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The Mosquitoes of Nebraska

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UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

Research Bulletin 133

The Mosquitoes of Nebraska

H. Douglas Tate and Doris B. Gates
Department of Entomology

LINCOLN, NEBRASKA
JUNE, 1944

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Summary

Mosquitoes, particularly flood water types, regularly reach high population levels in irrigated regions of Nebraska, often interfering with agricultural operations. Highly annoying numbers develop in non-irrigated areas during rainy periods. In irrigated sections mosquitoes breed almost entirely in drainage and seepage water.

Mosquito light traps were operated a total of 1152 trap nights in 19 different localities of the state during 1942 and 1943. Approximately 250,000 mosquitoes were collected and identified. Some material, including immature stages, was collected by hand by the authors and other workers in the state. Thirty-three species, representing eight genera, were obtained and fifteen of these were new records for the state.

Of the total light trap catch, 66 per cent were *Aedes*, 25 per cent *Culex* and 7 per cent *Culiseta*. In numbers, *Aedes vexans* comprised 52 per cent of the total catch, *Culex tarsalis* 23 per cent, *Culiseta inornata* 7.1 per cent, *Aedes dorsalis* 6.7 per cent, *Aedes nigromaculis* 6.6 per cent and *Psorophora signipennis* 1.5 per cent.

A table showing relative abundance of species taken in light traps and also a table showing collection records from the various trap sites is presented.

Four species of *Anopheles* were collected. Of these, *Anopheles walkeri* and *Anopheles punctipennis* were most common. *Anopheles quadrimaculatus* does not appear to be sufficiently abundant over a long enough period of time to be of more than local and temporary importance in disseminating malaria. *Anopheles occidentalis* was collected in small numbers by hand in north-western Nebraska.

Culex tarsalis, a known vector of St. Louis and western equine encephalitis viruses, ranked as second most abundant species in the state; and it has been demonstrated by various workers that *Aedes nigromaculis*, *Aedes vexans*, *Culiseta inornata* and *Culex pipiens*, all of which are common species in the state, are capable of transmitting one or the other of the encephalitis viruses under experimental conditions.

Brief biological and ecological notes, based largely on observations and records in Nebraska, are given for each of the 33 species collected.

The Mosquitoes of Nebraska

H. Douglas Tate and Doris B. Gates¹

Department of Entomology

A survey of mosquitoes in Nebraska was conducted by the Nebraska Agricultural Experiment Station during 1942 and 1943. The object of the study was to determine the species, relative abundance, seasonal occurrence, and principal breeding places of mosquitoes in representative areas of the state. This report presents the results of the survey, and, in addition, some records and observations made in Nebraska by other workers during and previous to initiation of the project.

Importance

Mosquito problems comparable to those in regions of higher rainfall do not occur in Nebraska. Nevertheless, periods of precipitation, and irrigation, now extensively practiced in some sections, often produce heavy populations. This is particularly true of the flood-water types including certain species of *Aedes* and, to a lesser extent, *Psorophora*. In irrigated regions they often attain plague proportions and seriously interfere with agricultural operations. In non-irrigated areas, highly annoying numbers develop during rainy periods causing considerable discomfort to both urban and rural inhabitants.

Mosquitoes are of greatest importance in this state as potential disease vectors. Their recent implication in the dissemination of equine encephalomyelitis is especially significant since epizootics and epidemics of this disease are of common occurrence in this area. *Culex tarsalis*, a dominant species in the state, has been demonstrated repeatedly by Hammon, Reeves and associates (5, 7, 8)² to be infected under natural conditions with the virus of St. Louis and western equine encephalitis and to be capable of transmitting the infection.

Culex tarsalis readily feeds on domestic mammals and birds (32), and probably on wild animals as well, a fact of particular importance since domestic fowl, domestic duck, pigeon, pheasant, cattle, goats and others may serve as inapparent reservoirs for

¹ The authors are especially indebted to W. W. Wirth, Raymond Roberts and Robert J. Walstrom who assisted with identification of light trap material during the early phases of the project.

² Numbers in parenthesis are references to complete citations on pages 25 ff.

encephalitis viruses (7, 8). Of those species of mosquitoes found in Nebraska, *Culex tarsalis*, *Culex quinquefasciatus*, *Culex pipiens*, *Aedes nigromaculis*, *Aedes vexans*, *Culiseta incidens* and *Culiseta inornata* have been shown capable of transmitting St. Louis encephalitis under experimental conditions (9); and it has been demonstrated that *Aedes vexans*, *Aedes dorsalis*, *Aedes nigromaculis*, *Culiseta incidens*, *Culiseta inornata* and *Culex tarsalis* can transmit the virus of western equine encephalomyelitis experimentally (9, 10, 11, 23). Hammon, Reeves and associates (8, 9) concluded that species of the genera *Culex*, *Aedes* and *Culiseta* must be regarded as potential vectors of St. Louis and western equine encephalitis viruses.

Anopheles quadrimaculatus is of major importance as a vector of malaria, and according to some authorities *Anopheles walkeri* should not be disregarded as a possible vector of this disease (1). It seems apparent, however, that *A. quadrimaculatus* is not present in sufficient numbers over a long enough period of time to be of serious consequence as a malaria vector in Nebraska.

Evidence indicates that mosquitoes may play a significant role in the dissemination of certain other diseases of man and animals that are known to occur in Nebraska. Fowl-pox, a disease of some importance in poultry, can be transmitted by certain mosquitoes (22, 25); among these are *Aedes vexans* and *Culex pipiens*, both common in the state. According to some investigators, mosquitoes are potentially important in spreading tularaemia infection (29). It has been reported that heartworm of dogs can be transmitted by several different species of mosquitoes, including *Aedes vexans*, *Culex pipiens*, *Culex restuans*, *Anopheles punctipennis* and possibly *Culex salinarius* (18). Many Nebraska birds are known to have bird malaria (3); Hewitt (17) reports successful transmission of the protozoon responsible for the disease by a number of different mosquitoes including the following species known to occur in Nebraska: *Aedes triseriatus*, *Culex pipiens*, *Culex salinarius*, *Culex tarsalis* and *Culex erraticus* (= *restuans*).

