

SEASONALITY OF MOSQUITOES IN NORTH DAKOTA, 2003–2006, WITH FOUR NEW STATE RECORDS

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ABSTRACT. Thirty-seven species and subspecies of mosquitoes were identified from 3,580,610 specimens collected in eastern (Cass, Nelson, and Richland counties) and western (Williams County) North Dakota in 2003–2006. Four species were new state records (*Aedes schizopinax*, *Psorophora ciliata*, *Ps. ferox*, and *Ps. horrida*). *Aedes vexans* was dominant (82.9%). Other relatively abundant species were *Ae. trivittatus* (7.7%), *Ae. melanimon* (2.7%), *Culex tarsalis* (2.6%), *Ae. dorsalis* (1.6%), *Ae. sticticus* (1.0), and *Culiseta inornata* (0.9%). The seasonality of the species is presented.

KEY WORDS *Aedes trivittatus*, *Ae. vexans*, *Culex tarsalis*, North Dakota species records, mosquito seasonality

INTRODUCTION

The nuisance of large numbers of mosquitoes in North Dakota was documented by early writers (Munroe and Telford 1943), and a listing of specific mosquito species was first published by Post and Munro (1949). Subsequent listings were published by Darsie and Anderson (1985) and Darsie and Ward (2005). A total of 43 species and subspecies was identified by Darsie and Ward (2005) in their Table 3 (“Synopsis of the occurrence of mosquito species in western United States”) and maps showing geographical distributions of species. However, sequential collections throughout the season in which all mosquitoes were identified to species have not been reported. In 2003–2006 we collected and identified more than 3 million specimens in eastern and western North Dakota and tested them for arboviruses (Anderson et al. 2015). We report here all mosquito species collected during 2003–2006, including 4 new state records, and their relative abundance throughout the season.

MATERIALS AND METHODS

Mosquito collections and identification

Trapping of mosquitoes was done in Cass County, North Dakota, in 2003–2005 and in Williams County in 2004–2006 (Anderson et al. 2015) (Fig. 1). Fargo (46°52′38″N/96°47′21″W), a city of 126,000 people, is the county seat in Cass County and is located on the western side of the Red River, which runs along the North Dakota–Minnesota border. Williston (48°08′49″N/103°37′05″W), a city of about 29,000 inhabitants, is the county seat in Williams County and is situated along the Missouri River near the

North Dakota–Montana border. Most collections were conducted outside of these cities because of active mosquito control programs. These two cities are about 392 miles apart. Mosquitoes were also collected in 2003 in Nelson County in the vicinity of Lakota, the county seat. Lakota (48°02′34″N/98°20′10″W) is an agricultural community with fewer than 700 inhabitants and is located in the northeastern portion of the county (Fig. 1). Mosquitoes were collected near Walcott (population less than 300; 46°32′52″N/96°56′19″W) in Richland County, which is adjacent to the southern border of Cass County, in 2003–2005 (Fig. 1). Trapping was carried out in weeks 27–39, 23–41, 21–40, and 23–36 in 2003, 2004, 2005, and 2006, respectively.

Six collecting sites were established in 2003 near Fargo as identified by Anderson et al. (2015). Traps were placed at each location during most weeks. Ten sites were trapped in Lakota for 1 or 2 nights. In 2004 and 2005, trapping was conducted near Fargo at the same sites as in 2003. Additionally, 3 collecting sites were added near Fargo, and trapping was carried out at 7 locations within Fargo. Mosquitoes were collected most weeks at 7 locations near Williston in 2004, and 6 locations in 2005 and 2006. Mosquitoes were collected with Centers for Disease Control and Prevention (CDC) miniature light traps baited with dry ice (Model 512; John W. Hock Co., Gainesville, FL), and with mosquito magnet experimental (MMX) traps (American Biophysics Corp., East Greenwich, RI).

Traps were set in the field in the afternoon or evening and collected the following morning. Mosquitoes were knocked down with dry ice or with low temperatures and transferred into glass vials sealed with rubber stoppers and gas-proof tape or in Mason jars sealed with lids and wrapped with gas-proof tape. Mosquitoes were kept at dry ice temperatures or lower and shipped on dry ice by overnight mail to the Connecticut Agricultural Experiment Station in New Haven. Mosquitoes were identified to species and recorded by date and collecting site (Carpenter and LaCasse 1955, Darsie

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FIG. 1. Mosquitoes collected in the 4 shaded counties in North Dakota, 2003–2006.

and Ward 1981, Andreadis et al. 2005, Darsie and Ward 2005).

