ARTICLES

CONTROL OF *CULEX TARSALIS* (COQUILLETT) AND *AEDES VEXANS* (MEIGEN) ON LEWIS AND CLARK LAKE (GAVINS POINT RESERVOIR) BY WATER LEVEL MANAGEMENT[1]

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INTRODUCTION

A marked increase in the mosquito population occurred following the construction of Gavins Point Dam and the impoundment of Lewis and Clark Lake. Because one of the two dominant species to develop was *Culex tarsalis,* a potentially severe public health hazard was indicated. The other abundant species was the noxious pest of man, *Aedes vexans.* These two species comprised over 90 percent of the total mosquito population.

The purpose of this study was to define the mosquito problems associated with the reservoir and on the basis of the findings to outline a suitable program of control. An experimental schedule for regulation of the water level was initiated during the study (1959 and 1960 seasons) in an effort to establish its usefulness on this reservoir.

It was demonstrated that both *C. tarsalis* and *A. vexans* could be adequately controlled by the same program of water level management.

PRE- AND EARLY POST-IMPOUNDMENT STUDIES. Gavins Point Dam and Reservoir, a unit of the Pick-Sloan Plan, is a project of the U. S. Army Corps of Engineers, Omaha District, located approximately five miles west of Yankton, South Dakota, on the Missouri River. The project was completed in 1955 with the primary purposes of flood control, navigation and the generation of hydroelectric power. Additional secondary functions include recreation, wildlife conservation, irrigation and other downstream needs.

The lake formed is approximately 35 miles long and from 1 to 3 miles wide. The shore line on the Nebraska side is approximately 95 percent abrupt and 5 percent flood-plain. The South Dakota side is approximately 75 percent abrupt and 25 percent low flood-plain. Springfield, South Dakota, the only city bordering on the reservoir, is located at the upper end of the reservoir.

During 1949–1958 several surveys were made in the impoundment area by the U. S. Public Health Service and the Nebraska and South Dakota State Health Departments. Results served to define the mosquito populations present before and after the formation of the reservoir and prior to the 1959–60 study. Such information was invaluable in analyzing the effects of the reservoir on the native mosquito population and in determining the controlling effects, if any, of the experimental water level management plan on the post-impoundment mosquito population.

The first records on mosquito incidence were from a light trap operated at Springfield, South Dakota, during the summers of 1949 and 1950. The average number of females per catch night was approximately 18 specimens, and over 90 percent were *A. vexans.* Second in abundance was *C. tarsalis;* however, it represented only about 5 percent of the total population, or approximately one female per catch night.

A malarial hazard survey of the proposed reservoir area was conducted while

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the impoundment was still in the planning stages and it was concluded that the hazard of malaria transmission in the reservoir environs was slight (U.S.P.H.S. Report, 1949). A re-evaluation study was conducted during August, 1954 (U.S.P.H.S. Report, 1954). Although some coves offering potential breeding sites during flood stages were noted along the upper end of the proposed reservoir, the river bottom southwest of Springfield was believed to be the principal source of any future mosquito problems.

After the closure of the dam, but while the reservoir was still in the process of filling, a third field study was conducted (U.S.P.H.S. Report, 1956). Approximately 400 acres of small willow growth in shallow water just south of Springfield proved to be the main source of mosquito production. It was concluded that filling of the pool to normal operating level would likely reduce this willow stand and alleviate most of the problem area. A human biting collection taken in Terrace Park in Springfield represents the first biting records for this area (Table 4). Of primary importance was the fact that 14 percent of the mosquitoes collected were *C. tarsalis*. This suggests a marked increase since the light trap operating 168 nights at Springfield during 1949 and 1950 produced only about one female *C. tarsalis* per catch night.

A final survey during August, 1958, after the pool had reached the normal operating level was prompted by an acute mosquito problem in the reservoir area. Eighty-one percent of the larvae collected were *C. tarsalis,* with counts as high as 20 pupae and 100 larvae per dip. Heavy production of *C. tarsalis* was found in several stations extending along the South Dakota side of the reservoir, from the Yankton Boat Basin adjacent to the dam to the Emmanuel Creek area southwest of Springfield. Because of the higher pool elevation in 1958 (1208 opposed to 1204 in 1956), the main source of mosquito breeding in 1956 was no longer present. However, the higher pool elevation created a vast acreage of shallow water southwest of Springfield where mosquito production was found to be extensive and intensive (Figs. 4 and 5). In limited observations made in shelters along the reservoir margin, over 100 female *C. tarsalis* were found in a privy in Terrace Park at Springfield. A one-hour biting collection made in Terrace Park yielded 612 mosquitoes of which 564 (92 percent) were *C. tarsalis* and 38 (6 percent) were *A. vexans* (Table 4). The findings during 1958 represented a forty-fold increase of potential encephalitis vectors over 1956.

During 1958 no attempt was made to control mosquito breeding by use of insecticides on the Gavins Point Project. The city of Springfield treated the city three times (about the second week in June, July and August) with 0.5 percent malathion applied as a residual spray. However, the inability of such a treatment to control adult mosquitoes when they are breeding in such overwhelming numbers was demonstrated by the fact that Mr. Beadle's collection (Table 4) was made just four days after the city and Terrace Park had been sprayed.

