JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
Volume 46, Number 4, October, 1971

THE DISTRIBUTION OF VERTEBRATES ON THE ISLANDS OF BOONE AND WATAUGA LAKES

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ABSTRACT

The species composition and distribution of vertebrates inhabiting selected islands in Boone and Watauga Lakes in eastern Tennessee is described. The dominant vegetation of the islands and the relative density of vegetative ground cover was determined and the distribution of the more common species of small mammals was examined quantitatively in relation to this factor. Snap trapping, shooting and direct observation during systematic searches were utilized in determining the kinds and numbers of terrestrial vertebrates. Only one amphibian and three reptile species were found on the islands. Nineteen species of birds were observed and nine species of mammals were collected. Ten of the 13 islands supported small mammal populations. Twice as many mammals were captured in dense or intermediate ground cover as in areas with sparse vegetative ground cover.

Smaller islands provided fewer kinds of habitat and harbored fewer mammalian species than did larger islands. Vegetational density and resulting ground cover seemed most important to small mammal population survival. Some speculation relative to lake island ecology is presented.

INTRODUCTION

Tennessee Valley Authority construction in East Tennessee resulted in the formation of several large lakes which are dotted by islands of varying size. These islands are unflooded remnants of wooded hilltops with a vegetative cover much like that of the adjoining mainland. Most of these lake islands are permanently separated from the mainland by the rather deep and cold waters of the TVA lakes.

Studies of island ecology in fresh water lakes and streams are not abundant, in spite of the potential held by these natural enclosures. Island habitats are ideal for studying effects of space and cover limitations, speciation, animal movements, plant succession, and interspecific competition. River island studies include those of Pruitt (1951) and Werner (1956). Conaway, Baskett, and Toll (1960) studied swamp rabbit populations in relation to flooding of islands in the Mingo Swamp in Southeast Missouri. Additional studies of islands found in lakes are those of Dice (1925), Blair (1946), Hatt et al. 1948), Ozoga and Phillips (1964) and Sheppe (1965).

Published studies of small mammal distribution in East Tennesse are scarce. Some information concerning small mammal distribution in East Tennessee is provided by Kellogg (1939) and Conaway and Howell (1953). Their work, however, was limited primarily to mountainous regions in Johnson and Carter Counties and consisted of only 2-4 days of trapping effort. Additional mammal surveys have been conducted in Carter County under the auspices of the U.S. National Muscum, but the results remain unpublished.

The purpose of this investigation is fourfold:

1) To describe the vegetation and document the kinds and numbers of vertebrates (especially mammals) found on selected islands in Boone and Watauga Lakes.
2) To determine the relative abundance of small mammals in relation to cover type and density on these islands.
3) To provide a background of information that will be relevant to future studies of island ecology conducted in this area and elsewhere.
4) To provide additional data on the distribution of mammals in the ecologically unique upper East Tennessee region.

DESCRIPTION OF STUDY AREAS

Both Boone and Watauga Lakes are located in the Ridge and Valley Physiographic Province of eastern Tennessee (Fenneman, 1938). Both lakes are artificial impoundments created by the construction of two dams by the Tennessee Valley Authority.

Boone Dam, constructed in 1952, is located on the South Fork of the Holston River, 2.3 km below its confluence with the Watauga River. The reservoir lies in Sullivan and Washington Counties, Tennessee. The lake is 27.9 km in length and 0.8 km in width at its widest point. The mean level of the lake surface above the sea is 419.7 m. The lake is of moderate depth (up to 33 m) but shows great seasonal fluctuation in depth, depending upon rainfall and electric power demands in the area.

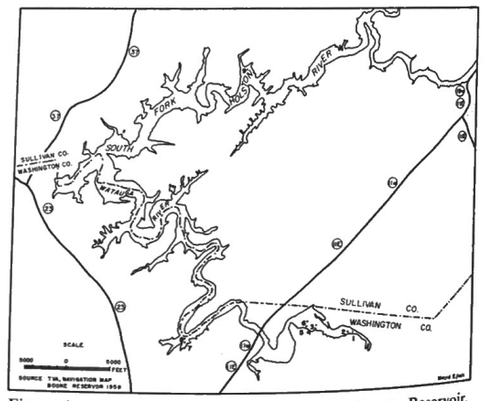

Figure 1. Map showing island locations in Boone Reservoir.