RESULTS

A total of 3,580,610 mosquitoes representing 37 species and subspecies, including 4 new state records, were collected in Cass, Nelson, and Richland counties in eastern and in Williams County in western North Dakota in 2003–2006 (Table 1). *Aedes vexans* Meigen was dominant throughout the state and represented 82.9% of the specimens identified. *Aedes trivittatus* (Coquillett), *Ae. melanimon* Dyar, *Culex tarsalis* Coquillett, and *Ae. dorsalis* (Meigen) made up 7.7%, 2.7%, 2.6%, and 1.6%, respectively. Seasonality of the 6 most abundant mosquitoes in eastern North Dakota and in western North Dakota is summarized in Figs. 2 and 3, respectively.

Twenty species and subspecies of *Aedes* were collected (Table 1). The 1,101 *Ae. campestris* (Dyar and Knab) collected in Cass County during weeks 23–40 were most abundant in weeks 25–32 and 39 when as many as 12 per trap night were collected in week 27. In Williams County, 491 were collected during weeks 23–38 and were most numerous from week 25–31, averaging 8 per trap night in week 27.

The 106 *Ae. canadensis* (Theobald) were collected in weeks 24–33 in Cass and Richland counties. A mean of 2 per trap night was recorded in week 27. A single specimen was collected in Williams County in week 29.

The 102 specimens of *Aedes cinereus* Meigen in Cass and Richland counties were collected in weeks

23–37 and were most abundant during weeks 27 and 28. The 6,513 mosquitoes collected in Williams County during weeks 24–38 were most abundant in weeks 27–34 with a mean of 122 per trap night in week 28.

Aedes dorsalis was abundant and collected during weeks 23–42 in Cass, Nelson, and Richland counties and weeks 21–37 in Williams County (Table 1 and Figs. 2 and 3). This mosquito averaged close to 50 or more specimens per trap night in weeks 23–32 and 24–32 in eastern and western North Dakota, respectively, and for weeks 36 and 37 in the east and week 36 in the west. Averages of 100 or more per trap night were noted during 7 weeks in the east and 5 weeks in the west.

Five *Ae. excrucians* (Walker) and 13 *Ae. fitchii* (Felt and Young) were collected in Williams County from weeks 26–28 and 28 and 29, respectively. The 820 *Ae. flavescens* (Muller) in Cass, Nelson, and Richland counties were collected in weeks 23–37, where numbers averaged 18 specimens per trap night in week 27. In Williams County, the 1,495 specimens were collected during week 23–39 and were most numerous from weeks 23–34 with an average of 30 per trap night in week 28.

Eleven, 3, and 1 specimens of *Ae. increpitus* (Dyar), *Ae. implicatus* (Vockeroth), and *Ae. intrudens* (Dyar), respectively, were collected in week 27 in Williams County. In weeks 23–42 96,560 *Ae. melanimon* were collected (Table 1). They were most abundant in Williams County, averaging 132 to more than 2,100 mosquitoes per trap night in weeks 24–30 with a peak of 2,169 in week 26 (Fig. 3). In eastern

Table 1. Mosquito species collected in 4 counties in North Dakota, 2003–2006.

