of occurrence of Microtus ochrogaster, M. pinetorum, Ondatra zibethicus, and Zapus hudsonius in West Tennessee. Symbols indicate records of occurrence as follows: specimens examined, open symbols with horizontal line; sight records, closed symbols*

Remarks.—Of the *Microtus ochrogaster ochrogaster* taken in this survey 65 per cent were from old fields and 35 per cent were in field-edge. Occasionally this species was found in fairly wet areas, but this was true for only 5 per cent of the specimens taken. The preferred grassy habitat for this species contains blackberry, sericea, broomsedge, goldenrod, brush piles, Johnson grass, and honeysuckle, in that order.

Specimens Examined.—85, from: *Benton County:* 0.5 mi. N Holladay, 2. *Carroll County:* 2 mi. SW McKenzie, 4; 2 mi. N Hollow Rock, 1; 1 mi. W Huntingdon, 1 (UTM). *Decatur County:* 4 mi. SW Bathsprings, 1; 5 mi. SE Scotts Hill, 2. *Dyer County:* 7 mi. NE Newbern, 3; 6 mi. SW Miston, 4. *Gibson County:* 1 mi. E Central, 3; 1 mi. N Bradford, 1. *Haywood County:* 5.5 mi. W Brownsville, 2; 4 mi. N Union, 1. *Henderson County:* 3 mi. NW Bargerton, 1. *Henry County:* 2 mi. SW Henry, 4; 2 mi. SW Paris Landing, 1; 4 mi. SW Paris Landing, 3. *Lake County:* 3 mi. NE Wynnburg, 3; 1.5 mi. E Tiptonville, 2 (UIMNH); 2 mi. E Tiptonville, 16 (UIMNH); 2 mi. NE Tiptonville, 4 (UIMNH). *Lauderdale County:* 9 mi. W Cherry, 2. *Madison County:* 4 mi. N Jackson, 1; Springcreek, 1. *Obion County:* 3 mi. NE Kenton, 1; 6 mi. NE Union City, 3; 4.25 mi. ESE Tiptonville, 2 (UIMNH). *Weakley County:* 2 mi. NE Gleason, 4; 2 mi. W Martin, 1; 1 mi. N Greenfield, 2; 3 mi. N Palmersville, 2.

Microtus pinetorum auricularis V. Bailey
Pine Vole

Distribution in West Tennessee.—All counties of West Tennessee (see Figure 1).

TABLE 2. *Measurements of Microtus pinetorum auricularis*

MALE

	Total Length	Tail Length	Hindfoot Length	Ear Length	N
Mean	115.9	20.2	15.7	11.0	40
Maximum	129.0	24.0	23.0	13.0	
Minimum	99.0	16.0	14.0	9.0	
Standard Deviation	6.9	2.0	1.6	1.2	

FEMALE

	Total Length	Tail Length	Hindfoot Length	Ear Length	N
Mean	115.3	20.6	15.7	10.9	30
Maximum	130.0	27.0	18.0	14.0	
Minimum	101.0	17.0	13.0	8.0	
Standard Deviation	8.6	2.8	1.3	1.4	

MALE AND FEMALE

	Condylobasal Length	Basilar Length	Zygomatic Breadth	Interorbital Breadth	Molar Length	N
Mean	24.5	21.4	15.0	4.3	6.1	24
Maximum	26.6	22.9	16.1	4.9	6.6	
Minimum	21.7	18.7	13.3	3.3	5.2	
Standard Deviation	1.1	1.0	0.8	0.3	0.4	

Measurements.—Selected measurements of 70 adults are given in Table 2.

Remarks.—*Microtus pinetorum auricularis* is common throughout West Tennessee. The preferred habitat for this species appears to be hedgerows or brush piles with some blackberry, honeysuckle, and deciduous saplings. Approximately 20 per cent were taken in deciduous woods and five per cent in open fields.