The health hazard which existed in the reservoir area during the summer of 1958 was viewed with grave concern and resulted in the following conclusions and recommendations (U.S.P.H.S. Report, 1958):

"1. Excessive production of *Culex tarsalis* associated with Lewis and Clark Reservoir constitutes a definite threat to public health from the standpoint of encephalitis transmission. Furthermore, the fullest use of recreational areas, including Terrace Park at Springfield, cannot be attained because of mosquito annoyance after dusk.

"2. Unless remedial measures are taken, the health hazard may increase in 1959 due to the tremendous buildup of *C. tarsalis* populations in 1958. Undoubtedly, high populations of female *C. tarsalis* will hibernate during the winter of 1958–59 in the reservoir area, particularly in the vicinity of Springfield.

"3. Immediate corrective action should be taken by all agencies concerned to alleviate the health hazard.

"4. The futility of relying solely on adult mosquito control was demonstrated in Springfield during 1958.

"5. The principal mosquito control needs at the Gavins Point Project are:

(a) A systematic entomologic appraisal to define the problem areas.

(b) Control operations geared to the entomologic findings.

(c) A change in the water level management schedule."

For the summer of 1959, on the agreement of mosquito control and wildlife interests, the following water level management plan was proposed, in the hope that it would aid in controlling mosquitoes without interfering with the designed purposes of the project or wildlife conservation:

"1. Attain maximum pool elevation approximately mid-June. (A high surcharge followed by a draw-down should be provided to strand flotage and drift.)

"2. Withdraw from the reservoir at the rate of 0.1 foot per week until approximately September 1. (July and August are critical months because the breeding of *C. tarsalis* is at a maximum during these two months.)

TABLE 1.—*A. vexans* and *C. tarsalis* collected by light trap and biting collections at Lewis and Clark Lake, June 16–Sept. 30, 1959.

	Light trap collections				Biting collections
	Dam site		Springfield		Springfield
Species	♂	♀	♂	♀	♀
Aedes vexans	895	1009	3258	4485	905
Culex tarsalis	402	1497	275	835	327
Other species	242	505	96	346	196
Total mosquitoes	1539	3011	3629	5666	1428
Total collections	106		101		20
Average ♀♀ per catch	29.4		56.1		71.4
Percent *A. vexans* (♀)	33.5%		79.2%		63.4%
Percent *C. tarsalis* (♀)	49.7%		14.7%		22.2%
Percent other species	16.8%		6.1%		14.4%

TABLE 2.—*A. vexans* and *C. tarsalis* collected by light trap and biting collections at Lewis and Clark Lake, May 1–September 30, 1960.

	Light trap collections						Biting collections
	Dam site		Springfield		Santee		Springfield
Species	♂	♀	♂	♀	♂	♀	♀
Aedes vexans	1300	482	10,919	4742	300	415	445
Culex tarsalis	1218	2183	154	279	95	167	137
Other species	1519	515	143	355	54	193	48
Total mosquitoes	3037	3180	11,206	5376	449	775	630
Total collections	65		46		42		14
Average ♀♀ per catch	48.9		116.9		18.5		45
Percent *A. vexans* (♀)	15.2%		88.2%		53.5%		70.6%
Percent *C. tarsalis* (♀)	68.6%		5.2%		21.5%		21.7%
Percent other species	16.2%		6.6%		25.0%		7.7%

"3. Refill the reservoir to maximum pool elevation approximately mid-September."

1959–1960 STUDY

METHODS. Mosquito populations were sampled by night and daytime biting counts, resting stations and light traps. During the summer of 1959, two light traps were operated seven days a week. One trap was located at the upper end of the reservoir in Terrace Park at Springfield, and the second near the dam at a heavily visited public use area. During 1960 three traps were operated on three rain-free nights each week. Two traps were maintained in the same locations as in 1959 and the third on the Nebraska side at the Santee Sioux Indian Tribal grounds.

Privies located at public use areas along the reservoir were used as resting stations and inspected periodically. Daytime biting collections were taken whenever daytime biting annoyance was noted. Nighttime biting collections were made on one rain-free night each week in Terrace Park at Springfield. Additional collections were made in other areas when mosquito annoyance was suspected.

All potential breeding areas on the reservoir were sampled for mosquito production. Any breeding source not directly associated with the reservoir but near enough to the reservoir to contribute to the population of the area also was investigated. A standard enamel dipper was used for sampling and the following population index was used: *heavy production*, more than 10 larvae or pupae per dip; *moderate production*, 1–10 larvae or pupae per dip; and *light production*, less than one per dip.