Species	Number	Percent	Counties ¹
<i>Aedes campestris</i>	1,592	0.04	C, W
<i>Ae. canadensis</i>	108	<0.01	C, R, W
<i>Ae. cinereus</i>	6,615	0.2	C, R, W
<i>Ae. dorsalis</i>	58,399	1.63	C, N, R, W
<i>Ae. excrucians</i>	5	<0.01	W
<i>Ae. fitchii</i>	13	<0.01	W
<i>Ae. flavescens</i>	2,315	0.07	C, N, R, W
<i>Ae. implicatus</i>	3	<0.01	W
<i>Ae. increpitus</i>	11	<0.01	W
<i>Ae. intrudens</i>	1	<0.01	W
<i>Ae. melanimon</i>	96,560	2.7	C, N, R, W
<i>Ae. nigromaculatus</i>	594	0.02	C, W
<i>Ae. schizopinax</i>	1	<0.01	W
<i>Ae. sollicitans</i>	1	<0.01	C
<i>Ae. spencerii idahoensis</i>	4,847	0.15	C, W
<i>Ae. spencerii spencerii</i>	897	0.03	C, R, W
<i>Ae. sticticus</i>	35,616	0.99	C, N, R, W
<i>Ae. triseriatus</i>	264	0.01	C, N, R, W
<i>Ae. trivittatus</i>	274,946	7.7	C, N, R, W
<i>Ae. vexans</i>	2,968,244	82.87	C, N, R, W
<i>Anopheles earlei</i>	183	0.01	C, N, R, W
<i>An. punctipennis</i>	20	<0.01	C, R
<i>An. quadrimaculatus</i>	120	<0.01	C, N, R, W
<i>An. walkeri</i>	269	0.01	C, N, R, W
<i>Coquillettidia perturbans</i>	5,117	0.14	C, N, R, W
<i>Culex pipiens</i>	78	<0.01	C, W
<i>Cx. restuans</i>	492	0.01	C, N, R, W
<i>Cx. salinarius</i>	9	<0.01	C, R
<i>Cx. tarsalis</i>	93,154	2.6	C, N, R, W
<i>Cx. territans</i>	1	<0.01	R
<i>Culiseta inornata</i>	29,922	0.86	C, N, R, W
<i>Cs. minnesotae</i>	59	<0.01	C, W
<i>Cs. morsitans</i>	10	<0.01	C, W
<i>Psorophora ciliata</i>	2	<0.01	C
<i>Ps. ferox</i>	139	0.01	C, R
<i>Ps. horrida</i>	1	<0.01	C
<i>Uranotaenia sapphirina</i>	2	<0.01	C
Total	3,580,610		

¹ C, Cass County; N, Nelson County; R, Richland County; W, Williams County.

North Dakota, they averaged less than 3, often less than 1 per trap night, with a peak of 10 in week 32.

In weeks 24–40 and 24–32, 594 *Ae. nigromaculatus* (Ludlow) were collected in Cass and Williams counties, respectively. Mosquitoes were most abundant in Cass County in week 35, averaging 9 per trap night. Twenty-four specimens were collected in Williams County during weeks 24–32. A single specimen of *Ae. schizopinax* (Dyar) was collected June 29, 2004, in Williams County. This species is a new state record. One specimen of *Ae. sollicitans* (Walker) was collected in week 32 in Cass County.

A total of 4,824 *Aedes spencerii idahoensis* (Theobald) was collected in Williams County in weeks 23–36. They were most numerous during weeks 23–29 with a peak average of 228 per trap night in week 24. In Cass County, 23 specimens were collected in weeks 23–29. The 335 *Ae. spencerii spencerii* (Theobald) from Cass and Richland

counties were collected in weeks 23–40. The average was 2–3 specimens per trap night. In Williams County, 562 specimens were collected in weeks 22–40. Mosquitoes averaged 9 per trap night in week 24.

The 35,616 specimens of *Ae. sticticus* (Meigen) were collected in eastern and western North Dakota but were more numerous in the east. They were captured in weeks 23–41 in Cass, Nelson, and Richland counties and weeks 23–36 in Williams County. They were most abundant in the east in weeks 25–28. Mosquitoes averaged more than 100 per trap night with a peak of 489 recorded in week 27 (Fig. 2). In Williams County, the 2,275 mosquitoes were most abundant in weeks 23–31 and averaged 50 per trap night at peak abundance in week 28.

The 264 *Ae. triseriatus* (Say) were collected primarily in Cass County, where females were captured in weeks 26–38 and averaged 1 or 2 per trap night. Four specimens were collected in Williams County in weeks 27 and 35. *Aedes trivittatus* was the second most abundant species. In weeks 23–42, 274,946 were collected (Table 1 and Fig. 2 and 3). They were most abundant in Cass, Nelson, and Richland counties in weeks 25–31, averaging more than 500 per trap night and peaking at 1,393 to 2,094 per trap night during weeks 25–28 (Fig. 2). In Williams County, females were collected in weeks 23–36, averaging 480 to 1,441 per trap night during weeks 27–29 (Fig. 3).