The skulls of *Microtus pinetorum* and *Microtus ochrogaster* can be differentiated, for the most part, in West Tennessee by comparing the ratio of the zygomatic breadth to the condylobasal length. *M. ochrogaster* appears to have a skull that is longer and narrower than that of *M. pinetorum*. When the ratios of these species are compared a slight over-lap appears. The ration in *M. ochrogaster* ranges from 54.09 percent to 61.68 percent with all but two of 35 skulls falling below 59.00 percent. The ratio in *M. pinetorum* ranges from 56.67 percent to 65.34 percent with 21 of the 24 skulls above 59.00 percent. (See Figure 2). Because of the over-lap this is not a perfect method of separating these two species. However, it appears that the separation point of these two species is a follows: 58.5 percent and above, *M. pinetorum*, 58.5 percent and below, *M. ochrogaster*. This method was valid in 91.5 percent of the specimens examined.

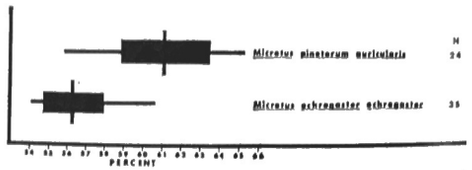

FIG. 2. *Percent of zygomatic breadth divided by condylobasal length. Narrow horizontal line indicates range, rectangle indicates one standard deviation on either side of the mean, vertical line indicates the mean, N indicates sample size*

Specimens examined.—139, from: *Benton County:* 3 mi. N Big Sandy, 3; 0.5 mi. N Holladay, 1; 4 mi. E Camden, 1. *Carrol County:* 1 mi. W Huntingdon, 2 (UTM). *Crockett County:* 4 mi. N Crockett Mills, 1; 1 mi. W Maury City, 1. *Decatur County:* 5 mi. SE Scotts Hill, 1; Lick Creek Lake, 1. *Dyer County:* 6 mi. SW Miston, 2. *Fayette County:* 3 mi. W Rossville, 4; 3 mi. SE Braden, 1. *Gibson County:* 1 mi. E Central, 5. *Hardeman County:* 10.5 mi. S Bolivar, 1; 5 mi. SW Hickory Valley, 1; 1 mi. W Pocahontas, 1; location unknown, 1 (UTM). *Hardin County:* 3 mi. E Morris Chapel, 6; 1 mi. SE Morris Chapel, 5. *Haywood County:* 5.5 mi. W Brownsville, 1. *Henry County:* 2 mi. NE Mansfield, 1; 3 mi. NE Cottage Grove, 1. *Lake County:* 2 mi. SW Ridgely, 1; Sunkist Beach N Tiptonville, 3 (UIMNH); 2 mi. SE Tiptonville, 16 (UIMNH); 4.5 mi. ESE Tiptonville, 1 (UIMNH). *Lauderdale County:* 1 mi. N Gates, 3; Open Lake, 1; 9 mi. W Cherry, 2; 2 mi. SW Gates, 1; 3.8 mi. E Open Lake, 1 (UIMNH). *Madison County:* Jackson, 2 (UTM). *McNairy County:* 5 mi. E. Selmer, 5; 6 mi. N Adamsville, 1; 5 mi. N Michie, 1. *Obion County:* 6 mi. NE Obion, 4. *Shelby County*, Memphis, 12; SE Memphis, 2; Gallaway, 1; 4 mi. NW Arlington, 1; 6 mi. N Memphis, 1; Whitehaven, 2; 3 mi. S Memphis, 1; 6 mi. N Memphis, 1; 1.5 mi. N Memphis, 1; Corner Walnut and Summer, Memphis, 8; Macon Rd., 6; Airways Blvd., 3; 1 mi. N Memphis, 1; Thomas Rd., 1 mi. NW U.S. 70, 1; Nonconnah Creek and I-40, 1; 0.5 mi. N U.S. 70 Memphis, 1. *Tipton County:* 7 mi. W Gilt Edge, 1; 5 mi. NW Mason, 2; 6 mi. E. Covington, 2; 3.3 mi. S Mumford, 1. *Weakley County:* 2 mi. W Martin, 1; Martin, 1 (UTM).