Species Collected

Mosquito light traps were operated a total of 1152 trap nights, and approximately 250,000 mosquitoes collected and identified (Table 1). Among these were 8 genera and 33 species, 15 of which are new records for the state. The species were distributed among genera as follows:

<i>Aedes</i> Meigen	12 species	<i>Mansonia</i> Blan-	
<i>Culex</i> Linnaeus	7 "	chard	1 species
<i>Anopheles</i> Meigen..	4 "	<i>Orthopodomyia</i>	
<i>Psorophora</i> Robin-		Theobald	1 "
eau-Desvoidy	4 "	<i>Uranotaenia</i> Lynch-	
<i>Culiseta</i> Felt	3 "	Arribalzaga	1 "

Of the total number taken in light traps, 66 per cent were *Aedes*, 25 per cent *Culex* and 7 per cent *Culiseta*. Over the two year period, *Aedes vexans* comprised 52 per cent of the catch, *Culex tarsalis* 23 per cent, *Culiseta inornata* 7.1 per cent, *Aedes*

TABLE 1.—Total mosquitoes taken in light traps in 13 localities in 1942 and in 11 localities in 1943 in Nebraska plus a small number of specimens collected by hand. Arrangement is on basis of relative abundance.

Species	Total
<i>Aedes vexans</i> (Meigen).....	128695
<i>Culex tarsalis</i> Coq.....	57734
<i>Culiseta inornata</i> (Will.).....	17551
<i>Aedes dorsalis</i> (Meigen).....	16743
<i>Aedes nigromaculis</i> (Lud.).....	16699
<i>Psorophora signipennis</i> (Coq.).....	3456
<i>Culex salinarius</i> Coq. ²	1658
<i>Culex pipiens</i> L.....	1549
<i>Aedes trivittatus</i> (Coq.).....	1174
<i>Culex restuans</i> Theob. ²	633
<i>Anopheles walkeri</i> Theob. ²	536
<i>Anopheles punctipennis</i> (Say).....	330
<i>Uranotaenia sapphirina</i> (O.S.) ²	157
<i>Aedes triseriatus</i> (Say).....	104
<i>Anopheles quadrimaculatus</i> Say.....	95
<i>Aedes flavescens</i> (Müller) ²	77
<i>Psorophora ciliata</i> (Fabr.).....	57
<i>Anopheles occidentalis</i> (D. and K.).....	55
<i>Culex apicalis</i> Adams ²	52
<i>Aedes impiger</i> Walk. ²	51
<i>Culex erraticus</i> D. and K. ²	33
<i>Aedes stimulans</i> group ^{1 & 3}	30
<i>Aedes spencerii</i> (Theob.) ²	24
<i>Aedes cinereus</i> Meigen ²	21
<i>Psorophora ferox</i> (Humbdt.) ²	6
<i>Aedes sticticus</i> (Meigen) ²	4
<i>Culiseta impatiens</i> (Walk.) ²	3
<i>Mansonia perturbans</i> (Walk.) ²	2
<i>Aedes idahoensis</i> (Theob.) ¹	1
<i>Culex quinquefasciatus</i> Say ¹	1
<i>Orthopodomyia signifera</i> (Coq.) ²	1
<i>Psorophora confinnis</i> (L.-Arr.).....	1
<i>Culiseta incidens</i> (Thomson) ¹	1
	247534

¹ Hand collections, all previous to 1942.

² New records for Nebraska.

³ "Stimulans group" refers to the *stimulans-excrucians-fitchii* complex.

dorsalis 6.7 per cent, *Aedes nigromaculis* 6.6 per cent and *Psorophora signipennis* 1.5 per cent. Considerable numbers of *Culex salinarius*, *Culex pipiens*, and *Aedes trivittatus* were taken. Since species exhibit marked variations in response to light stimuli (4, 14, 26), a numerical ranking based on light trap collections cannot be regarded as representing actual proportionate abundance in nature. It does, however, provide a useful indicator. Our light-trap data is in general agreement with the results of hand collection of adults, larval records and general field observations by the writers.

TABLE 2.—Adult female mosquito collections in Nebraska Aug. 5 to Sept. 2, 1943 by W. C. Reeves and P. Galindo.

Species	Nos. collected ¹		
	in shelters	horse & human bait	light trap
<i>Aedes nigromaculis</i>	0	626	0
<i>triseriatus</i>	0	29	0
<i>trivittatus</i>	0	9	19
<i>vexans</i>	6	8,206	152
<i>Anopheles punctipennis</i>	20	36	1
<i>quadrifasciatus</i>	24	0	0
<i>Culex apicalis</i>	1	0	0
<i>erraticus</i>	11	4	0
<i>pipiens & restuans</i>	1,092	7	17
<i>salinarius</i>	47	16	4
<i>tarsalis</i>	476	139	23
<i>Psorophora ciliata</i>	0	15	3
<i>confinnis</i>	0	0	3
<i>signipennis</i>	0	24	9
<i>Culiseta incidens</i>	1	0	0
<i>inornata</i>	3	0	0

¹ Collected larvae of all species, except *Culiseta inornata* and *Culiseta incidens*, and, in addition, larvae of *Orthopodomyia signifera*, *Aedes dorsalis* and *Uranotaenia sapphirina* were taken.

All records of *Aedes idahoensis*, *Aedes (stimulans group)*, *Anopheles occidentalis* and *Culex quinquefasciatus* refer to hand collection of adults made previous to 1942, a detailed account of which has been published by Tate and Wirth (36). Larval collections and adult biting records were obtained in various parts of the state during 1942 and 1943, particularly in the Scottsbluff and Whitney areas and along the eastern border of the state.

