DISTRIBUTION AND ECOLOGY OF TREE-HOLE MOSQUITOES ALONG THE MISSOURI AND PLATTE RIVERS IN IOWA, NEBRASKA, COLORADO, AND WYOMING[1, 2]

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ABSTRACT. Tree-hole mosquitoes were collected from western Iowa across Nebraska into eastern Wyoming and eastern Colorado to learn more about their distribution and the ecological factors which might influence their distribution. *Aedes triseriatus* (Say), *Aedes hendersoni* Cockerell, *Anopheles barberi* Coquillett, *Orthopodomyia signifera* (Coquillett), and *Orthopodomyia alba* Baker were found in Iowa and Nebraska. The occurrence of *O. alba* in Iowa and Nebraska represented new records for these two states. Only *Ae. hendersoni* was found in Colorado and Wyoming. For each sample site the following data were recorded: elevation, tree type, diameter of opening into tree hole, height of tree hole above ground, water temperature and pH, and average annual precipitation. The strongest correlation between environmental factor and species distribution appeared to be the influence of precipitation on the distribution of *Ae. triseriatus*. This mosquito was not found where the average annual precipitation was less than 20 inches.

INTRODUCTION

Gaps exist in our knowledge of the geographical distribution of many species of mosquitoes in the United States. This is particularly true for the tree-hole mosquitoes in the midwestern states. To learn more about these insects in the Midwest, Nebraska was selected for intensive study, but collecting was extended into western Iowa, eastern Wyoming and eastern Colorado.

Very little literature was available on the tree-hole mosquitoes in Nebraska. Rapp (1959) published a small number of records on the 3 species known to occur in the state, viz., *Anopheles barberi* Coquillett, *Aedes triseriatus* (Say), and *Orthopodomyia signifera* (Coquillett). There was no aditional literature until Lunt (1969) reported the occurrence of *Ae. hendersoni* Cockerell, a species very similar to *Ae. triseriatus*. All records for *Ae. triseriatus* published prior to 1969 were then open to question because of the likelihood that some of the material may have been *Ae. hendersoni*. The only tree-hole mosquito listed for Colorado by Harmston and Lawson (1967) and for Wyoming by Nielsen et al. (1967 and 1968) was *Ae. hendersoni*. Knight and Wonio (1969) and Pinger and Rowley (1972) reported the occurrence of *An. barberi, O. signifera,* and *Ae. triseriatus* in Iowa. Zavortink (1972) listed *Ae. hendersoni* for Iowa based on a single female specimen from the USNM (collected at Ames in 1919).

Nebraska appeared to be a good state in which to study these mosquitoes because only 1 (*hendersoni*) of the 4 species known to be present in Nebraska and Iowa had been reported in Colorado and Wyoming. Therefore, this study was undertaken to determine the east-west distribution of these mosquitoes in Nebraska, eastern Wyoming, eastern Colorado, and western Iowa, and what factors might influence their distribution.

METHODS AND MATERIALS

The Platte River and its 2 main tributaries, the North Platte and South Platte, were selected as the collecting routes because they are part of the Missouri River drainage system and traverse Nebraska from west to east. Furthermore, the flood plain deciduous forest associated with this drainage system provides a habitat for breeding and a continuous corridor for the

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potential migration of tree-hole mosquitoes in Iowa, Nebraska, Wyoming, and Colorado.

During the period May through October, 1971, collections were made at about 10-mile intervals along the Platte, the North Platte, to Norden Dam in Wyoming, and the South Platte to Sterling, Colorado. Collecting in Nebraska was also done along the floodplain area of the Missouri River from Omaha south to the junction of the Missouri and Platte. In Iowa collecting was done in the floodplain area between Council Bluffs and Lake Manawa State Park, south of Council Bluffs. Water samples or bottom sediment and scrapings from inside the holes were collected. Pockets formed at the base of an area from which 2 or more tree branches arose represented the majority (80%) of the tree holes referred to in this study. At each sample site the tree was identified and the altitude recorded. Measurements were made of the diameter of the opening into the hole and its height above ground. When water samples were obtained the water temperature was recorded and the hydrogen ion concentration determined using a pH meter. Larvae from each hole were identified and reared separately to obtain associated larval, pupal, and adult specimens for each species. Bottom sediment and scrapings from dry holes were repeatedly flooded with distilled water; all larvae that hatched were then treated in the same manner as those from water-filled holes.