RESULTS. ADULT MOSQUITOES COLLECTED. Numbers of mosquitoes taken during 1959 and 1960 are presented in Tables 1 and 2. Data representing the average number of females per catch night are not representative of the seasonal population as indicated by the much higher number of females per catch in Springfield during 1960 than in 1959 in spite of the much lower seasonal abundance in 1960 (Fig. 2). Such a misrepresentation resulted from a few extremely high catches in early September of 1960. *A. vexans* was the dominant species in Springfield both years and at Santee the one year sampled. *C. tarsalis* was the dominant species at the dam both years.

TABLE 3.—Species of mosquito collected by light trap and biting collections at Lewis and Clark Lake during 1959 and 1960.

Species	Total number	Percent of total population
Aedes canadensis	3	*
A. dorsalis	28	*
A. flavescens	2	*
A. nigromaculis	74	*
A. sticticus	9	*
A. stimulans	1	*
A. triseriatus	258	.6
A. trivittatus	381	.9
A. vexans	29,155	73.0
Anopheles barberi	1	*
A. punctipennis	372	.9
A. quadrimaculatus	71	*
Culex erraticus	9	*
C. restuans	587	1.4
C. salinarius	881	2.2
C. tarsalis	7,569	18.9
C. territans	52	*
Culiseta inornata	257	.6
Orthopodomyia signifera	4	*
Psorophora ciliata	1	*
P. ferox	6	*
P. longipalpus	1	*
P. signipennis	7	*
Uranotaenia sapphirina	195	.6
Total	39,924	100

* Less than .5 percent.

Table 3 contains a list of males and females taken. Several new records for this area and South Dakota were established (Edman, 1962). *A. vexans* comprised 73 percent of the total population and *C. tarsalis* 18.9 percent, the two totaling approximately 92 percent of all mosquitoes collected. Next ranked *Culex salinarius, Culex restuans, Aedes trivittatus* and *Anopheles punctipennis*, respectively.

The seasonal abundance of *A. vexans* and *C. tarsalis* from the Springfield trap during 1959 and 1960 is shown in Figure 2. Although *A. vexans* was dominant both

TABLE 4.—Number of mosquitoes taken by L. D. Beadle (human bait) in one hour at Terrace Park, Springfield, South Dakota (1960 collection made by J. D. Edman).

Species	1956 (Aug. 9)	1958 (Aug. 18)	1959 (Aug. 20)	1960 (Aug. 17)
Culex tarsalis	14	564	17	0
Aedes vexans	88	38	59	3
Miscellaneous species	25	10	10	12
Total	127	612	86	15

years, the population was much smaller during 1960 except for the high peak in early September. The *C. tarsalis* population was also lower in 1960. Seasonal biting activity at Terrace Park correlated closely with the light trap catches for Springfield.

The seasonal abundance at the dam site trap is illustrated in Figure 1. The dominant species both years was *C. tarsalis*. A good correlation exists between the *C. tarsalis* population curves for the two years. The *A. vexans* population was lower in 1960.

A. vexans was the dominant species at the Santee trap; however, the mosquito population here proved to be by far the lowest of the three areas sampled.

Lack of daytime biting activity and mosquitoes present in resting stations prevented the accumulation of any systematic data from these sources.