Dr. W. C. Reeves and Mr. P. Galindo of the George Williams Hooper Foundation for Medical Research, University of California, collected mosquitoes in eastern Nebraska during August and September, 1943, as part of a study concerned with encephalitis under the direction of Dr. William McD. Hammon, and they have kindly given the authors permission to include their records in

this report. Table 2 is a summary of these records. Since collections by the different methods were made under highly variable conditions, comparisons are of questionable value. Nevertheless, it is of interest to note that the frequency of occurrence of the major species in biting records closely approximates that of the light trap, except for *Aedes nigromaculis*. It will also be noted that large numbers of *Culex pipiens-restuans* were collected in shelters but, comparatively speaking, very few were found biting man or horses. Dr. Reeves and Mr. Galindo reported that they found it impossible to separate most females of *pipiens* and *restuans* collected in this area.

Significance of Light Trap Collections

Opinion varies regarding the value of light trap collections. There are a number of factors which greatly influence adult mosquito behavior some of the primary ones being humidity, temperature, wind velocity, precipitation and light. As has been pointed out by Van Derwerker (37), Rowe (33), Huffaker and Back (19) and others, trap catches should not be regarded as giving qualitative and quantitative population records applicable in detail to an area. A more complete picture of the mosquito problem can be obtained by employing not only trap collections but also hand collections from diurnal shelters, biting records, larval collections and any other available methods (12). Nevertheless records from traps operated at frequent intervals over a long period of time give valuable information regarding the mosquito population of a locality, especially the more abundant species.

Since there are many factors which influence adult mosquito activity, the relationship of trap-catch to human comfort is a controversial point. Headlee (13) and Mulhern (26) presented data to show that, under New Jersey conditions, a catch of 24 females per trap-night should be regarded as the initial nuisance level or the point of minimum density at which the average individual becomes conscious of mosquito annoyance. Van Derwerker (37) published data to show that the initial nuisance level might vary from a low of eight females, or even less with certain species among "mosquito conscious individuals," to as high as 40 among people unaware of the benefits to be derived from control operations.

Nebraska Topography and Climate

Nebraska is a comparatively level state. Altitude range is from 5340 feet in the west to 825 feet in the southeast; and average annual rainfall varies from 16 inches in the west to 35 inches in

the southeastern corner. The state is roughly bisected in an east-west direction by the Platte River. Its chief tributaries are the Loup and Elkhorn rivers which drain north central and northeast sections of the state. The Niobrara River runs along the northern border, the Missouri along the east and northeast, and the Republican along the southern borders.

For the purpose of this report the state is arbitrarily divided into six roughly defined topographic areas (Fig. 1). They are: 1, Loess and Drifthills, located in the eastern part of the state with

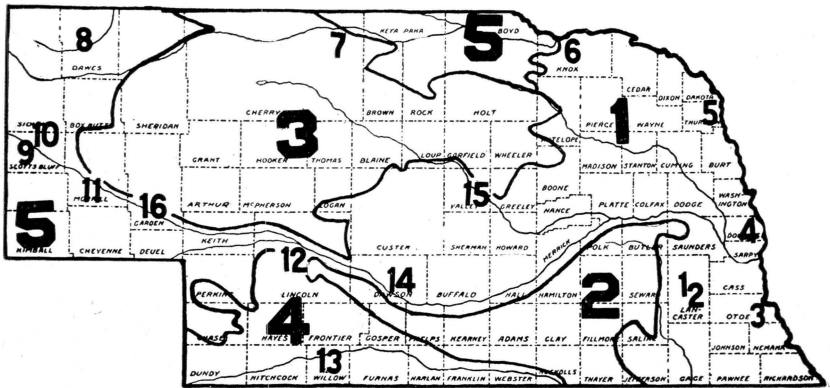


FIG. 1. Large numbers represent topographic areas of Nebraska: 1. Loess and Drifthills; 2. Loess Plains; 3. Sandhills; 4. Republican River Valley; 5. High Plains.

Small numbers represent light-trap locations: 1 and 2, Lincoln; 3, Nebraska City; 4, Omaha; 5, Walthill; 6, Niobrara; 7, Valentine; 8, Whitney; 9 and 10, Scottsbluff; 11, Bridgeport; 12, North Platte; 13, McCook; 14, Lexington; 15, Ord; 16, Oshkosh.

a westward extension along the Platte River to about the center of the state; this area is characterized by rounded hills separated by flat-bottomed valleys; 2, Loess Plains, occupying a portion of the southeast quarter of the state; this area is nearly flat, broken in places by small undrained basins; 3, Sandhills in the north-central and northwest area; 4, Republican Valley area—this includes the river valley proper and its watershed, a badly eroded region in south central and southwestern Nebraska; 5, High Plains, an area one to three counties in width lying largely along the western border of the state; and 6, River Valley Lowlands which include bottom lands along streams. Since this area is subject to flooding and contains a large part of the irrigated lands of Nebraska, naturally it is here that mosquito development reaches its highest level.

Light Trap Locations³

Thirteen New Jersey type mosquito traps located in various parts of the state were operated three to five nights each week from May to October in 1942; and eleven traps in 1943, six of them in new locations. An effort was made to distribute the light traps so as to obtain representative samples of mosquitos under the various conditions. Individual trap sites were selected on the basis of their favorableness for adults, at the same time necessarily taking into consideration availability of satisfactory operators and their convenience in performing the work. The traps were operated by paid cooperators. Each trap-night represents an approximately 12-hour run per trap. The samples were placed in individual paper boxes and mailed to Lincoln where they were sorted, identified and counted with the aid of a dissecting microscope. During rainy periods or periods of excessively high humidity samples frequently arrived at Lincoln in such poor condition that they were discarded. Following is a brief discussion of the trap locations along with a list of the major species of mosquitos taken at each: Their geographical location and a summary of collection data are given in Figure 1 and Tables 3 and 4.

