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SCIENTIFIC NOTE

A SURVEY OF MOSQUITOES IN SOUTHERN AND WESTERN MISSOURI

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ABSTRACT. A survey of adult and immature mosquitoes in southern and western Missouri conducted from June 14 to September 23, 2016, yielded 32 species and 7 genera. The invasive species *Aedes albopictus* and *Ae. japonicus* were dispersed widely in the state, but the survey failed to collect any *Ae. aegypti*. This note discusses the impact of changes in the Missouri mosquito fauna on the risk of human disease transmission.

KEY WORDS Mosquitoes, Missouri, Ozarks

Relatively little is known about the mosquito fauna of Missouri. Most mosquito surveys in the state have covered relatively small geographical areas or have used a limited range of mosquito-sampling techniques (Dickson 1979, Leak 2010). Also, 2 important invasive species, *Aedes albopictus* (Skuse) and *Ae. japonicus* (Theobold), have established populations in recent years and may have impacted the mosquito populations. A survey of tree-hole mosquitoes in Boone county from 1986 to 1988 failed to detect either of these species; the most abundant tree-hole mosquito was *Ae. triseriatus* (Say) (Debboun et al. 2005). In 2006 researchers reported *Ae. japonicus* (Theobold) in St. Louis County (Gallitano et al. 2005) but not elsewhere in Missouri. The presence of *Ae. japonicus* in the surrounding states of Iowa and Arkansas (Dunphy et al. 2009, Gaspar et al. 2012) suggests that this mosquito is present elsewhere in Missouri. The status of *Ae. aegypti* (L) in Missouri is also important because of its ability to serve as a vector of several arboviruses, including the Zika virus (CDC 2018). The Centers for Disease Control and Prevention (CDC) contends this species is likely to be present in the southern and western regions of the state (CDC 2016). Eisen and Moore (2013), however, stated that southern Missouri is the extreme northern margin of the *Ae. aegypti* range.

In 2016, the lack of current data on the mosquito fauna of Missouri and the theoretical potential for mosquito-borne Zika transmission in the state prompted the Missouri Department of Health and Senior Services (MDHSS) to complete a mosquito survey in the more densely populated parts of the state. The MDHSS officials decided to focus on mosquitoes that develop in artificial containers due to the disease risk these species pose and to the dearth of information about these species in the state.

Researchers with Missouri State University conducted the survey in the summer of 2016 (June 14 through September 23). To focus on artificial containers, field workers found survey sites at used tire dealers, automobile salvage yards, and cemeteries near human population centers in 31 counties in Missouri. Most of the counties were in the Ozarks region of the state, though the survey included some counties in the far western and southeastern parts of the state because the CDC listed these regions as likely to harbor *Ae. aegypti* populations. The survey utilized both larval and adult surveillance techniques. Adult traps included the Fay-Prince omnidirectional trap (139 trap-nights), the CDC standard light trap (129 trap-nights), and the CDC ruggedized light trap (62 trap-nights). In September, some BG Sentinel® traps were added to the survey (8 trap-nights). All traps used dry ice as baits, and some were also baited with octenol. The BG traps used a commercial lure (BG-Lure®, Bioquip Inc., Rancho Dominguez, CA). Workers placed the traps onsite after 3:00 p.m. and picked them up before 10:00 a.m. the next day.

Field workers also collected larvae in the vicinity of the adult trapping sites using turkey basters or standard plastic dippers; typical containers included used tires, salvaged automobiles, the beds of pick-up trucks, and various artificial containers. The survey included more than 435 different artificial containers. Field workers removed the larvae from the water with pipettes and placed them in a Whirl-Pak® (Bioquip) has with water from the site, then placed the bag in a cooler for transportation back to the laboratory in Springfield, Missouri. Laboratory workers removed larvae and pupae from the bags and placed them in emergence cages with a small amount of Tetramin® fish food, then placed each cage on a shelf covered with plastic sheeting and heated with an incandescent bulb between 9:00 a.m. and 5:00 p.m. Any mosquitoes that emerged as adults were killed by freezing, pointed and pinned, and then identified using keys in Darsie and Ward (2005) and Burkett-Cadena (2013).

In total, this survey identified 17,230 mosquitoes representing 32 species and 7 genera. Table 1

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Table 1. Mosquitoes from survey of southern and western Missouri (June–September 2016).