Aedes vexans was collected on most collecting dates. The highest average numbers, usually exceeding 4,000 per trap night, were collected in eastern North Dakota in weeks 25–29 (Fig. 2). Numbers then fell to an average of over 200 per trap night by week 33, but then increased to more than 1,000 per trap night in weeks 36–39. A few mosquitoes were present in week 42. In Williams County, an average of more than 6,000 were collected per trap night in week 23 and reached a pinnacle of more than 30,000 in week 28, then declining to 2,700 in week 33 (Fig. 3). Mean numbers declined to 200 by week 37.

Four species of *Anopheles* were collected in relatively small numbers (Table 1). Thirty-six *Anopheles earlei* Vargas were collected in eastern North Dakota in weeks 29–34. In the western part, 147 were collected in weeks 23–38, where it was most numerous in weeks 28–32. Twenty *An. punctipennis* (Say) were collected in Cass and Richland counties during weeks 26–37. Nineteen *Anopheles quadrimaculatus* (Say) were collected in Cass, Nelson, and Richland counties in weeks 23–39. In the west, 101 were collected from week 24–37 and were most abundant during weeks 30–34. During weeks 23–41, 251 *Anopheles walkeri* Theobald were collected in Cass, Nelson, and Richland counties and were most abundant in week 27. Eighteen specimens were collected in Williams County during weeks 32–37.

Coquillettidia perturbans (Walker) were relatively abundant in both eastern and western North Dakota (Table 1). In weeks 23–35, 1,067 were collected in