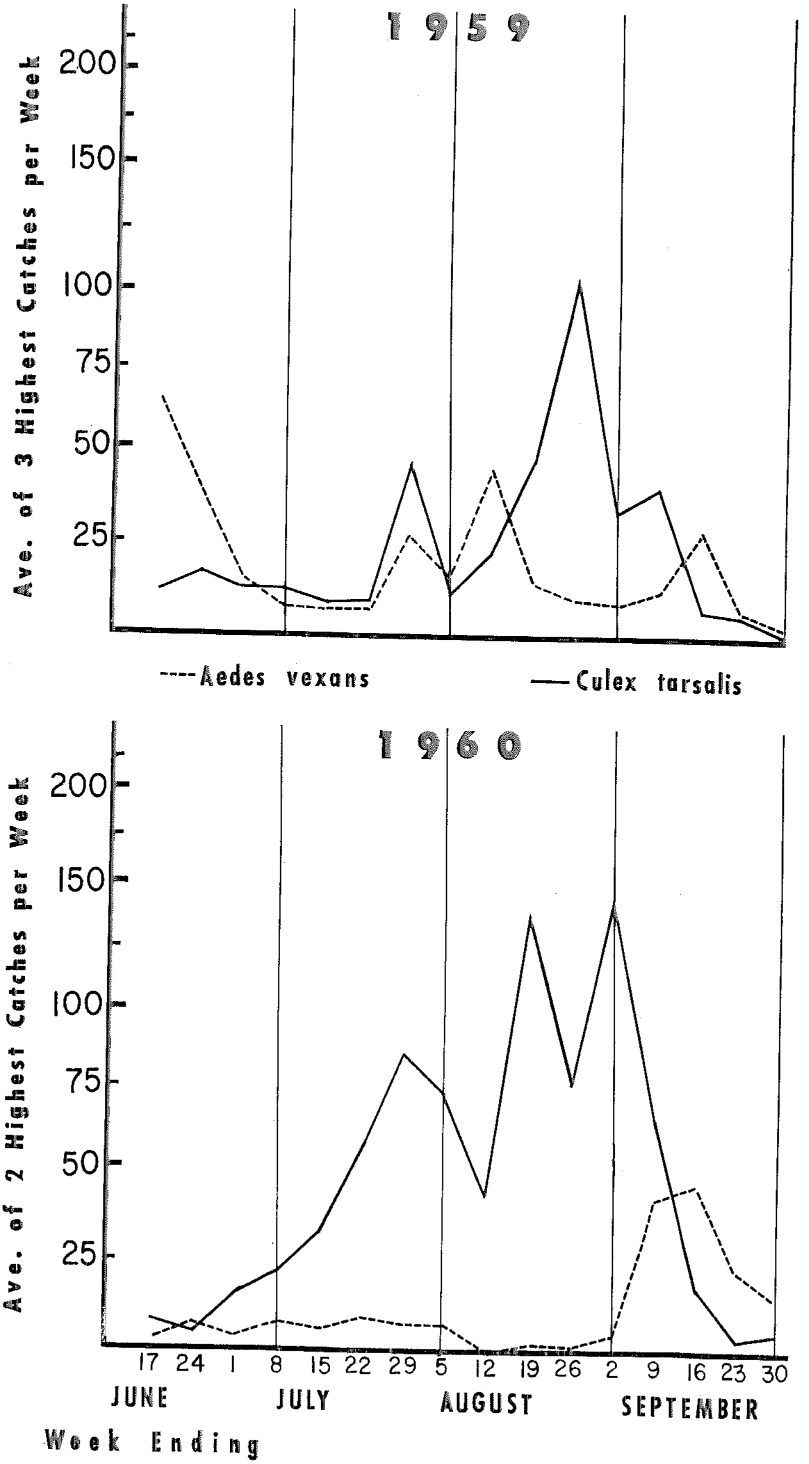
WEATHER CONDITIONS. Rainfall during the 1958 mosquito season was far less than in either 1959 or 1960. The 1960 period received over 6 inches more rain than the 1959, and totaled 7 inches above the normal rainfall for this period. Mosquito samples were highest during 1958, decreased in 1959, and were at the lowest seasonal level during 1960. Hence, the high mosquito population in 1958 was not the result of above-normal rainfall and the lower populations in 1959 and 1960 were not the result of below-normal rainfall.

The mean daily temperatures in 1958 averaged about four degrees lower during the three summer months than in 1959. June, in particular, was much warmer during 1959. During 1960 the July temperatures were comparable to July of 1959; August was slightly cooler than in 1959, while June of 1960 was comparable to June of 1958. Temperatures, along with the rainfall results, indicate that weather conditions cannot adequately explain the population trends during the three summers.

RESERVOIR OPERATION. Reservoir pool levels May 20-September 23 of 1958–60 are graphically illustrated in Figure 3. In view of the high mosquito population during August, 1958, the 4-foot rise in the pool level from July 15 to August 15 was particularly significant.

At the June, 1959, meeting of the Lewis and Clark Inter-Agency Council, the Division Office of the Corps of Engineers outlined the experimental operation plan for the pool which had been suggested. This plan was installed during the 1959 and 1960 summers.

In general, the outlined plan was followed with the major exceptions of the late start in 1959 and the 3-foot rise August 23–31 in 1960. The late start in 1959 resulted from the prolonged threat of spring floods which delayed filling of the pool to maximum level until after July 1. The resultant rising pool during June can be correlated with the higher *A. vexans* population during this period. The 3-foot rise during late August, 1960, was of considerable importance because on September 5, twelve days after the onset of the rise, the *A. vexans* population at Springfield rose from 5 mosquitoes on the previous collection night to 8,420 specimens. Twelve days is about the time required for *A. vexans* to mature after inundating water causes the eggs to hatch under favorable conditions. Smaller increases of *A. vexans*


1959
Ave. of 3 Highest Catches per Week
200
150
100
75
50
25
----Aedes vexans
——Culex tarsalis
1960
Ave. of 2 Highest Catches per Week
200
150
100
75
50
25
17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30
JUNE
JULY
AUGUST
SEPTEMBER
Week Ending