Species	No. caught as adults	No. caught as immature mosquitoes
Aedes albopictus	4,056	1,944
Ae. vexans	606	104
Ae. thibaulti	239	5
Ae. triseriatus/hendersoni[1]	166	84
Ae. canadensis	57	240
Ae. trivvittatus	45	0
Ae. sticticus	33	3
Ae. japonicus	5	128
Ae. solicitans	4	0
Ae. grossbecki	3	0
Ae. cinereus	2	0
Ae. atlanticus	1	0
Ae. spp.	57	5
Anopheles quadrimaculatus group	4,909	4
An. punctipennis	43	10
An. crucians complex	2	0
An. spp.	6	0
Culex eraticus	1,524	97
Cx. peccator	76	1
Cx. quinquefasciatus[2]	66	100
Cx. salinarius	10	2
Cx nigripalpus	4	8
Cx. pilosus	15	0
Cx. restuans	1	15
Cx. tarsalis	1	0
Cx. coronator	1	0
Cx. territans	0	1
Cx. spp.	82	10
Psorophora cyanescens	115	3
Ps. columbiae	63	40
Ps. ferox	58	0
Ps. ciliata	35	15
Ps. horrida	3	0
Ps. spp.	3	0
Toxorhynchites rutilus	0	14
Culiseta spp.	1	0
Orthopodomyia signifera	4	0
Culicidae	600	139
Males	884	2,008

[1] *Ae. hendersoni* and *Ae. triseriatus* are difficult to distinguish in the adult stage, so the numbers for these 2 species are combined.
[2] *Cx. pipiens* and *Cx quinquefasciatus* are difficult to distinguish as adults and may interbreed in Missouri.

provides a list of all species caught during the survey along with the number of specimens of each species caught during adult and immature stages. The most numerous "container breeder" was *Ae. albopictus*, which was abundant in all surveyed counties. More *Anopheles quadrimaculatus* (Say) than any other species were caught as adults, though the abundance of this species was highly variable between sites. Very few *Anopheles* emerged from the larval stage, though some larvae of this taxon were collected. Two species, *Toxorhynchites rutilus* (Coquillet) and *Cx. territans* Walker, occurred only in larval collections.

Aedes japonicus was the third most numerous species to emerge from larval samples. Norton and Claborn (2016), using preliminary data from this study, reported *Ae. japonicus* in the following Missouri counties: Barry, Butler, Cass, Howell, Laclede, Polk, Stone, Taney, Vernon. The following counties are added here: Buchanon, Camden, Christian, Cole, Greene, Jackson, Miller, and New Madrid.

This survey failed to detect *Ae. aegypti*. Though the absence of *Ae. aegypti* from this survey does not prove its absence from Missouri, the finding is consistent with Goddard et al. (2017), who failed to find *Ae. aegypti* in an extensive larval survey of Mississippi. However, Bradt et al. (2017) reported *Ae. aegypti* in nearby Oklahoma, and, on the East Coast, there are reports of this species surviving in urban habitats as far north as New Jersey (Eisen and Moore 2013) and Washington, DC (Lima et al. 2016).

Aedes aegypti in the central USA is at its extreme northern limit. Perhaps this tenuous existence has been further stressed by the recent invasions of 2 competitors, *Ae. albopictus* and *Ae. japonicus*. Both have dispersed extensively through the southern half of Missouri, and the former is very abundant. *Aedes albopictus* was caught in every county that was surveyed, and *Ae. japonicus* is widely dispersed in the Ozarks region (Fig. 1). At least 3 other possible competitors, *Ae. vexans*, *Ae. triseriatus*, and *Ae. canadensis* (Theobold), are also well established and widely dispersed in the state (Fig. 1).

The impact of these changes to the mosquito fauna of Missouri on the human disease risk in the state is unclear. *Aedes aegypti* is the primary vector of Zika virus in the New World and is probably a more effective vector than other species in the United States. Its absence from Missouri (or at least cryptic presence) could be interpreted as good news with regard to disease risk. Alternatively, the abundance and wide distribution of *Ae. albopictus*, a secondary vector of Zika, may increase the risk of disease transmission. The invasive species *Ae. japonicus* is a potential vector of other arboviruses, including West Nile virus and St. Louis encephalitis virus, both of which occur in the state (Gallitano et al. 2005). One issue that may be important to future surveillance of this species is the fact that, even though the larvae were common, very few of this species occurred in adult traps (only 5 for the entire summer). This is inconsistent with the findings of Dunphy et al. (2009), who obtained several specimens of this species in adult traps. Those researchers used other types of traps not used in this survey, including Mosquito Magnets®, grass-infused gravid traps, and New Jersey light traps.

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Fig. 1. Distribution of 4 abundant *Aedes* species by county during 2016 survey of southern and western Missouri. The survey included counties in white. J = *Ae. japonicus*, C = *Ae. canadensis*, T = *Ae. triseriatus*, V = *Ae. vexans. Aedes albopictus* occurred in every county included in the survey. (All surveyed counties are in the Ozarks region of the state except for those noted with a lower case x.)

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