Nine islands in Boone Lake, ranging in size from 1.2 to 30 ares, were selected for study (Fig. 1). Two of the islands show mud flat connection with the mainland during periods of extremely low water levels.

Watauga Dam, constructed in 1948, is located on the Watauga River 49.1 km from the river's mouth. The reservoir lies in Carter and Johnson Counties, Tennessee. The lake is 26.9 km in length and 1.3 km in width at its widest point. The mean level of the lake surface above the sea is 593.9 m. The lake is of moderate depth (up to 40 m) and shows substantial seasonal fluctuation in water levels.

Four islands in Watauga Lake, ranging in size from 9 ares to 299 ares, were selected for study (Fig. 2). All of the islands are wooded hilltops that were surrounded by water after closure of the dam. The elevation of these islands varies from 605 to 625 m above sea level. One island is connected with the mainland during periods of extremely low water levels.

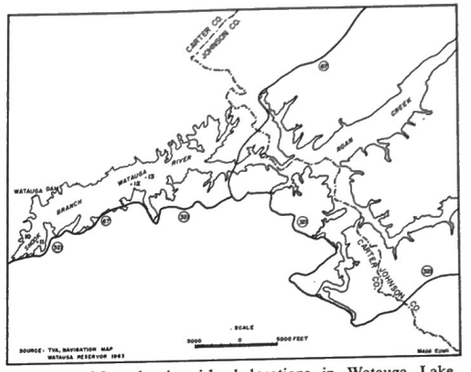

Figure 2. Map showing island locations in Watauga Lake.

The climate of the area encompassing the two lakes is mild. The average precipitation in the Boone Lake area in 1968 was 83 cm with maximum precipitation occurring in July. The total precipitation at Watauga Dam in 1968 was 99.4 cm. The average annual air temperature for both areas was approximately 12.5°C. Summers are mild in both areas with July, 1968 minimum-maximum air temperatures of 12.7° and 34.4°C in the Boone Lake area and 11.1° and 33.8°C at Watauga Dam. Winters are moderately cold with minimum air temperatures of -17°C and -16°C in the Boone and Watauga Lakes areas, respectively. Some of the shallow inlets of both lakes are frozen over during the winter but the main surfaces of the lakes are never completely frozen over.

The islands covered in this study, together with their name and/or location, field measured size, and major plant communities are given below. The name of the plant communities refers to the dominants in the various strata present. Plant nomenclature follows Fernald, 1950.

1. Hodge Island complex in Boone Lake. 9 ares. American elm (*Ulmus americana*) with understory of meadow fescue (*Festuca elatior*) and Terrell grass (*Elymus virginicus*).

2. Hodge Island complex in Boone Lake. 9 ares. American elm and Box-elder (*Acer negundo*) with herbs sparsely represented by meadow fescue and Terrell grass. Buckwheat (*Polygonum lapathifolium*) and yellow cress (*Rorippa islandica*) were also present.

3. Unnamed island in Boone Lake (islands 3, 4, 5, and 6 are located in a cluster close to the south shore of the lake, approximately 21 km from the river's mouth). 3 ares. Silver maple (*Acer saccharinum*) with the understory composed of a blackberry thicket (*Rubus* sp.) and open areas covered by a sedge (*Cyperus* sp.).

4. Unnamed island in Boone Lake. 2 ares. Silver maple and American elm with a sedge (*Cyperus* sp.) dominant in the understory.

5. Unnamed island in Boone Lake. 30 ares. A meadow, quite variable in composition. The dominant on 15% of the island was the smooth sumac (*Rhus glabra*). The dominants of most of the remaining area were a grass (*Poa* sp.) and a sedge (*Cyperus* sp.). A small portion (about 5%) of the island was covered exclusively by a rush (*Juncus* sp.).

6. Unnamed island in Boone Lake. 1.2 ares. Silver maple with a sedge (*Cyperus* sp.) and Terrell grass dominant in the understory.

7. Unnamed island in Boone Lake near junction of Boone's Creek and the reservoir. 4 ares. American elm with understory of several grasses (*Festuca* sp., *Elymus* sp., *Poa* sp.). A dense growth of Japanese honeysuckle (*Lonicera japonica*) covered 30% of the island.

8. Unnamed island in Boone Lake near junction of Boone's Creek and the reservoir. 5 ares. White mulberry (*Morus alba*) and box-elder. Understory of grasses (*Festuca* sp., *Poa* sp.) and a sedge (*Cyperus* sp.). Also well represented, *Daucus* sp.