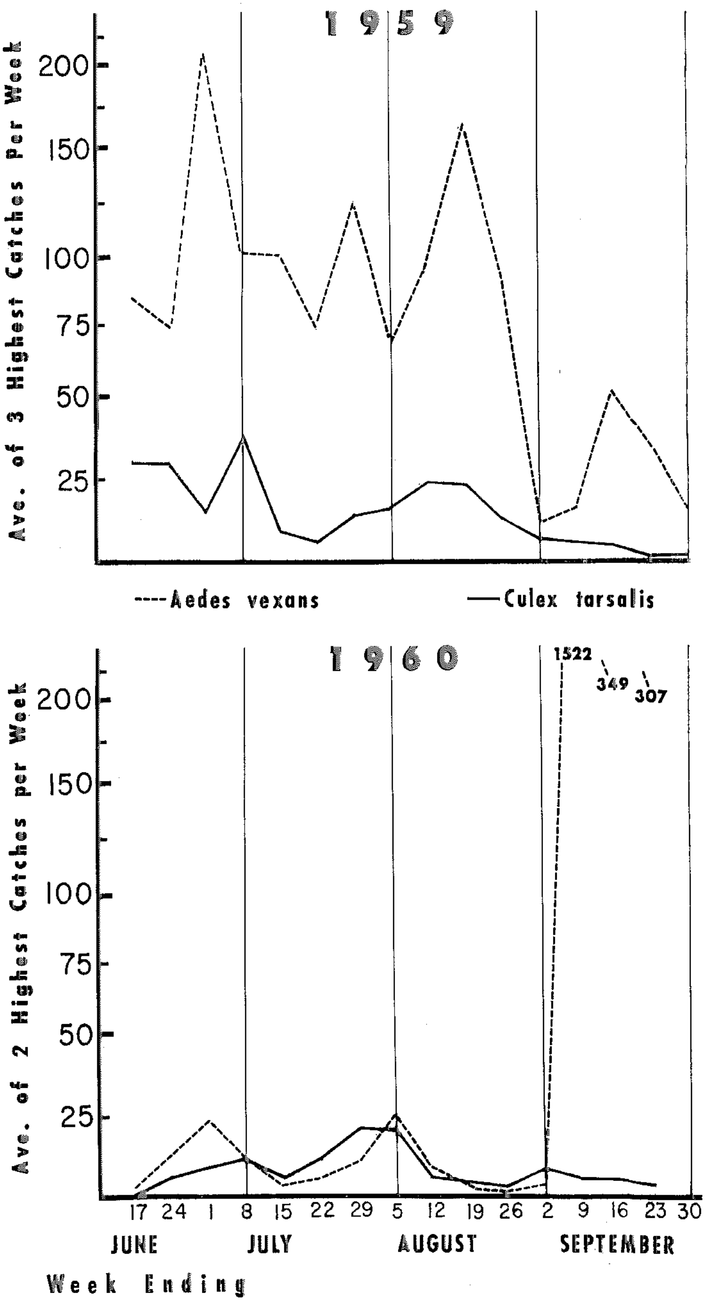


FIG. 2.—Seasonal abundance of *A. vexans* and *C. tarsalis*, Springfield light trap, 1959 and 1960.