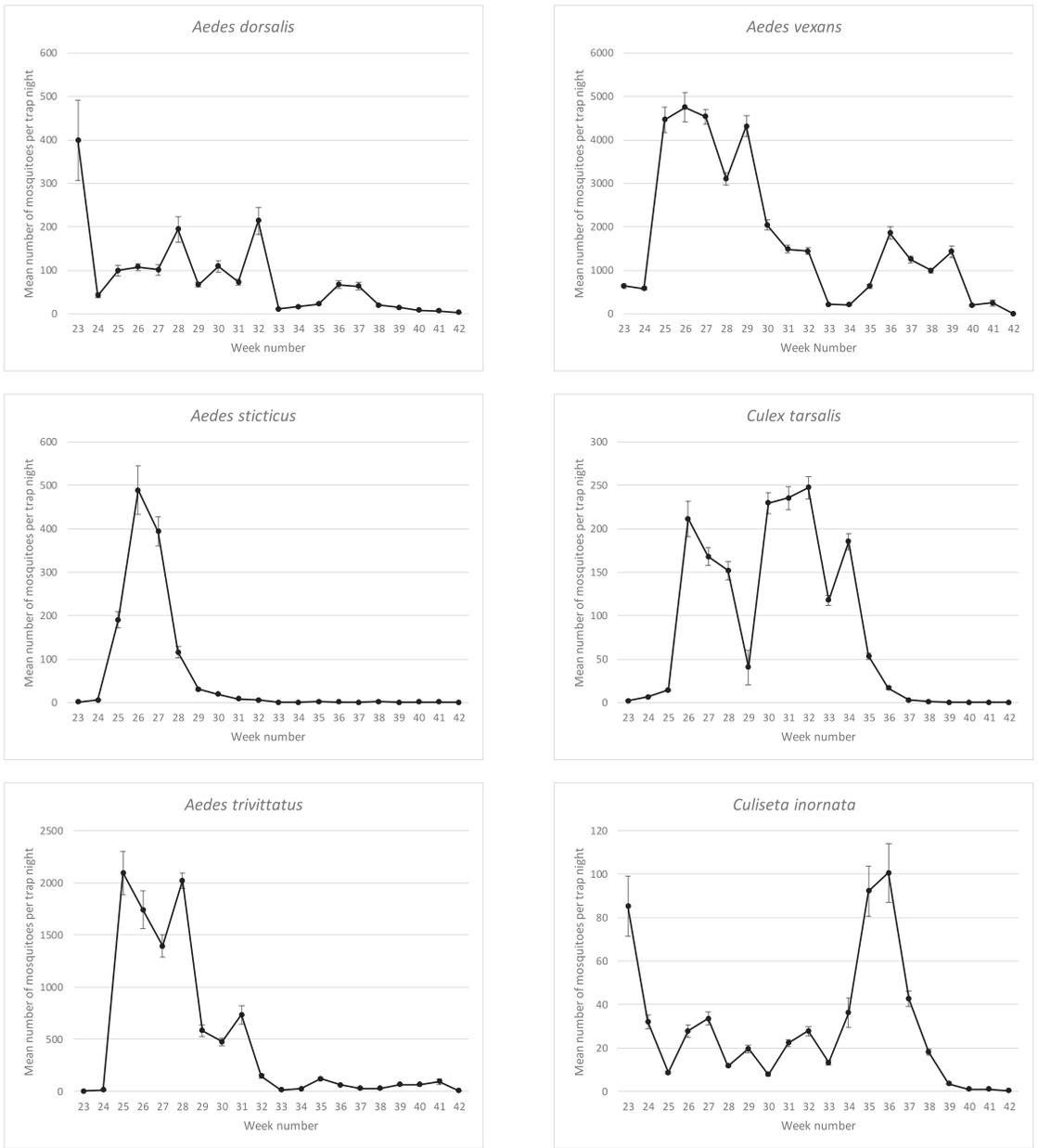


FIG. 2. Mean weekly numbers per trap night (\pm SEM) of 6 species of mosquitoes in eastern North Dakota, 2003–05.

Cass, Nelson, and Richland counties. In Williams County, 3,150 were collected during weeks 25–37. They were most abundant during weeks 26–32 in the east and weeks 27–32 in the west.

Five species of *Culex* were collected (Table 1). Seventy-seven *Culex pipiens* L. were collected in Cass County in weeks 23–39 and were most abundant in week 33. A single specimen was collected in week 24 in Williams County. A total of 478 *Cx. restuans* Theobald was collected in the eastern counties of Cass, Nelson, and Richland

during weeks 24–41. They were most numerous during weeks 25–34. Fourteen specimens were collected in Williams County in weeks 27–35. Nine *Cx. salinarius* Coquillett were collected in Cass and Richland counties during weeks 26–39. *Culex tarsalis* was the dominant *Culex* species, and 93,154 were collected in weeks 23–41 in the east and weeks 23–37 in the west (Table 1 and Figs. 2 and 3). In Cass, Nelson, and Richland counties, mosquitoes often averaged 150 to 250 per trap night in weeks 26–34, and in Williams County, mosquitoes