RESULTS AND DISCUSSION

Four hundred and thirty-four separate samples collected from 199 tree holes resulted in a total of 2,976 larvae, pupae, and adults. The species collected in Nebraska were *Aedes hendersoni*, *Ae. triseriatus*, *Orthopodomyia alba* (new state record), *O. signifera*, and *Anopheles barberi*. Only *Ae. hendersoni* was collected in Colorado and Wyoming. *Ae. hendersoni*, *Ae. triseriatus*, *An. barberi*, *O. signifera*, and *O. alba* (new state record) were found in Iowa.

DISTRIBUTION (FIG. 1). *Ae. hendersoni* was uniformly distributed from western Iowa across Nebraska into Wyoming and Colorado. Overall it was the most common mosquito, representing 75% of the total specimens. *Ae. triseriatus* was the second most common species (20%). It was found only in Iowa and the eastern half of Nebraska. It was the most common species in Iowa and extreme eastern Nebraska. Larvae of these two species occupied the same tree hole in 22% of the collections taken in the area of their sympatry. Eighteen percent of the tree holes having either or both of these mosquitoes also contained 25 larvae with characteristics of both species. These larvae appeared to match the description of F_1 hybrid larvae reported by Truman and Craig (1968). Therefore, we considered our specimens to be putative hybrids, but they will have to be studied in greater detail to determine their exact status. The absence of *Ae. triseriatus* in the western half of Nebraska and the relatively small number of specimens collected is a finding that differs from reports of Rapp (1959) and Edmunds (1958) which indicated that *Ae. triseriatus* was the most common and widespread tree-hole mosquito in the state. Our data suggest that much of the material identified by these workers as *Ae. triseriatus* was actually *Ae. hendersoni*. It should be pointed out that *Aedes hendersoni* did not have full specific rank until 1960 (Breland 1960).

O. signifera was collected from 10 widely separated sites making it the third (3%) most common species. This mosquito was found in the eastern two-thirds of Nebraska but was more common in the eastern third of the state and in Iowa. *O. alba* was found in only 4 tree holes making it the least commonly collected species. One collection was in Iowa and 3 were in eastern Nebraska. These 2 similar species were found together in 2 tree holes.

An. barberi, the fourth most commonly collected species, was found in 8 widely separated sites mainly in the eastern half of Nebraska and in Iowa. The number of *An. barberi* larvae in a collection never

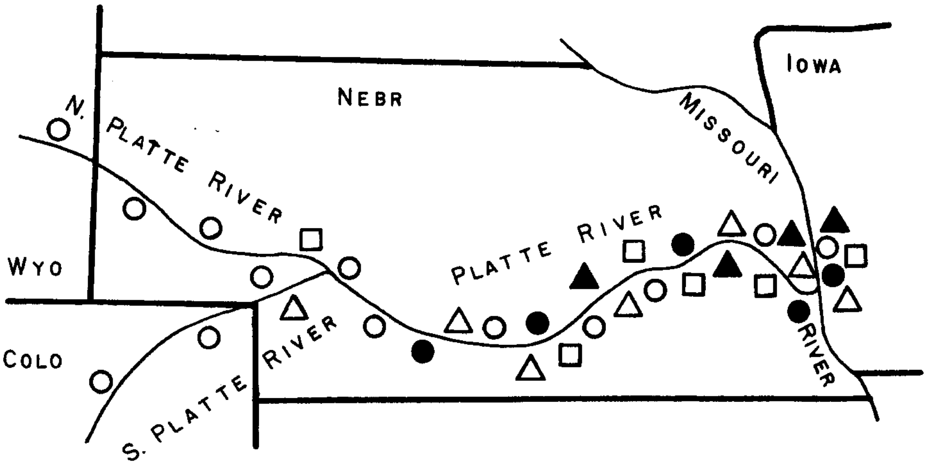

Fig. 1. The east-west distribution of *Aedes hendersoni* (○), *A. triseriatus* (●), *Orthopodomyia signifera* (△), *O. alba* (▲), and *Anopheles barberi* (□) in western Iowa, Nebraska, and the eastern portions of Wyoming and Colorado.

exceeded 9. The number of larvae of other species found in the same tree hole with *An. barberi* was usually small, possibly due to *barberi's* predacious nature.