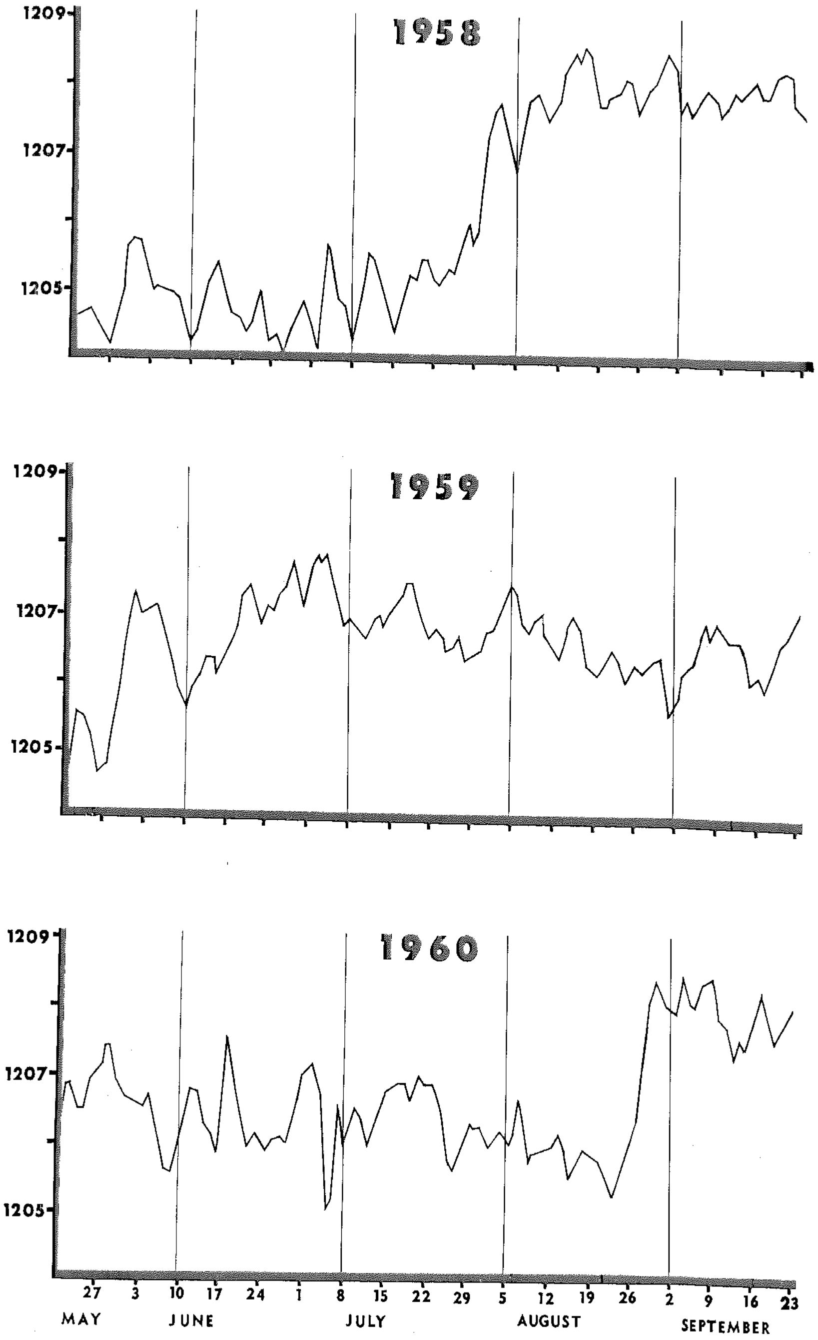


FIG. 3.—Reservoir pool elevation, in feet, May 20-September 23, 1958-60.

also occurred concurrently at the Santee and dam site traps.

LARVAL STUDIES. Twelve species representing four genera were collected in larval samples. In direct accordance with adult samples, *A. vexans* and *C. tarsalis* were the most abundant. *C. salinarius* and *A. punctipennis,* though less numerous, were often found. Twenty-nine different stations were established of which ten were directly associated with the reservoir. The larval collecting stations are grouped and discussed under seven areas. The first five areas were located near enough to the reservoir to contribute to the mosquito population of that area but they were not associated with the reservoir waters. The last two areas involve reservoir waters.

AREA I. Drainage area below the dam: A series of drains under the earth-rolled portion of the dam gave rise to a network of drainage ditches below the dam. Heavy growth of vegetation and algae in some ditches slowed the water and sufficient warming resulted to allow limited breeding of *A. punctipennis* and *C. tarsalis. A. punctipennis* favors cooler water (Horsfall and Morris, 1952), but *C. tarsalis* in water as cold as 63° F. appears rather unusual. During 1959, one of the larger arterials of this drainage network was dammed by beavers which resulted in the formation of a pool filled with a dense algal growth of *Chara;* it contained *A. punctipennis* and some *C. tarsalis.* Construction equipment and tractor tires left several depressions which offered moderate *C. tarsalis* breeding.

AREA II. Artesian wastes: Free-flowing artesian wells near the dam produced several small ponds, offering very limited mosquito production, generally only *A. punctipennis* because of the low temperatures. One area, located less than one-half mile from the dam site light trap, and the most heavily used public use area on the reservoir, was the main continuing source contributing to the high *C. tarsalis* population near the dam. Here, a large, free-flowing artesian well flooded about one-fourth acre of heavily vegetated and shaded pasture land. Cattle provided organic material and hoof print depressions. Up to 50 larvae and pupae per dip were taken regularly in most of the area.

AREA III. Rain pools: Within the limits of the Springfield bottom land are a few areas, particularly road ditches, not directly associated with the reservoir. These areas were suited for temporary rain pools which at times produced moderate numbers of *A. vexans.* The road ditches along the bottoms road may be detected in the upper right of the aerial photograph (Fig. 4).

AREA IV. Springfield sewage lagoon: The Springfield sewage lagoon located less than one mile east of the city was a source of heavy *C. tarsalis* production during 1959; as many as 100 larvae and pupae were taken per dip (Fig. 7). Only limited production was found in 1958. This lagoon was too large for the amount of liquid being pumped into it and the bottom was not properly sealed, resulting in shallow water and invasion of vegetation. During the fall of 1959 this lagoon was rebuilt and supported no breeding during 1960.

AREA V. Miscellaneous non-reservoir areas: Several other small isolated areas, exclusive of the reservoir itself, were found breeding mosquitoes (e.g., old boats, tree holes, duck ponds, etc.).

AREA VI. Driftwood accumulations in coves: Coves and inlets along the reservoir shore acquired accumulations of driftwood and debris which tended to minimize the wave action and produced quiet, shaded waters behind them. Moderate numbers of *C. tarsalis* were found in such habitats (Fig. 6).

AREA VII. Flood-plains: Santee, Weigand, from the Gavins Point area to the dam and the Springfield bottoms (Fig. 4 and 5) have a flood-plain type of shore, subject to a wide variation in water level, depending on the water level of the reservoir.

The flood-plain bordering the Weigand area was smallest and highest in elevation, and water inundated the border vegetation