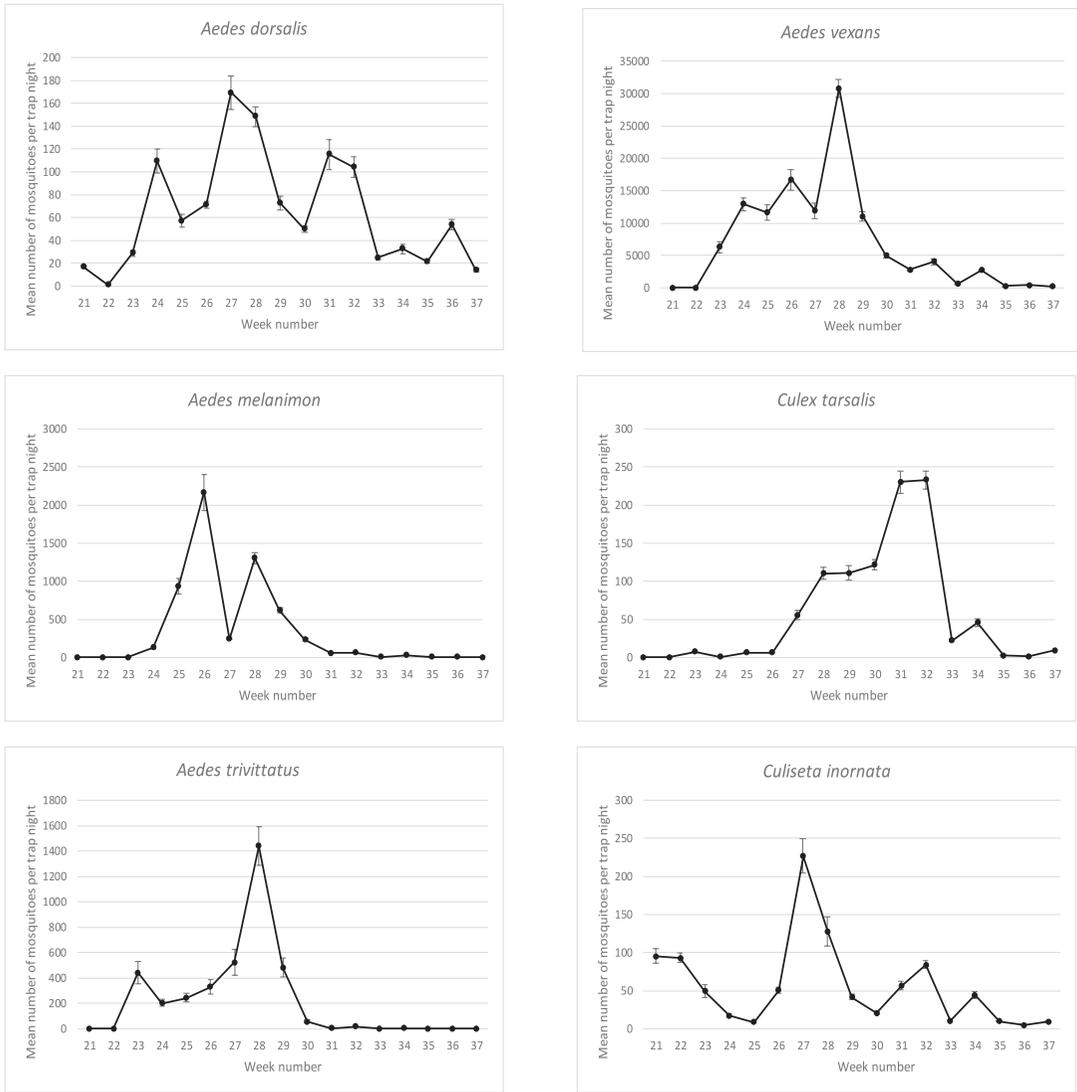


FIG. 3. Mean weekly numbers per trap night (\pm SEM) of six species of mosquitoes in western North Dakota, 2004–06.

usually averaged 50 to 233 per trap night in weeks 27–34. A single *Culex territans* Walker was collected in week 25 in Richland County.

Three species of *Culiseta* were collected (Table 1). Fifty-nine and 10 specimens of *Cs. minnesotae* Barr and *Cs. morsitans* (Theobald), respectively, were identified. A single specimen of *Cs. minnesotae* was collected in week 38 in Cass County, and in Williams County 58 specimens were collected in weeks 24–35 with the largest numbers collected in week 31. *Culiseta morsitans* was collected in week 31 in Cass County and weeks 31 and 35 in Williams County. *Culiseta inornata* (Williston) was dominant with 29,922 specimens collected on both sides of the state during weeks 23–42 in the east and weeks 21–37 in the west (Table 1 and Figs. 2 and 3). Peak collections averaging 85 per trap night were recorded in the east

in week 23, and they averaged 92 and 100 per trap night in weeks 35 and 36. In Williams County, mosquitoes averaging 84–227 per trap night were collected in weeks 21, 22, 27, 28, and 32.

Three species of *Psorophora* were collected (Table 1). Two specimens of *Ps. ciliata* (Fabricius) were collected in weeks 26 and 35 in Cass County. The 139 *Psorophora ferox* (von Humbolt) were collected in Cass and Richland counties during weeks 25–29, with the largest numbers collected in weeks 26–28. A single specimen of *Ps. horrida* (Dyar and Knab) was collected in Cass County in week 29. These 3 species are new state records.

Two specimens of *Uranotaenia sapphirina* (Osten Sacken) were collected in Cass County in weeks 34 and 37.

DISCUSSION

With the report of West Nile virus (WNV) causing human disease in North Dakota in 2002 and its subsequent annual infections in humans (Bell et al. 2005, CDC 2023), the earlier reports of western equine encephalitis (Leake 1941), and the infections of domestic animals with Cache Valley encephalitis virus (Redden 2011), mosquitoes are a significant health risk to humans and domestic animals and a major nuisance. We collected 33 of the 43 species and subspecies reported by Darsie and Ward (2005) to occur in North Dakota and documented 4 species that represent new state records. Mosquitoes were collected during weeks 21–42 with the largest numbers collected in weeks 23–39.