9. Unnamed island in Boone Lake off Wagner's Bend. 8 ares. Black locust (*Robinia pseudoacacia*) with variable understory. A dense thicket of blackberry, catbriar (*Smilax* sp.), honeysuckle, and sumac covered 40% of the island. A sedge (*Carex* sp.) was dominant in the remainder.

10. Unnamed island in Watauga Lake located on the west side of Shook Branch. 9 ares. Shortleaf pine (*Pinus echinata*) and white oak (*Quercus alba*). The tulip poplar (*Liriodendron tulipifera*) was also well represented. The understory was composed of seedlings of the dominant species.

11. Unnamed island in Watauga Lake located due north of Estep Cemetery in Shook Branch. 10 ares. Scrub pine (*Pinus virginiana*) with an understory of catbriar and grasses (*Poa* sp., *Avena* sp., *Agropyron* sp.). A sedge (*Carex* sp.) was also prominent in the understory.

12. Unnamed island in Watauga Lake located between river kilometers 64 and 65. 9 ares. Scrub pine and tulip poplar with an understory of smooth sumac and several grasses (*Poa* sp., *Festuca* sp., *Agropyron* sp.).

13. Unnamed island in Watauga Lake located between river kilometers 64 and 65, due north of island 12. 299 ares. Scrub pine, white oak, and bitternut hickory (*Carya cordiformis*). About 25% of the island was a meadow in which a sedge (*Carex* sp.) was dominant. The understory was sparse in the forested areas with the maidenhair fern (*Adiantum* sp.) common in moist sites.

MATERIAL AND METHODS

Sampling of the vertebrate populations on the islands was carried out from June 19 to August 12, 1968.

The small mammal populations were sampled by means of snap traps baited with a mixture of peanut butter, oatmeal, and oil of anise. Traps were placed in a straight line at four-meter intervals with a line on each side of the island and a third line placed in the middle of the island. No trapping was done for the larger mammals but a careful search was made for evidence of their presence.

Pitfall traps, used on 10 of the 13 islands, were of two different types. One type was constructed by burying a one-gallon paint can so that the mouth of the can was just below the surface of the ground. The other type was constructed by excavating a smooth-sided hole about one meter deep with a post-hole digger.

Snap traps were checked and rebaited daily and left set a minimum of four nights on each island before being moved to another island. The pitfall traps, once emplaced, were left on the islands for the duration of the study. The accumulated trap-nights for snap traps totaled 5,010. The trap-night total for pitfall traps was 3,500.

A systematic daily search for other terrestrial vertebrates and birds was made after checking and setting small mammal traps.

In addition to recording the dominant vegetation of the islands, the relative density of vegetative ground cover was estimated and recorded. The distribution of the more common small mammals was examined quantitatively in relation to this factor. Trapping results are expressed in number of animals captured per 100 trap-nights per habitat or habitat component. Ground cover in the form of small shrubs and grasses was rated

as dense (no barren patches of ground), intermediate (abundant vegetation with some barren areas showing), or sparse (barren areas predominant).

All animals collected were placed in the East Tennessee State University collection. Standard measurements for all animals collected were recorded and placed with the collection.

Results

Amphibians and Reptiles

The species observed or collected on the islands were: Fowler's toad (*Bufo fowleri*), box turtel (*Terepene carolina*), and the common water snake (*Natrix sipedon*). The snapping turtle (*Chelydra serpentina*), while not an island resident, was seen on islands 2 and 8. Fowler's toad was the most widely distributed species of this group and was common to abundant on the islands of both lakes. The common water snake was seen on several islands and is probably a visitor on any of the islands having suitable shore-line cover. No terrestrial reptiles other than the box turtle were found on any of the islands yet several terrestrial forms occur commonly on the mainland. Also, noteworthy by their absence, are the salamanders of this region. While they are common on the surrounding shores and hillsides in comparable habitat, they were absent from all islands investigated.

Birds

The distribution of birds on the islands is shown in Table I. The song sparrow and Belted Kingfisher were by far the most abundant species on these islands with the Carolina wren ranking a distant third in occurrence. Song sparrows and Carolina wrens are rather abundant in East Tennessee and are quite easily trapped using a peanut butter bait. Nine song sparrows, seven Carolina wrens, and three starlings were captured in snap traps. All of the song sparrows were captured on island 9. Either these birds were attracted to the peanut butter bait or possibly they were captured while trying to feed on insects that were attracted to the bait.