Lincoln. Lincoln is located in the Loess Hills area about 50 miles from the Missouri river. Two traps were operated here. One was in a rural area just outside the city limits and about one mile from the Lincoln Air Base. Nearby is a shallow, alkaline lake (25 acres) surrounded by flood areas. The other trap was located about six miles from the first in a sparsely settled suburban area of Lincoln. There were no extensive natural mosquito breeding places in the immediate vicinity of this trap. Major species collected at the first trap, which was operated in 1942 only, were: *Culex tarsalis*, *Aedes vexans*, *A. nigromaculis*, *Culiseta inornata* and *A. dorsalis*. At the second trap the more abundant species were: *A. vexans*, *C. inornata* and *C. tarsalis* in 1942, and *A. vexans* and *C. tarsalis* in 1943. *Anopheles punctipennis* and *A. quadrimaculatus* were obtained in larger numbers at Lincoln than any other trap location.

Nebraska City. A trap was operated (1942 and 1943) in a residential district of Nebraska City, a town on high bluffs overlooking the Missouri River in the southeastern part of the state. Ap-

³ The authors wish to express their appreciation to the following individuals who cooperated by operating mosquito light traps in their respective communities: James Adams, Lexington; E. M. Brouse, Valentine; Raymond Roberts, Lincoln; Mrs. Blanche Brubaker, Lincoln; Calvin Mount and Helen Darnell, Bridgeport; George Gregory, Walthill; H. A. Hauke, Oshkosh; Dr. H. E. McClure, Ord; R. N. Spearman, Whitney; Varro Tyler, Jr., Nebraska City; I. S. Ulrich and Stan Hacker, Scottsbluff; Joyce Viehmeyer and Mrs. H. E. Jones, Niobrara; Jack Walstrom, Omaha; Rosalie and John Wirsig, McCook; and L. L. Zook, North Platte.

parently no extensive mosquito breeding areas were within effective range. The total catch included 18 species, two of which were comparatively abundant, namely, *Aedes vexans* and *Culex tarsalis*.

Omaha. This trap was located in a sparsely settled residential district near the outskirts of Omaha, a city of 250,000 population. There were no natural mosquito-breeding sites of importance within several miles. Trap catches (1942 and 1943) were the lowest recorded for the state. *Aedes vexans* was most abundant, followed by *Culiseta inornata* and *Culex tarsalis*.

Walthill. Walthill is in a narrow valley of the Loess Hills Region of northeast Nebraska. Mosquito breeding sites are confined largely to low places along small creeks and occasional artificial pools and lakes. The trap was situated on the back lawn of a home in the residential section. Of 21 species collected during the two seasons of operation, *Aedes vexans* was by far the most numerous, followed by *Culex tarsalis*. *A. nigromaculis*, *Culiseta inornata*, *Psorophora signipennis* and *A. trivittatus*. Biting records showed *A. trivittatus* to be considerably more abundant at times than trap records indicate.

Niobrara. This trap was located in the Niobrara-Missouri River valley lowlands on the Niobrara State Park Grounds. Within a radius of a mile were extensive flood areas and several small, semi-permanent to permanent bodies of water. Immediately surrounding the trap site were shade trees and only a few hundred yards distant, wooded areas. Nineteen species were collected during the two seasons, the major ones being: *Aedes vexans*, *A. nigromaculis*, *Culiseta inornata* and *Culex tarsalis*. *A. nigromaculis* was predominantly a spring and early summer form.

Valentine. Valentine is in north central Nebraska on the eastern border of the Sandhills Region. The trap (operated in 1942 only) was located on the Valentine Substation grounds about one mile from the Niobrara River, and three miles from the Niobrara Natural Game Preserve where there are a number of swampy areas favorable for mosquito breeding. A total of 17 species was collected, the major ones being: *Culex tarsalis*, *Culiseta inornata*, *Aedes vexans*, *A. dorsalis* and *A. nigromaculis*.

Whitney. Whitney, a small town in northwestern Nebraska, is in an irrigation district. Formerly mosquitoes were of little significance here, but following the development of irrigation a few years ago their attacks on men and livestock became a serious impediment to agricultural operation. The trap (operated in 1942 only) was located on a farm where adjacent land was under irrigation. The more numerous of 10 species collected were: *Culex*

tarsalis, *Aedes vexans*, *A. nigromaculis*, *A. dorsalis* and *Culiseta inornata*. Peak abundance occurred during August, the average catch per trap-night being 863 as compared to 607 and 458 for July and September, respectively.

Scottsbluff. Scottsbluff is in the North Platte valley of western Nebraska, one of the state's most highly developed irrigation districts. Here mosquitoes breed largely in seepage and surplus irrigation water. Bordering the river are extensive, poorly drained, and in some instances, alkali pasture lands where shallow, grassy pools form during the irrigation season.

The trap was located at the Scotts Bluff Substation, about 3½ miles from the North Platte River, in 1942, and about one-fourth mile from the river near the city limits of Scottsbluff in 1943. The major species were: 1942, *Aedes dorsalis*, *Culex tarsalis*, *Culiseta inornata* and *A. vexans*; 1943, *A. vexans*, *C. tarsalis* and *A. dorsalis*.

Bridgeport. Bridgeport, also located in the irrigated region of the North Platte valley, is about 35 miles east of Scottsbluff. However, a smaller proportion of the adjacent land is irrigated and under cultivation, and the valley is less than half as wide at this point. This location was selected partly to compare the results with those obtained at Scottsbluff. A dense growth of shade trees surrounded the trap site. Within a radius of about one-half mile were small flood areas and a number of sand pits containing water more or less permanently. For the same period (1942 only) 13 per cent fewer females were collected at Bridgeport than at Scottsbluff. Although varying somewhat in numerical rank, the major species were identical at the two locations. A total of ten species were collected at Bridgeport as compared to nine at Scottsbluff. The leading species were: *Aedes vexans*, *A. dorsalis* and *Culex tarsalis*.