North Dakota is notable for being positioned in the center of the continent of North America. Our efforts were focused on 2 major geographic regions, the Red River Valley in the east and the Missouri plateau in the west. Our collections were made on the extreme eastern edge of the state in and around Fargo, bordering Minnesota, and on the extreme western edge of state in Williston, near Montana. The climate is continental with long, cold winters and short hot summers and is windy. Wetlands, of which there are more than 1.5 million, are present in many areas of the state. Mosquitoes develop along the rivers and in wetlands, including temporary, semipermanent, and permanent waters during the spring and summer months. Specialized breeding areas, such as tree holes and tire dumps, are limited. Large numbers of many species of aquatic and land birds and small, medium, and large (cattle and deer) mammals ensure an abundance of host animals for the different species of mosquitoes.

Of the 37 species and subspecies identified, 20 belonged to the genus *Aedes*. With the exception of *Ae. triseriatus*, a mosquito that breeds in tree holes, all others are floodwater species. *Aedes vexans*, *Ae. trivittatus*, and *Ae. dorsalis* made up 82.7%, 7.7%, and 1.6%, respectively, of the specimens and thrive in eastern and western North Dakota. *Aedes melanimon* and *Ae. sticticus* represented 2.7% and 1.0% of the collection, respectively, and were prevalent in the western and eastern parts of the state, respectively. *Culex tarsalis* and *Cs. inornata*, which lay their eggs on water and overwinter as adults, were common in eastern and western North Dakota and made up 2.6% and 0.9% of the total collection. These 7 species made up 99.2% of the total.

It is difficult to distinguish adult females of *Ae. dorsalis* from *Ae. campestris* based on appearance of the fore claws and abundance of dark scales on a wing vein, the characters used in the key of adult *Aedes* (Darsie and Ward 2005). Furthermore, differences in the claws are often observable only under a compound microscope, which is not convenient or possible for the identification of large numbers of individuals (Gimnig and Eldridge 1999). We judged most of the collected specimens to be *Ae. dorsalis*.

The North Dakota mosquito fauna consists of several species associated with plains and with wooded habitats and those that do well in both environments (Horsfall 1955, Barr 1958, Darsie and Ward 2005). *Aedes nigromaculis*, *Ae. flavescens*, *Ae. dorsalis*, *Ae. melanimon*, the 2 subspecies of *Ae. spencerii*, *Ae. campestris*, and *Cx. tarsalis* are associated with the plains. Species found more often in wooded habitat include *Cs. minnesotae*, *Ae. cinereus*, *Ae. excrucians*, *Ae. fitchii*, and *Ae. canadensis*. *Aedes vexans*, *Ae. trivittatus*, and *Cs. inornata* use both habitats successfully. *Aedes sticticus* is more common in wooded areas but extends into the prairie. The 7 most abundant species are all associated with the plains.

Aedes vexans was dominant and appeared during all weeks of collecting. An average of more than 30,000 per trap night was recorded in week 28 along the Missouri River near Williston. While not as numerous along the Red River in eastern North Dakota, numbers averaged 3,500 to more than 4,000 per trap night during 5 wk. These average numbers were far greater than those reported in forested areas of Connecticut, where numbers of *Ae. canadensis* exceeded those of *Ae. vexans* (Andreadis et al. 2004). *Culex tarsalis* was the most abundant *Culex* and was present during most weeks. *Culiseta inornata* was the dominant species of this genus and was collected during all weeks. These 2 species are absent or rare in Connecticut, where *Cx. salinarius*, *Cx. pipiens*, and *Cx. restuans* are the most numerous *Culex*, and *Cs. melanura* (Coquillett) is the most common *Culiseta* (Andreadis et al. 2005). *Coquillettidia perturbans* were relatively abundant in eastern and western North Dakota as they are throughout many areas of North America with cattail marshes (Horsfall 1955).

Psorophora are floodwater species that are more common in milder climates (Darsie and Ward 2005). Three species were collected for the first time in North Dakota, with more than 100 specimens of *Ps. ferox* collected in 2 counties. *Psorophora ciliata* and *Ps. horrida* have been collected occasionally in Minnesota (Barr 1958). It is unknown if these species will become permanently established in North Dakota.

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