Small rookeries of the green heron were found on islands 1 and 2 in Boone Lake and island 10 in Watauga Lake. The Boone Lake islands are nearly adjoining and had a total of nine green heron nests. The nests were simply constructed of dead twigs and formed a crude platform for eggs and young. Most of the nests were 3-5 m above the ground. The Watauga Lake rookery had five nests that were known to be active in 1968.

Although details of nesting effort and survival of offspring are not known, the following notes were made on nesting success. Seven of the nine nesting attempts on Boone Lake were apparently successful as judged by the extensive whitewash around the nests and on the ground below the nests. Remains of three dead juvenile herons were found beneath separate nests on the Boone Lake islands. The causes of death could not be established. Using the criterion of extensive whitewash, all five nests on island 10 were successful. Other species known to nest on the islands are the mallard, Carolina wren, catbird, mockingbird and Red-wing Blackbird.

TABLE I

THE DISTRIBUTION OF BIRDS ON THE ISLANDS OF BOONE AND WATAUGA LAKES

	Island Number												
	Boone Lake									Watauga Lake			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Great Blue Heron	x	x											
Green Heron	x	x								x			
Wood Duck	x	x											
Mallard								x					
Sparrow Hawk	x					x							
Woodcock		x											
Belted Kingfisher	x	x	x	x	x	x			x	x	x	x	x
Crow										x	x		x
Carolina Wren						x	x	x	x				
Catbird								x			x		x
Brown Thrasher		x						x					x
Mockingbird						x							
Starling						x	x						
Yellow-Breasted Chat									x				
Red-Wing Blackbird		x				x							
Purple Grackle				x	x	x							x
Cardinal									x				x
Song Sparrow	x		x	x	x	x	x	x	x	x	x	x	x
Total Number of Species	6	7	2	3	3	8	3	5	5	4	4	2	6

TABLE II

THE DISTRIBUTION OF SMALL MAMMALS ON THE ISLANDS OF BOONE AND WATAUGA LAKES

	Island Number												
	Boone Lake									Watauga Lake			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Blarina brevicauda		x	x			x		x					x
Tamias striatus											x		
Sciurus carolinensis													x
Peromyscus maniculatus	x								x				x
Peromyscus leucopus		x		x	x	x							x
Microtus pennsylvanicus		x			x								x
Microtus pinetorum	x	x	x	x		x		x	x				x
Ondatra zibethicus				x		x		x					
Sylvilagus floridanus									x				x
Total Number Species	2	4	2	3	2	4	0	3	3	0	1	0	7

Any of the resident bird species plus several migrants could frequent these islands from time to time yet the avifauna is neither diverse nor abundant even on the larger islands.

Mammals

The distribution of nine species of small mammals that were collected is given in Table II. Ten of the 13 islands supported small mammal populations at the time of the study but the uninhabited islands showed evidence, in the form of burrows, runways, cuttings, and droppings, of having supported small mammal populations within recent times. The distribution and relative abundance of the five species of small mammals most frequently collected in relation to various components of habitat is given in Table III.

Short-tailed shrew (*Blarina brevicauda*). This shrew was common to abundant on five islands. It was most abundant (abundance hereafter referred to as number of animals captured per 100 trap-nights unless otherwise noted) in the relatively open, mixed pine-deciduous forest (mean = 0.62) and common in the deciduous forest (mean = 0.58). Few short-tailed shrews were collected in the meadow habitat (mean = 0.25). They showed a preference for intermediate ground cover (mean = 0.95) and were less than half as abundant in dense cover (mean = 0.40). Few shrews were taken in sparsely vegegtated areas (mean = 0.12).

Chipmunk (*Tamias striatus*). A small population of these ground squirrels was found on island 11 in Watauga Lake and apparently they were the sole mammalian inhabitants of the island. One male was shot and no attempt was made to collect other specimens. Freshly dug burrows were in evidence on all parts of the island, with no distinct preference for density of vegetative ground cover exhibited.

Gray squirrel (*Sciurus carolinensis*). One mature, female gray squirrel was trapped on island 13 in Watauga Lake. The squirrel population was apparently small as little evidence of the presence of this species was found. Island 13 was the only study island with sufficient stands of oak and hickory to support this species.