Oshkosh. Oshkosh is located at a point where the sandhills and North Platte river valley lowlands merge. A small proportion of the valley is under irrigation. Along the river, about 1½ miles distant, are low spots in which water accumulates during rains and following irrigation. The trap was operated only in 1943. In the order of decreasing abundance, the four major species were: *Culex tarsalis*, *Aedes vexans*, *A. dorsalis* and *A. nigromaculis*. Both *C. tarsalis* and *A. dorsalis* occurred in greatest numbers in late July and in August.

North Platte. North Platte is in southwestern Nebraska near the edge of the Sandhills area where the North and South Platte Rivers meet and form a wide valley. The valley is characterized by numerous low spots where water temporarily stands follow-

ing irrigation or rain. The trap was situated on the North Platte Substation grounds four miles south of town. Major species were the same for 1942 and 1943, namely, *Aedes vexans*, *Culex tarsalis* and *Culiseta inornata*.

Lexington. A considerable proportion of the land surrounding Lexington, a central Nebraska town on the Platte River, is irrigated. Residents report a high mosquito nuisance level during the irrigation season. The senior author spent a few days there in the spring of 1943 and found *Aedes vexans*, and to a lesser degree *Psorophora signipennis*, in such abundance and biting so fiercely in late afternoons and evenings that residents were practically forced to remain indoors. Trap data (1943 only) show foremost species to be *Aedes vexans*, *Psorophora signipennis* and *Culex tarsalis*.

Ord. Conditions surrounding the Ord trap, which was near a farm home in the North Loup River valley, were very favorable for mosquito breeding. A few hundred yards distant were partly shaded bayous and permanent pools with cat-tails along the border, and at times an abundant growth of floating vegetation such as duckweed. Within a distance of three or four miles were a number of cat-tail marshes, some several acres in size, and low, flood areas in pasture lands along the valley. Pump irrigation is practiced on a few valley farms. In 1943 the trap was transferred to a farm home about one-half mile from that of the previous year. This site was somewhat less favorable from the standpoint of immediate surroundings, but still well within the valley proper. The average catch for 63 nights of operation between May 18 and October 14, 1942 was 739 ($\delta\delta$ and ♀♀) per trap night, highest record for the state. Dominant species, which were identical for the two seasons (1942 and 1943) were: *Aedes vexans*, *Culex tarsalis*, *A. nigromaculis*, and *A. dorsalis*.

McCook. The trap was located in a residential district of McCook, a town in southwestern Nebraska. McCook is in the Republican River Valley area which is regarded as the most seriously eroded section of the state, near the transition zone between the valley lowlands and hills section. Few favorable mosquito breeding places were within effective range of the trap. The more numerous of the 15 species collected in light traps during the two seasons were: *Aedes vexans*, *Culex tarsalis*, *Culiseta inornata*, *A. nigromaculis* and *C. pipiens*. The relatively high rank of *C. inornata* is due largely to a high peak of abundance in September, 1942.

Notes on Species ⁴

The species of mosquitoes known to occur in Nebraska are discussed in the following pages. Remarks on species are confined largely to records and observations made in the state either by the authors or other workers of the Department of Entomology. Statements regarding abundance are based principally on light trap collections.

Aedes dorsalis (Meigen)

Aedes dorsalis ranked fifth in abundance for the state as a whole in light-trap collections, occurring in greatest numbers in irrigated regions of western Nebraska. It was the seasonal dominant at Scottsbluff and maintained high numerical rank at other stations in that area. Relatively small numbers were collected in central and eastern Nebraska except for a Lincoln trap which was located near a large, alkaline lake surrounded by extensive flood areas. Larvae were found abundantly in both alkaline and fresh water; a preferred habitat seemed to be grassy pools on the prairie.

During the two seasons (1942-43), peak abundance in irrigated sections occurred during the first half of the season, and a similar tendency was evident in other parts of the state. The flood system of irrigation practiced in some parts of the state provides ideal conditions for breeding of this species. Frequency of irrigation roughly coincides with the duration of the life cycle of *A. dorsalis* (7 to 12 days from egg to adult) resulting in population levels of serious proportions. In non-irrigated regions its importance as a pest mosquito seems to be local and temporary.

A. dorsalis is a vicious biter readily attacking man and livestock, and it occasionally enters dwellings. On numerous occasions females were collected while biting or in an engorged condition resting about windows in livestock barns. In the Scottsbluff and Whitney districts *A. dorsalis* was observed to attack in such numbers that working in fields during the late afternoon often was difficult; on some occasions livestock, especially horses, became highly excited and restless as a result of its attack.

Experiments by Hermes (16), Knowlton (23) and Hammon et al. (10) show that *A. dorsalis* is capable of transmitting western equine encephalomyelitis.

Aedes campestris D. & K.

Occasionally specimens having "wing scales uniformly mottled black and white" (24) as in *Aedes campestris* were collected, par-

⁴ The authors are indebted to Dr. Alan C. Stone of the U. S. National Museum for checking identification of the species marked with an asterisk.

ticularly in western Nebraska. In one instance adults reared from larvae collected near Lincoln in late May and early June had the wing character of *A. campestris*. For other reasons, however, especially the presence of numerous intergrading forms, all of this material has been included with *A. dorsalis*. Dr. Herbert H. Ross of the Illinois Natural History Survey, who examined some of the specimens, concurred in this opinion.

***Aedes nigromaculis* (Lud.)**

Aedes nigromaculis, which occupied fourth place in numbers, was taken more or less uniformly throughout the state. It was commonly associated with *A. dorsalis* and frequently occurred in about equal numbers. The larvae breed in either fresh or salt water. Although present throughout the season, it was more abundant in light traps during spring and early summer. Some specimens lacking the characteristic white-banded proboscis were identified as *A. nigromaculis*, a determination which was confirmed by Dr. Alan Stone of the U. S. National Museum.