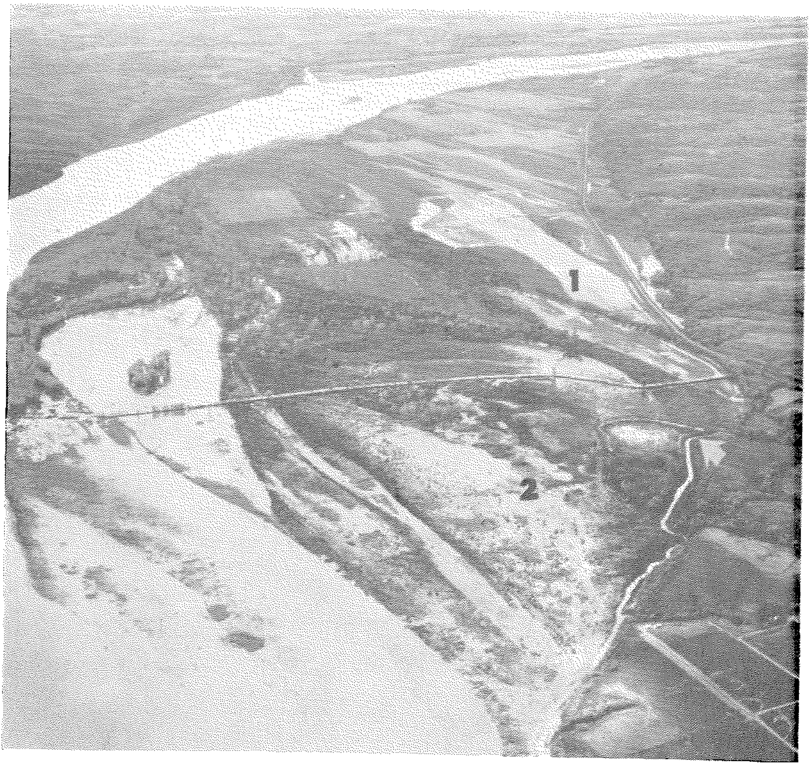


FIG. 4.—Aerial view of Springfield flood-plain. 1 & 2 locate the approximate centers of the two large larval stations in the bottoms transected by the dike running through the middle of the picture. The arrow locates where Emmanuel Creek enters the bottoms. The outskirts of Springfield can be seen in the lower right hand corner.

only at extremely high lake levels, near 1208 ft. Here, larval samples and biting counts indicated small *A. vexans* and *A. trivittatus* populations.

The Santee flood-plain was also limited, but it offered breeding habitats for both flood-water and permanent-water breeders, whenever a rising pool occurred.

The flood-plain from the dam to near the Gavins Point area, consisting of several low bays, was extensive and originally seeded to alfalfa. During August, 1958, when the pool had been steadily rising for about one month, approximately five acres of the alfalfa were inundated by water. Extremely high *C. tarsalis* production was found. The absence of rising water during July and August of 1959 resulted in a shore line free of vegetation and no mosquito production. During 1960, the experimental water level management plan again kept this area relatively free from breeding mosquitoes until August 23, when the unscheduled rising pool produced a brood of *A. vexans*. Some *C. tarsalis* breeding was observed in early September, but too late for a large build-up. A portion of this flood-plain, as seen after the 1960 draw-down, is illustrated in Figure 8, showing the clean shore line and stranded driftwood resulting from the surcharge followed by a draw-down.

The Springfield flood-plain is by far the largest mosquito breeding habitat on Lewis

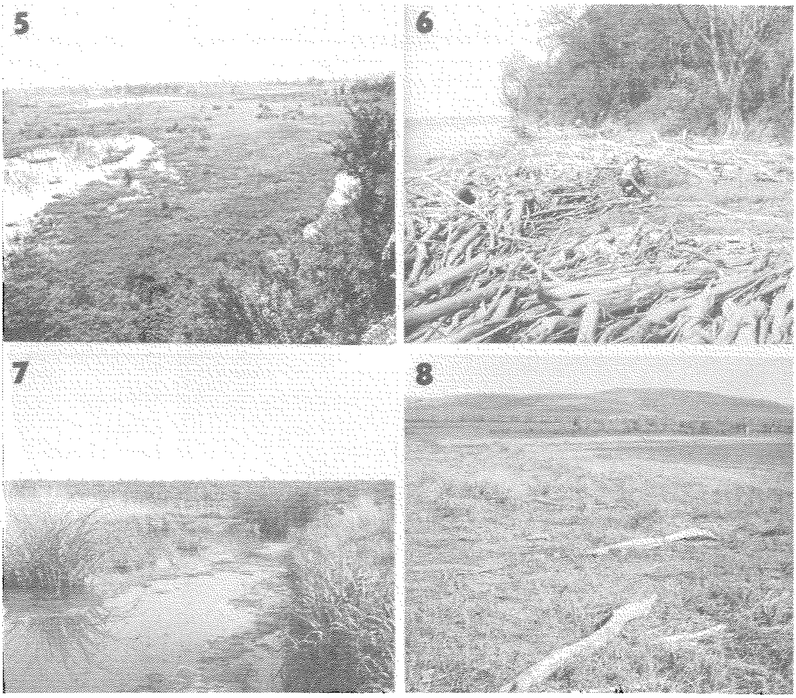


FIG. 5.—Extensive shallow water area in the vicinity of Emmanuel Creek, adjacent to Springfield, South Dakota (1958).
FIG. 6.—Cove with accumulations of driftwood at Sand Creek area (1959).
FIG. 7.—Springfield city sewage lagoon (1959).
FIG. 8.—Flood-plain near Yankton swimming beach with stranded flotage resulting from surcharge followed by draw-down (1960).

