SEASONAL OCCURRENCE AND SPECIES COMPOSITION OF MOSQUITO ADULTS AND LARVAE IN A FRESH WATER BREEDING SITE NEAR SASKATOON, SASKATCHEWAN[1]

W. W. A. STEWART

Research Station, Research Branch, Agriculture Canada, University Campus, Saskatoon, Saskatchewan

ABSTRACT. A fresh-water breeding site near Saskatoon, Saskatchewan was sampled for mosquito adults and larvae from snow-melt to freeze-up during 1970, 1971 and 1972. Twenty species of adults representing five genera were taken in the CDC light traps and 15 species of larvae representing four genera in the dipping samples. Nine species of adults and five species of larvae reached pestiferous levels (1 percent or more of the total population). The adults in decreasing order of abundance were *Culiseta inornata, Aedes vexans, Aedes campestris, Aedes flavescens, Aedes dorsalis, Aedes spencerii, Culex tarsalis, Aedes fitchii, Anopheles earlei* and the order for larvae *Culiseta inornata, Aedes flavescens, Aedes fitchii, Culex tarsalis, Aedes dorsalis.* Two rather distinct populations were evident; populations arising from overwintered eggs of the genus *Aedes,* and populations arising from overwintered females of the genera *Culiseta, Culex, Anopheles* and *Mansonia.* The rationale of control in such fresh-water breeding sites is discussed.

INTRODUCTION. This study on seasonal occurrence and species composition of mosquitoes near Saskatoon, Saskatchewan was begun in 1970 because of a need for precise information for planning rational experiments on control of these pests in the field. Rempel (1950, 1953) detailed the species of larvae and adults in Saskatchewan and gave brief notes on their biology and distribution. McLintock and Rempel (1963) reported on the relative abundance of mosquitoes caught in light traps at five locations in southern Saskatchewan during 1962. They began trapping between June 26 and August 1 and ceased trapping September 16. McLintock *et al.* (1966) gave similar information for the period June 1 to September 30, 1963. These excellent reports, however, gave few data on the relative abundance of the species at the extremes of the season and the comparative abundance of the larvae.

The objectives of this study were to determine the species composition and seasonal occurrence of mosquitoes at a fresh-water breeding site near Saskatoon, Saskatchewan based on samples of larvae and light trap collections of adults taken each year from the first occurrence of larvae in spring to the final disappearance of adults in the fall. The study was designed to be intensive rather than extensive. Physical limitations of time and space precluded parallel studies in other ecological areas of the province of Saskatchewan.

METHODS. The samping site was located near Saskatoon, Saskatchewan at 52°03′N; 106°30′W. It consisted of a permanent natural pond, circular in form, comprising 2.56 acres with a grassy flood plain of .5 acre which was contiguous with the SE quadrant of the pond and became flooded when the pond level was raised by spring run-off or heavy downpours of rain during summer. The pond had steep banks and the main pond body was not suitable for mosquito production except at the outflow where there was a gradual sloping area 6 ft by 3 ft. The flood plain was the main mosquito breeding area at the site. The pond was open and unshaded except for two small clumps of willows, *Salix planifolia* Pursch. and *Salix rigida* Muhl. on the banks. The flood plain dominants were tall manna grass, *Glyceria grandis* S. Watts and awned sedge, *Carex atherodes* Spreng. The associated species were cattails, *Typha latifolia* L.; basket willow, *Salix petiolaris* Smith; northern reed grass, *Calamagrostis inexspansa* A. Gray; *Scirpus acutus* Muhl.

[1] Contribution No. 514 of the Research Station.

and *Juncus balticus* var. *montanus* Englm. The site was situated in a broad, shallow valley with many similar permanent ponds, temporary ponds and low areas that received snow-melt water and rain from heavy downpours. The closest pond was 600 yd. distant but a roadside ditch that became flooded in spring and during heavy rain was within 10 yd. of the margin of the flood plain. The area was located in the transition zone between open prairie and parkland (Mitchell *et al.* 1944).

Adult mosquitoes were taken in modified CDC light traps which were operated nightly from May 7 to November 9, 1970, from May 8 to October 29, 1971 and from April 26 to October 30, 1972. Two traps were employed in 1970 and five traps in 1971 and 1972. The traps were located within 10 yd. of the periphery of the pond and associated flood plain. In 1970 one trap was located on the east side and one on the west side. In 1971 and 1972 one additional trap was located on the north side, one on the south and an additional trap on the west side. The traps were placed at the same spot each year. Each modified trap (Stewart 1970) was equipped with a killing jar to prevent escape of captured specimens and with a photoelectric switch to assure uniformity in the time of day that traps became operational. The traps were cleared daily at the start and end of the season and thrice weekly in the interim. The mosquitoes were identified by the author and Mr. D. Noga using the keys of Carpenter and La Casse (1955). The few specimens for which identifications were not certain were referred to Dr. J. J. R. McLintock of our Station for confirmation.