Ondatra zibethicus zibethicus (Linnaeus)
Muskrat

Distribution in West Tennessee.—All counties of West Tennessee (see Figure 1).

Measurements.—Hall and Kelson (1959) reported the average external measurements of seven adults as: total length, 500 mm; tail length, 226 mm; hindfoot length, 76 mm.

Remarks.—Of the specimens of *Ondatra zibethicus zibethicus* sighted, collected, or otherwise reported, all but one was found either in farm ponds, streams, or small rivers. The one exception was a road kill found in an area where there was no visible aquatic habitat.

No muskrat houses were observed during the study but several dens were seen. The den-entrances were below the water line and led into the bank. In only one case was the entrance above water at the time of observation.

Family: Zapodidae
Zapus hudsonius intermedius Krutzsch
Meadow Jumping Mouse

Distribution in West Tennessee.—Northern counties: Lake, Obion, Weakley, Henry, Benton, most of Carroll, the northern half of Gibson, and probably Dyer counties (see Figure 1).

Measurements.—The three males and one female of this species that were examined during this study had external measurements of: total length, 171, 200, 186, and 159 mm; tail length, 104, 126, 118, 101 mm; hindfoot length, 27, 29, 29, 26 mm; ear length, 12, 12, 12, 10 mm, respectively.

Remarks.—*Zapus hudsonius intermedius* is quite scarce in West Tennessee. This is suggested by the taking of only four specimens during this survey. The subspecies found in the area of this survey is currently recognized as *Z. h. intermedius* Krutzsch (1954).

The four specimens were taken in low bottomland fields. These fields were damp and the grass was from one and one-half feet to four feet high.

Summary

A survey of the microtine and zapodid rodents of West Tennessee was conducted from late March to late October 1968. Four species were collected in the study area.

The study was based on 21,200 trapnights. A total of 235 specimens was collected or examined. Specimens collected, those reported in the literature, and those sighted, were incorporated into this paper to present a more comprehensive survey of the four species present.

The species involved in this survey were *Microtus pinetorum auricularis, Microtus ochrogaster ochrogaster, Ondatra zibethicus zibethicus,* and *Zapus hudsonius intermedius. M. p. auricularis* and *O. z. zibethicus* were found throughout the study area. *M. o. ochrogaster* was found throughout West Tennessee except in the southern tire of counties, and *Z. h. intermedius* was found only in the northern half of the study area.

This survey made possible sufficient data to allow a skull comparison between *M. o. ochrogaster* and *M. p. auricularis*. It was found that the ratio between zygomatic breath and the condylobasal length in the prairie vole is 58.5 percent or lower and that of the pine vole is 58.5 percent or higher (see Figure 2).

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Literature Cited

Calhoun, J. B. 1941. Distribution and food habits of mammals in the vicinity of the Reelfoot Lake Biological Station. J. Tenn. Acad. Sci. 6:177-225.

Goodpaster, W. W. and D. F. Hoffmeister. 1952. Notes on the mammals of western Tennessee. J. Mamm. 33:362-371.

Hall, E. R. and K. R. Nelson 1959. The mammals of North America. The Ronald Press Company, New York. 2 vol.

Kellogg, R. 1939. Annotated list of Tennessee mammals. Proc. U. S. Nat. Mus. 86:245-303.

Krutzsch, P. H. 1954. North American jumping mice (genus *Zapus*). Univ. Kansas Publ. Mus. Nat. Hist. 7:349-472.

Rhoads, S. N. 1896. Contributions to the zoology of Tennessee. No. 3, Mammals. Proc. Acad. Nat. Sci. Phila. p. 175-205.