Since the females readily attack man and animals, inflicting a painful bite, *A. nigromaculis* is regarded as a major pest in the state. Evidence that western equine encephalomyelitis and St. Louis encephalitis viruses can be transmitted under experimental conditions by this species increases its potential significance (9).

***Aedes vexans* (Meigen)**

Aedes vexans is by far the most widely distributed and most abundant species in Nebraska. Of 13 traps operated in 1942, *A. vexans* held first place in all except four, and of 11 operated in 1943, it held first place in all except one. It was preceded in two instances by *Culex tarsalis*, and at two other locations it ranked third and fourth. There was a general tendency toward predominance of *C. tarsalis* and *A. dorsalis* in the western counties. A study of daily and monthly trap records for the two-year period shows that adults occur with about equal frequency throughout the season, except as influenced by rainfall and irrigation. At intervals waves of emergence were evident, male emergence usually preceding that of the females by about two days, indicating more than one brood in this area. Adults are strongly attracted to light traps.

Larvae were found associated with *C. tarsalis*, *A. dorsalis*, *C. pipiens*, *A. nigromaculis* and occasionally *P. signipennis*. They were collected periodically throughout the season in a wide variety of locations, including both contaminated and fresh water, rain pools, flood water, and seepage and surplus water from irrigation. Temporary pools in open pasture land seemed to be especially favorable.

Because of its abundance, wide distribution and vicious biting habits, *A. vexans* is of first importance as a pest species in the state. The adults feed in the shade to some extent during the day, and they are especially annoying at dusk and early evening. Recent discoveries that this species can transmit the virus of both St. Louis encephalitis and western equine encephalomyelitis greatly increases its potential importance (8, 9).

***Aedes trivittatus* (Coq.)**

Aedes trivittatus ranked ninth in abundance in light trap collections for the two-year period (1942-43). It appeared in larger numbers in eastern Nebraska than elsewhere; biting records showed that it occasionally became a dominant, particularly during rainy periods in the early spring months. With the exception of Whitney, *A. trivittatus* was rare in light traps in irrigated regions. Numerous hand collections and biting records were obtained in the eastern and central parts of the state. The adults are not strongly attracted to light traps.

The females are vicious biters which readily attack during the day when their resting places in wooded areas are invaded. In the authors' opinion their bite is the most painful and their attacks the most persistent of any mosquito in the state. However, it is given a moderate to low rank as a pest in Nebraska since the occurrence of outbreak numbers is limited largely to wooded areas and then only during rainy periods.

***Aedes triseriatus* (Say)**

Small numbers of this mosquito were taken in light traps along the eastern border and occasional specimens showed up in central Nebraska. In addition, hand collections of larvae and adults were obtained from various parts of the state including Glen and Monroe Canyon in northwestern Nebraska. The fact that *Aedes triseriatus* breeds principally in tree-holes greatly limits its distribution and abundance in this state. On a few occasions during rainy periods in early spring, the authors have observed females biting in sufficient numbers in shady places to be of local importance. Generally speaking, it ranks as a minor species in the state.

***Aedes flavescens* (Muller)**

Small numbers of *Aedes flavescens* were taken in light traps in all sections of the state. In open prairies of western Nebraska females were occasionally observed biting at any time during the day. Because of its rarity, this species is regarded as of only minor importance as a pest in the state.

***Aedes cinereus* Meigen**

Aedes cinereus is a comparatively rare northern species which occurs in woodland mountain areas. Our records of this species consist of 16 females and 1 male taken in light traps at Bridgeport in June and four males at Ord in early July, 1942.

***Aedes stimulans* Walk.**

The Department of Entomology collection contains 29 mosquitoes (♀ ♀) from Glen and one (♀) from Pine Ridge, Nebraska, which have been identified as *Aedes (stimulans* group.*) Both localities are in the northwestern part of the state near foothills of mountainous, wooded areas where *stimulans* would be most likely to occur. These specimens have been designated as *stimulans* group because of the difficulty of separating, with certainty, the females of *stimulans*, *excrucians* and *fitchii* (36).

***Aedes impiger*⁵ Walk.**

Specimens of *Aedes impiger* were obtained in light-trap collections at Scottsbluff during July and early August, 1943. Since it has been described as a forest species (27, 30) breeding in pools formed by melting snow, its appearance on the plains of Nebraska is somewhat unexpected. However, the elevation at Scottsbluff is about 4,500 feet and the light trap was located along the border of a sparsely wooded area of several acres.

***Aedes idahoensis** (Theob.)**

Our records consist of a single female collected at Glen, Nebraska, which is in the northwest corner of the state. This mosquito has been reported as an important pest in Montana (37), Utah (30) and some other areas of northwestern United States.

***Aedes spencerii* (Theob.)**

Aedes spencerii is typically a plains species, although its distribution is not limited to this region. A total of 24 specimens (22 ♀ ♀, 2 ♂ ♂) were obtained from light traps in three localities of northeastern Nebraska, namely, Walthill, Ord, and Niobrara, and at McCook in the southwestern part of the state.

***Aedes sticticus* (Meigen)**

Four specimens of *Aedes sticticus*, two females from Walthill and one female and a male from Niobrara, were collected in light traps in 1942.

⁵ The authors are indebted to Dr. Herbert H. Ross of the Illinois Natural History Survey for identification of this species.

Anopheles occidentalis D. & K.

Anopheles occidentalis was not collected in light traps during the two-year period of operation, but the Department of Entomology has records of 55 females taken in 1905 and 1906 at Glen which is in the northwestern corner of the state. These identifications have been checked by Dr. Alan C. Stone of the U. S. National Museum. King and Bradley (20) also reported this species from Glen, Nebraska. Quite possibly a search in suitable breeding places would reveal its presence at additional locations and in greater numbers than our records indicate.