Larvae were sampled with a 1 litre aluminum dipper 13.25 cm inside diameter over the same seasonal schedule as for adults. Ten dips were taken at each sampling date, the larvae concentrated with a larval concentrator (Husbands 1969), returned to the laboratory and the species and instar determined. Representative samples of larvae were reared to fourth instar or to adults to aid in species determinations which were done with the keys of Carpenter and La Casse (1955).

Daily records were kept of rainfall, air and water temperatures, water levels, humidity and wind velocity and direction.

Results. Table 1 shows that a total of 20 species of adults were taken in the light traps over the 3-year trapping period. In 1970, using only two light traps, 16 species were taken and in 1971 and 1972, using five light traps, 15 and 13 species were taken respectively. A total of 15 species of larvae were taken in the dipping samples during the 3 years, 10 species in 1970, 11 species in 1971, 8 species in 1972.

The totals of adults (males plus females) trapped during the 3 years are shown in descending order of abundance in the column "Total adults" of the table. Those species that constituted 1 percent or more of the total number of adults trapped in the 3 years were considered pests and those of less than 1 percent as incidental. In all of the 3 years of trapping seven species occurred at pestiferous levels, *C. inornata, A. vexans, A. campestris, A. flavescens, A. dorsalis, C. tarsalis* and *A. fitchii.* In addition, *A. riparius, C. morsitans* and *A. earlei* exceeded the 1 percent of population level in 1970 as did *A. spencerii* in 1971 and *A. earlei* in 1972. Each year the pestiferous species accounted for 98 percent of the total mosquitoes trapped. The ratio of number of pestiferous species to total number of species trapped each year was as follows: 10 to 16 in 1970, 8 to 15 in 1971, 9 to 13 in 1972.

C. inornata was the most abundant species trapped each year and for the total of 3 years. *A. vexans* adults ranked second in the total collections and in 1971, but fifth in 1970 and eighth in 1972. The large catch in 1971 resulted from heavy rainfall (3.62 in.) during the last week of July with a subsequent emergence in August; 1329 specimens of *A. vexans* were trapped in the period August 6 to 20. *A. spencerii* numbers were high also in 1971 because of August 6–20 emergence; 514 of the 572 specimens trapped were taken

TABLE 1.—Species composition of mosquito adults and larvae near Saskatoon, Saskatchewan, 1970–1972.

Species	1970				1971				1972				Total Adults		Total Larvae	
	Adults		Larvae		Adults		Larvae		Adults		Larvae					
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Culiseta inornata	573	57.3	16,488	80.6	4,396	45.7	17,403	76.7	583	42.0	828	33.2	5,552	46.2	34,719	76.0
Aedes vexans	34	3.4	0	<1	1,906	19.8	100	<1	25	1.8	0	<1	1,965	16.4	100	<1
Aedes campestris	99	9.9	0	....	789	8.2	180	....	241	17.4	0	....	1,129	9.4	180	....
Aedes flavescens	126	12.6	2,979	14.6	697	7.2	2,492	11.0	209	15.0	680	27.2	1,032	8.6	6,151	13.5
Aedes dorsalis	23	2.3	0	<1	650	6.8	312	1.4	115	8.3	134	5.4	788	6.6	446	1.0
Aedes spencerii	8	<1	5	....	572	5.9	2	<1	4	<1	7	<1	584	4.9	14	<1
Culex tarsalis	27	2.7	10	....	382	4.0	812	3.6	74	5.3	0	....	483	4.0	822	1.8
Aedes fitchii	54	5.4	777	3.8	92	1.0	768	3.4	76	5.5	798	32.0	222	1.8	2,343	5.1
Anopheles earlei	20	2.0	0	<1	86	<1	0	<1	39	2.8	0	<1	145	1.2	0	<1
Aedes cataphylla	5	<1	43	....	32	....	107	....	14	1.0	11	....	51	<1	161	....
Culiseta morsitans	16	1.6	0	....	6	....	0	....	3	<1	35	1.4	25	....	35	....
Aedes riparius	11	1.1	130	....	7	....	0	....	0	....	0	<1	18	....	130	....
Culiseta minnesotae	1	<1	0	....	6	....	0	....	0	....	0	....	7	....	0	....
Aedes excrucians	0	....	0	....	0	....	172	....	3	....	2	....	3	....	174	....
Aedes punctor	0	....	10	....	2	....	0	....	0	....	0	....	2	....	10	....
Culex restuans	0	....	0	....	0	....	355	1.6	1	....	0	....	1	....	355	....
Culex territans	0	....	0	....	1	....	0	<1	0	....	0	....	1	....	0	....
Aedes implicatus	1	....	10	....	0	....	0	....	0	....	0	....	1	....	10	....
Aedes intrudens	1	....	0	....	0	....	0	....	0	....	0	....	1	....	0	....
Mansonia perturbans	1	....	0	....	0	....	0	....	0	....	0	....	1	....	0	....
Aedes stimulans	0	....	3	....	0	....	0	....	0	....	0	....	0	....	3	....
Totals	1,000		20,455		9,624		22,703		1,387		2,495		12,011		45,653	