TABLE III

DISTRIBUTION AND RELATIVE ABUNDANCE OF FIVE SPECIES OF MAMMALS IN RELATION TO VARIOUS COMPONENTS OF HABITAT ON THE ISLANDS OF BOONE AND WATAUGA LAKES

Habitat Components	Total number of trap-nights/component	Blarina brevicauda	Peromyscus maniculatus	Peromyscus leucopus	Microtus pennsylvanicus	Microtus pinetorum	Total
Deciduous Forest	1555	0.58	*0.58	0.45	0.39	0.39	2.39
Meadow	1200	.25	.25	.50	.92	.42	2.34
Mixed Pine-Deciduous Forest	2255	.62	.71	.40	.18	.22	2.13
Dense Cover	1505	.40	.86	.27	.80	.53	2.86
Intermediate Cover	1885	.95	.58	.63	.27	.16	2.59
Sparse Cover	1670	.12	.54	.30	.24	.30	1.50

*Number collected per 100 trap-nights.

Deer mouse (*Peromyscus maniculatus*). This rodent was common to abundant on three islands. It was collected most frequently in the mixed pine-deciduous forest (mean = 0.71) and pure deciduous forest (mean = 0.58). This species occurred occasionally in meadow areas (mean = 0.25). The deer mouse showed a distinct preference for dense ground cover (mean = 0.86) and was collected in approximately equal numbers in intermediate (mean = 0.58) and sparse (mean = 0.54) ground cover.

Wood mouse (*Peromyscus leucopus*). This species was common to abundant on five islands. No distinct preference was shown for either deciduous forest (mean = 0.45) or meadow areas (mean = 0.50) although this species was less abundant in the mixed pine-deciduous forest (mean = 0.40). The wood mouse exhibited a preference for intermediate ground cover (mean = 0.63) and was much less abundant in areas with dense (mean = 0.27) and sparse (mean = 0.30) ground cover.

Meadow vole (*Microtus pennsylvanicus*). This vole was collected on three islands and showed a marked orientation to meadow areas (mean = 0.92) but was also common on one island in the deciduous forest (mean = 0.39) habitat. This species was rarely collected in the mixed pine-deciduous forest (mean = 0.18). A distinct preference for dense ground cover (mean = 0.80) was noted as opposed to intermediate (mean = 0.77) and sparsely vegetated (mean = 0.24) areas.

Pine vole (*Microtus pinetorum*). The pine vole was the most widely distributed small mammal collected.

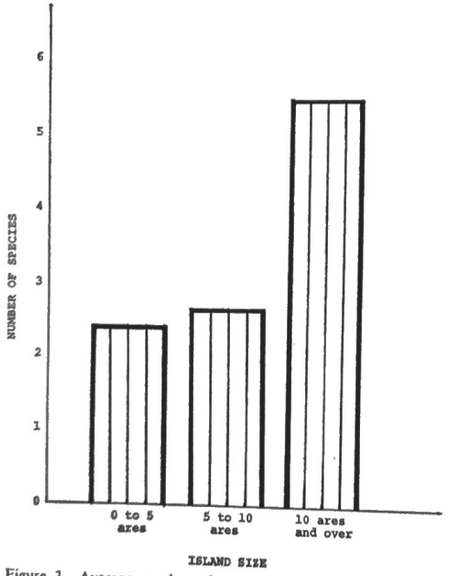

Figure 3. Average number of mamalian species in relation to island size.

Pine voles were collected on eight of the ten islands inhabited by small mammals. This vole was collected in such small numbers on each island that habitat preferences could not be ascertained. They were, however, collected in approximately equal numbers in the deciduous forest (mean = 0.39) and meadow (mean = 0.42) areas. Few were found in the mixed pine-deciduous forest (mean = 0.22). A strong preference for, or restriction to, dense ground cover (mean = 0.53) was exhibited. They were collected more frequently in sparse (mean = 0.30) than in intermediate cover (mean = 0.16). This widely distributed species was probably more abundant than the trapping data indicate because traps were not set specifically for pine voles.

Muskrat (*Ondatra zibethicus*). Inhabited muskrat dens were found on three islands. No specimens were collected.

Cottontail (*Sylvilagus floridanus*). Two islands were found to support cottontail populations. A single animal was live-trapped in order to insure correct identification since the New England cottontail (*Sylvilagus transitionalis*) has been reported from higher elevations in this area. This species was observed to be common on island 13 in Watauga Lake. Island 9, in Boone Lake, also supported a population of cottontails. The scarcity of droppings and other signs indicate that it was a small population.