Anopheles punctipennis Say

This is the most abundant and widely distributed anopheline in the state. It was taken in light traps in all locations except Scottsbluff, Bridgeport, Whitney and Oshkosh, but with much greater frequency in eastern Nebraska. A large majority of the specimens were taken during the latter part of the summer, particularly in late August and in September, 1942. It seems evident that the adults are strongly attracted to lights. Adults also have been taken by hand at Dunbar, Lincoln, and Waverly, all in eastern Nebraska. Larvae were found breeding abundantly in grassy lowland pools at Dunbar in association with *Culex tarsalis*, and on one occasion in an artificial container beneath a house in Lincoln.

Anopheles quadrimaculatus* Say

Anopheles quadrimaculatus was collected in relatively small numbers in light traps. A majority of them came from along the eastern border of the state, largely at Lincoln and Nebraska City. A few specimens were taken along the northeastern border and at McCook in southwestern Nebraska. None were found in northwestern Nebraska. With the exception of a few isolated specimens, all adults were collected in late August and in September, 1942, a period characterized by unusually cool wet weather. Operation of light traps in especially favorable sites, together with extensive hand collections in diurnal shelters, and biting records probably would reveal *A. quadrimaculatus* to be more numerous and more widely distributed than our records show; this is indicated by the report of Reeves and Galindo (Table 2).

Anopheles walkeri Theob.

Comparatively large numbers of *Anopheles walkeri* were collected in the light trap at Ord in 1942, and isolated specimens were taken at Valentine, Lexington and Omaha. Adults were taken more or less uniformly through the season. The 1942 trap location at Ord was especially favorable for *A. walkeri*. Within a radius of a few miles were several cat-tail marshes, partly shaded bayous

and permanent pools. The immediate surroundings of the 1943 site were less favorable and relatively few *walkeri* were collected.

***Culex tarsalis* Coq.**

Culex tarsalis ranked second in abundance in light trap collections, being surpassed only by *A. vexans*. It occurs as one of the major species throughout the state, but in somewhat greater numbers in central and western Nebraska. In three locations, namely, Whitney, Valentine and Oshkosh, it ranked first. The average nightly catch of this species at Whitney between June 1 and October 2, 1942, was 287 (♂ and ♀); for approximately the same period at Ord (central Nebraska) the average was 127, at Valentine (northern Nebraska) 90, and at one Lincoln trap (eastern Nebraska) 103. It was present more or less consistently from late spring to early fall, except for fluctuations due to rain and irrigation, and a reduction in midsummer possibly due to high temperatures.

Numerous hand collections of adults and larvae were made in various parts of the state. Larvae were taken in a variety of habitats, including both alkaline and fresh water, temporary ground pools, stagnant pools contaminated by refuse from slaughter yards, hoof prints in pastures, and seepage and surplus water from irrigation. In the plains region of western Nebraska larvae were found abundantly in small temporary rain pools on open prairies.

Adults are strongly attracted to light. The authors' observations, together with reports from others, indicate that *C. tarsalis* is more common in rural areas. Although regarded primarily as a zoophilous species in this state, the females were found to occasionally attack man in the open, and to enter dwelling houses in a few instances. The females inflict a painful bite. They attack horses and cattle with avidity, usually in the late afternoon and early evening, and both engorged and unengorged females were collected during the day in resting places in livestock barns.

Its numerical abundance and the wide host range (including both avian and mammalian hosts) (32) together with its known ability to transmit western equine and St. Louis encephalitis viruses (6, 9) place major importance on *C. tarsalis* in Nebraska.

***Culex pipiens* L.**

Culex pipiens is generally known as the common house mosquito of the northern states. It was comparatively abundant in light trap collections in eastern and southern Nebraska, but relatively rare in other sections. It frequently occurred in mixed populations with *Culex restuans*. Since females of the two species

could not be separated with certainty, mixed populations of *pipiens* and *restuans* were designated as *Culex* spp. (Tables 3 and 4). All males were determined by examination of terminalia.

Except on rare occasions, *C. pipiens* was not found in human habitations or biting people. Reference to Table 2 in this report shows that Reeves and Galindo found *pipiens-restuans* to be the most abundant species encountered in shelters but rare on "horse and human bait."

***Culex restuans** Theob.**

This species occurred throughout the state in trap collections, frequently in about the same numbers as *pipiens*. Apparently, however, there was a tendency towards a predominance of *restuans* in north-central and northwestern Nebraska and *pipiens* in eastern and southern areas. Distribution and abundance records were based largely on male determinations. Females having the characteristic white spots on the mesonotum (21, 24) were not encountered. Because of this, together with the fact that light-trap specimens usually are imperfect, it was regarded as impossible to separate mixed populations of female *restuans* and *pipiens*.

***Culex salinarius* Coq.**

Culex salinarius was the second most abundant and the second most widely distributed *Culex* species taken in light traps. Specimens were taken in each trap operated during the two-year period, except at Scottsbluff in 1942 and North Platte and Oshkosh in 1943. No evidence of seasonal occurrence other than that resulting from rainfall or irrigation was apparent. Heaviest populations were indicated in traps located in or near wooded areas and permanent bodies of water. It is abundant enough at times to be an important pest locally since females readily attack man.

***Culex apicalis* Adams**

A few specimens of *Culex apicalis* were taken in light traps at Lincoln, Nebraska City, Walthill, Niobrara, and Valentine. Apparently the adults do not bite man. There is some evidence that they feed on certain cold-blooded animals (34) and possibly on birds (15).

***Culex erraticus* D. & K.**

A total of 33 *Culex erraticus* were obtained in traps during the two-year period, all of them in eastern Nebraska, namely, Lincoln, Nebraska City, Omaha and Walthill. The larvae are said to develop in grassy, permanent pools and in swampy places.