and Clark Lake (Fig. 4). The effect of the water level management plan in controlling mosquitoes was most critical, because of the large size of the area (approximately 500 acres), and its location at the upper end of the reservoir where minor pool fluctuations result in major shore line changes. Compared with the high *C. tarsalis* population found during 1958, the light trap (Fig. 2) and biting records from Springfield during 1959 reflect a *C. tarsalis* population which never exceeded the high of 40 per night taken in June. This represents a great reduction from the 564 *C. tarsalis* taken in a one hour biting collection from the same location in 1958, just one year previous. Larval samples throughout the entire bottoms during 1959 yielded only small numbers of *C. tarsalis* except in a few isolated pools. *A. vexans* were found in several rain pools in the bottoms area to help account for the *A. vexans* population expressed through the Springfield light trap (Fig. 2). Practically no *A. vexans* breeding could be demonstrated in this reservoir flood-plain after July 1, 1959.

Populations of both *A. vexans* and *C. tarsalis* larvae were low during 1960 with one exception. The unscheduled three-foot rise in the pool during late August of 1960 had an even greater effect on the Springfield flood-plain than it did on the other flood-plain areas. The *A. vexans* population in Springfield increased from an average of 4 mosquitoes per night during the week ending September 2, to an average of 1,522 females per night during the week ending September 9. Just prior to this tremendous increase in the adult population, 4th instar larvae and pupae up to 40 per dip were found throughout the vast inundated vegetation in the Springfield flood-plain.

DISCUSSION

C. tarsalis was more abundant in catches from the dam site than *A. vexans*, whereas at Springfield *A. vexans* was much the most abundant species. Few aquatic habitats favorable for *A. vexans* were present in the vicinity of the dam during 1959 or 1960, with the one exception in late August of 1960 when there was a rising pool. However, the production of *C. tarsalis* found in the artesian-fed permanent water pasture area was sufficient to account for the high population of *C. tarsalis* collected at the dam site trap.

Light trap and biting collections at Springfield reflected mosquito production directly associated with the reservoir. In 1959 the experimental operating plan could not be put into effect until the first part of July. Thus, during early June the rising water inundated *A. vexans* egg beds, causing a large population. Because this occurred in June, it had little effect on the *C. tarsalis* population since this species was just starting to develop. The peak for *C. tarsalis* at Springfield was found in June and early July; this was believed to be the result of the large over-wintering population stemming from the previous year. The receding pool level during July and August prevented this early population from multiplying.

In 1960 the experimental operating plan was placed into effect on schedule and followed throughout most of the summer. The unplanned rising pool during the period from August 23–31 gave further evidence of the effectiveness of the water level management as demonstrated by the tremendous rise in the mosquito population which occurred in early September. Because of the lateness of the season, *C. tarsalis* did not have an opportunity to take advantage of the permanent mosquito breeding habitat which was created after the rise. The topography of the area surrounding the reservoir is such that these extremely large rains did not create an abundance of flood-water areas off the reservoir. Thus, increases in flood-water mosquitoes could be attributed for the most part to the effect of rains on the pool elevation in the reservoir itself. Larval samples also substantiated this conclusion.

Light trap and biting collections made at Springfield from 1949–60 give a rough picture of the population changes for *A. vexans* and *C. tarsalis*. Because of the sketchy information available for the earlier years, it is difficult to make any informative comparisons for the entire period. It appears that the *C. tarsalis* population was much more affected by the formation of the reservoir, with the resultant slow rising pool, than was the *A. vexans* population. The *C. tarsalis* population increased steadily until 1959 when the water level management plan was put into effect. The trend in total numbers of the two mosquito populations from 1956 through 1960 can best be illustrated by comparing four biting collections made at the same place at approximately the same date on four different years (Table 4). It is unfortunate that there are not more complete data for the years prior to 1959, particularly for 1958; however, the information available for 1958 varies so conclusively from the more complete 1959–60 data that the biggest question left unanswered is whether the mosquito population in 1958 rose even higher.

SUMMARY

1. Twenty-four species representing seven genera of mosquitoes were found in the Lewis and Clark area. *A. vexans* and *C. tarsalis* comprised approximately 90 percent of all specimens collected.

2. High populations of both *C. tarsalis* and *A. vexans* can be developed in this

reservoir when favorable breeding conditions are afforded.

3. Weather was not a major factor controlling the mosquito populations in this area.

4. Mosquito populations were closely correlated with the operation of the reservoir water level.

5. The experimental water level management plan installed during the 1959 and 1960 seasons called for a maximum pool in mid-June, a high surcharge followed by a draw-down to strand flotage, with subsequent withdrawal from the reservoir at the rate of 0.1 foot per week until Sept. 1.

6. The experimental plan was effective in controlling *C. tarsalis* and *A. vexans* breeding in the reservoir, with the exception of late June of 1959 and late August of 1960, when the proposed plan of operation was not followed.

7. The critical factor favoring the production of mosquitoes was a rising water level during the summer months.

8. The principal controlling force in a receding pool was the restriction of shallow water from bordering vegetation.

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