The larger islands averaged a greater number of species than did the smaller islands (Fig. 3). Islands above 10 ares in size average 5.5 species per island while smaller islands averaged 2.5 species per island.

A total of 116 mammals was collected with snap traps. The trap-night success ratio was 2.29%. Of the 116 mammals collected, 43 were collected in dense cover, 48 in intermediate cover, and 25 in sparse cover. Six different species of mammals were collected in snap traps.

A total of seven mammals was collected in pitfall traps for a trap-night success ratio of 0.2%. Two species of mammals (the meadow vole and wood mouse) were collected in pitfall traps. Such traps proved more effective in trapping toads than mammals, a total of 54 Fowler's toads being captured in pitfall traps.

Discussion

The paucity of terresterial vertebrate species on such islands is characteristic of island faunae. The explanation most often given is that the relatively small size of such islands reduces the total number of kinds of habitats available (Dice 1925, Blair 1946, Werner 1956, Sheppe 1965). The results of this study are in general agreement with this explanation as the larger islands did afford more diverse habitat and did average more species of animals than the smaller islands. The scarcity of terrestrial vertebrates on these lake islands is rather interesting when one considers how the islands must have received their original stocking of animals. The surrounding lakes were formed soon after completion of their respective dams and rising floodwaters forced inhabitants toward higher ground. The remaining

areas offering refugia for these terrestrial forms are the islands that have been investigated in this study. Although no information is available on species composition or abundance immediately after flooding, one would expect the islands to all possess a full complement of the local vertebrate forms. If this is so, then several species have been lost in the approximate 20 years that the islands have been in existence. It has been argued (MacArthur and Wilson, 1967) that the paucity of species on some islands is due to the inability of numerous species to reach and colonize these areas. Findings of this study suggest that even when islands begin with a full complement of species, not all of the species can maintain viable island populations. The islands in this study, while appearing to offer a variety of suitable habitats and ranging in size from 1.2 to 299 ares, could not support anywhere near the number of vertebrate species trapped there by the rising floodwaters.

Three of the study islands did not have small mammal populations during the study period. Two of these three islands show connection with the mainland during periods of low water levels. Sheppe (1965) found that close proximity to the mainland facilitated small mammal emigration as well as immigration. Both of the islands periodically connected with the mainland showed characteristic sign of past small mammal activity. No factor was found which would account for the absence of small mammals on these two islands except for the possibility that emigration of the population had occurred during a period of connection with the mainland. The third uninhabited island had relatively sparse vegetative ground cover and was completely devoid of other forms of cover, such as rocks or logs. Lack of cover alone may explain the absence of small mammal populations as predation by avian predators is doubtless made easier by the absence of dense ground cover. In this regard, Bendell (1961) notes that habitat selection in the white-footed mouse (*Peromyscus leucopus noveboracensis*) on the islands of Lake Opincon was primarily for protective cover.

Cameron (1962) and Ozoga and Phillips (1964) point out that the habitats selected by *Peromyscus maniculatus* and other small rodents on islands was different from that of relatives on the mainland. We found *P. maniculatus* in greater abundance than *P. leucopus* in the more open type woods but Conaway and Howell (1953) working in Johnson County Tennessee, found *P. leucopus* to be more abundant in open type woods than *P. maniculatus*. These changes in habitat selection may represent either a temporary reversal of habitat selection or an adaptive change in the ecology of these two island-inhabiting rodents.

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PREFERRED TEMPERATURE RANGES OF *CICINDELA REPANDA* DEJEAN AND *CICINDELA RUFIVENTRIS RUFIVENTRIS* DEJEAN (COLEOPTERA: CICINDELIDAE)

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Abstract

The tiger beetles *Cicindela repanda* and *Cicindela rufiventris rufiventris* were exposed to a temperature gradient to determine their preferred temperature ranges. *C. r. rufiventris*, a summer species, selected a range of 27.4 to 33.5° C; the range selected by *C. repanda*, a common spring and fall species, was 26.7 to 30.9° C. Statistical comparison indicated a significant difference between the preferred temperature means.

Introduction

Temperature gradient studies were conducted on the tiger bettles *Cicindela repanda* and *C. rufiventris rufiventris* collected at two sites in Shelby County, Tennessee. *C. repanda*, a common fluvial species, is a spring and fall form; *C. r. rufiventris* is a summer species which