Ecological Factors (Table 1). Each of the 5 species was found in both pure and mixed cultures. Collections were taken from 8 different species of trees, all quite common across Nebraska except the silver maple, which is limited to the eastern part of the state. Cottonwoods were the most common trees and provided 73% of the samples. The *Orthopodomyia* and *Anopheles* species were encountered too infrequently to determine if they had a preference for certain trees. In contrast, sufficient data were collected for the *Aedes* species, and there was no obvious preference. It appeared they would use any tree which provided an aquatic habitat.

Table 1. Summary of ecological data for the five tree-hole mosquitoes.

	Aedes hendersoni	*Aedes triseriatus*	*Orthopodomyia signifera*	*Orthopodomyia alba*	*Anopheles barberi*
Tree Type	Cottonwood American Elm Willow Hackberry Boxelder Green Ash White Mulberry	Cottonwood Amer. Elm Willow Silver Maple Boxelder Green Ash	Cottonwood Amer. Elm Willow Hackberry	Cottonwood Amer. Elm	Cottonwood Amer. Elm
Diameter of Opening (cm)	1.5–31	2–31	5–20	8–25	1.5–1.7
Height of Tree Hole (m)	0–4.5	0–3.0	0–3.0	0–2.2	.30–2.5
Elevation (ft)	1000–4400	1000–2600	1000–3000	1000–2800	1000–1500
Water Temp. (°C)	16.0–26.0	17.0–25.5	18.5–23.5	18.5–24.0	18.0–21.0
pH	6.8–9.3	7.4–9.1	8.3–8.9	8.4–9.1	8.5–8.7
Aver. Ann. Precip. (in)	13–28	20–28	18–28	24–28	18–28

The size of the opening into the tree hole ranged from 1.5–31+ cm. Limited data for *Orthopodomyia* and *Anopheles* species preclude conclusions regarding this factor. However, *O. alba* was found only in tree holes with a narrow opening (1.5—1.7 cm); this agreed with the report of Breland (1959) that *alba* prefers a small opening. For the *Aedes* species there appeared to be no preference for the size of the opening.

The height of the holes above ground ranged from 0–4.5m. No species appeared to show preference for a given height.

The range in elevation was 1000–4400 feet. Elevation did not limit the distribution of *Ae. hendersoni,* but may have affected *Ae. triseriatus.* The latter species was not collected above 2600 feet. *O. signifera, O. alba,* and *An. barberi* were not collected above 3000 feet, 1500 feet, and 2770 feet respectively, but Nielsen et al. (1967 and 1968) found all three at much higher elevations in Arizona. Therefore, elevation probably was not a limiting factor for those three species.

Temperatures ranged from 16.0–26.0° C, but did not appear to be a limiting factor.

The pH generally was neutral to slightly basic, but ranged from 6.8–9.3. *Ae. triseriatus* and *Ae. hendersoni* were most often found in water slightly acid to slightly basic. The *Orthopodomyia* and *Anopheles* species were found only in slightly basic water. These data are generally in agreement with reports by Zavortink (1968 and 1970) and Peterson and Chapman (1969).

The average annual precipitation ranged from 13 inches in the west to 28 inches in the east. *Ae. hendersoni* was found over that entire range, but *Ae. triseriatus* was found only where the precipitation averaged 20 inches or more per year—east of the 100th meridian which bisects Nebraska.

Since the majority (80%) of the water-holding cavities found in this study were the type directly dependent on rainfall, it is obvious that precipitation and evaporation would be major factors in determining the availability of water in which the immature stages of these arboricolous mosquitoes could develop. Lawson et al. (1971) studied the spatial and temporal dimensions of drought occurrence in Nebraska using Palmer's meteorological drought index formula which took into consideration 7 moisture factors, including total precipitation and potential evaporation on a monthly basis. A computer analysis was carried out using monthly values of drought in 8 precipitation districts for the years 1931 through 1969. These authors concluded that the western part of the state had the highest percentage of drought occurrence (60%). Obviously, a fairly frequent occurrence of annual drought could serve as an effective long-term barrier to the western extension in the range of distribution of mosquitoes not tolerant of arid conditions. This appears to be true for *Ae. triseriatus* and perhaps for the *Orthopodomyia* and *Anopheles* species. On a short-term basis, the east-west distribution of drought intolerant species may vary from year to year depending on drought conditions. In a particularly wet year the drought intolerant species (e.g., *Ae. triseriatus*) might be found farther west than in a dry year.

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