Reeves and Galindo ⁶ reported having found larvae of *C. erraticus* in eastern Nebraska during the summer of 1943 in impounded water where cat-tails and algae were growing. They were developing in association with *Anopheles punctipennis*, *A. quadrimaculatus*, *Uranotaenia sapphirina*, *Culex tarsalis* and *C. salinarius*. The adults of *erraticus* are strongly attracted to light traps. Its comparative rarity in Nebraska places it among the unimportant species.

***Culex quinquefasciatus** Say**

Culex quinquefasciatus is known as the southern house mosquito. According to King and Bradley (20) and others it is generally the most abundant night-biting mosquito in the cities and towns of the Southern States. Our records consist of one male collected at Lincoln. The determination was verified by Dr. Alan C. Stone. Its usual range does not extend as far north as Nebraska.

***Culiseta inornata* (Will.)**

Culiseta inornata is a large, grayish brown mosquito which commonly occurs throughout the state. It ranked third and fifth respectively in light trap collections for the two seasons (1942 and 1943). It is markedly seasonal in occurrence. In eastern Nebraska, a few specimens were collected in early spring (May and early June); only small numbers were present during the hot summer months (July and August) and relatively speaking, large numbers appeared in the fall with the approach of cool weather. In western, and to a lesser extent in north-central counties, where summer minimum temperatures are lower, adults persisted throughout the season but with a definite drop during mid-summer. Frequently several thousand *inornata* were taken in traps in a single night during the fall of 1942 when practically no other insects were active because of low temperatures.

Larvae were collected in a number of situations. More typical sites were open grassy pools, but they were also found in such places as lily ponds and in water contaminated with garbage. No larvae were observed during the hot summer months in eastern Nebraska, but in the milder climate of Scottsbluff and Whitney they were present throughout the season. They were commonly associated with *Culex tarsalis* and *C. pipiens* and occasionally with *Aedes dorsalis*, *A. nigromaculis* and *A. vexans*.

Hibernating females have been collected by the senior author throughout the winter months in sheltered places. Large numbers were observed in unheated garages and similar locations. The

⁶ Personal communication to authors.

females attack man only occasionally but they readily attack domesticated animals. Hammon and Reeves (9, 11) recently reported successful transmission of western equine and St. Louis encephalitis viruses by *C. inornata*.

***Culiseta incidens** (Thomson)**

The Department of Entomology collection contains one specimen of this mosquito from War Bonnet Canyon (northwestern Nebraska). Reference to Table 2 will show that Reeves and Galindo collected one specimen in eastern Nebraska during the summer of 1943. Mail (27) reports that it shows a decided preference for livestock blood. Hammon and Reeves recently reported successful transmission of western equine and St. Louis encephalitis by this species (8, 10).

***Culiseta impatiens* (Walk.)**

Three individuals of this species were collected in light traps, two at Lincoln and one at Walthill. It is reported as being typically a mountain species, indicating that its presence in Nebraska is incidental.

***Psorophora signipennis* (Coq.)**

This strikingly colored mosquito ranked sixth and fifth respectively in abundance for the two seasons (1942 and 1943) of mosquito trap operation. It was present in significant numbers throughout the state. Particularly large numbers were taken at Lincoln, Niobrara, Bridgeport, Whitney and Lexington, which represent all sections except those along the southern border. Although adults were collected continuously during the period of mosquito activity—late May to early October—daily and monthly trap records show a tendency toward predominance in the fore part of the season, especially June and July.

On several occasions this species, which inflicts a painful bite, was observed attacking man in annoying numbers. The senior author spent three days at Lexington (Dawson Co.) in early July, 1943, at which time mosquitoes were present in plague proportions; *P. signipennis* was one of the major species involved.

***Psorophora ferox* (Humbdt.)**

Psorophora ferox, known as the "white-footed woods mosquito," was encountered in wooded and shady spots throughout the Missouri valley region of Nebraska. Females are persistent and painful biters. Only ten specimens showed up in traps, all of them along the eastern border of the state. Adults are not strongly attracted to lights.

***Psorophora confinnis* (L.-Arr.)**

This species is a fierce biter which occurs in great abundance in some of the south-central and southeastern states. Bishopp (2) reports loss of livestock in Florida due to its attack. In Florida it is known as the "Florida glades mosquito" and in Arkansas as the "dark rice-field mosquito." One female was taken in a light trap at Dunbar (Otoe Co.) in 1941 by W. W. Wirth and three specimens in 1943 by Reeves and Galindo at Norfolk (Table 2). Nebraska is outside its usual range.

***Psorophora ciliata* (Fabr.)**

This is a large, yellowish-black mosquito with heavily scaled legs. Adults are familiarly known as "gallinippers." It breeds in temporary rain pools and its larvae feed on those of other mosquitoes. The females are severe biters. Small numbers of *Psorophora ciliata* were taken in light traps throughout eastern and north-central Nebraska. Biting records show that they are present in larger numbers than is indicated by the light trap data.

***Mansonia perturbans* (Walk.)**

This mosquito is widely distributed in the eastern and southern states, and in many localities becomes a serious pest (21). Larval development is unique in that upon hatching they attach themselves to aquatic plants below the water surface and from these obtain the necessary oxygen. Two females of *Mansonia perturbans* were collected in mosquito traps, one at Valentine in 1942 and one at Oshkosh in 1943.

***Orthopodomyia signifera* (Coq.)**

Orthopodomyia signifera breeds largely in tree-holes. One specimen was taken at Nebraska City. Reeves and Galindo (Table 2) collected larvae in Scribner, Nebraska, during August of 1943 from which adults were reared.

***Uranotaenia sapphirina* (Osten-Sacken)**

Uranotaenia sapphirina is a small, dark mosquito characterized by the presence of sapphire-colored scales on the thorax and wings. This species was collected in light traps from June until September in central and eastern Nebraska, but none were taken in western locations. It was more common in or near wooded areas. It is of no economic importance in Nebraska.

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