then. Lacking the unusual rainfall *A. vexans* would have ranked fifth in abundance and *A. spencerii* would not have ranked as a pest. *A. campestris* ranked third or higher in abundance each year and in total abundance. The remainder of the pestiferous species attain their rank largely because of the preponderance of the 1971 collections which were almost four times greater than those of 1970 and 1972 combined.

The totals of larvae taken during the 3 years are shown in the last column of Table 1. The larvae of five species only exceeded the 1 percent level of total abundance over the whole 3-year period. In order of abundance the species were *C. inornata, A. flavescens, A. fitchii, C. tarsalis* and *A. dorsalis*. In all years *C. inornata, A. flavescens* and *A. fitchii* occurred at pestiferous levels. Only these three species were taken at pestiferous levels in 1970; in addition *C. tarsalis, A. dorsalis* and *C. restuans* exceeded the 1 percent level of abundance in 1971 as did *A. dorsalis* and *C. morsitans* in 1972. The ratio of number of pestiferous species to total number of species collected each year was 3 to 10 in 1970, 6 to 11 in 1971 and 5 to 8 in 1972. Each year the pestiferous species accounted for at least 98 percent of the total larvae collected.

The seasonal patterns of abundance of larvae and adults of the pestiferous species were determined from the weekly collections. The pestiferous species were divided into two groups: *populations* arising from *overwintered females*, (POF) and *populations* arising from *overwintered eggs*, (POE). The POF group included *C. inornata, C. tarsalis, C. morsitans, C. restuans* and *A. earlei*. The POE group included *A. vexans, A. campestris, A. flavescens, A. dorsalis, A. spencerii, A. fitchii, A. riparius* and *A. cataphylla*. The number of specimens in the weekly samples of larvae and adults in each group were plotted as log (n+1) and the yearly results appear in Figures 1, 2, 3. The weekly mean air temperature °F and weekly precipitation are included also in these figures. Figure 4 illustrates the 3-year totals of the population data and includes all specimens of each pestiferous species.

The 1970 (Fig. 1) adult POF consisted of *C. inornata, C. tarsalis, A. earlei, A. morsitans* and larval POF was *C. inornata* only. The adult POE consisted of *A. flavescens, A. campestris, A. fitchii, A. vexans, A. dorsalis, A. riparius* and the larval POE of *A. flavescens* and *A. fitchii*. The 1971 (Fig. 2) adult POF was *C. inornata* and *C. tarsalis* and the larval POF was *C. inornata, C. tarsalis* and *C. restuans*. The adult POE was *A. vexans, A. campestris, A. flavescens, A. dorsalis, A. spencerii, A. fitchii* and the larval POE was *A. flavescens, A. fitchii* and *A. dorsalis*. The 1972 (Fig. 3) adult POF was *C. inornata, C. tarsalis, A. earlei* and the larval POF was *C. inornata* and *C. morsitans*. The adult POE was *A. campestris, A. flavescens, A. dorsalis, A. fitchii, A. vexans, A. cataphylla* and the larval POE was *A. flavescens, A. fitchii* and *A. dorsalis*.

Figures 1, 2 and 3 show that the larval POE maintained similar characteristics each year; hatching at the site began during the 15th or 16th week, larval development was complete by the 22nd to 23rd week and maximal larval density occurred during the 17th to 19th week. However, in 1971 there was a second larval brood during the 30th to 31st week. This resulted from heavy rains during the 30th week which inundated the flood plain that had been dry for the preceding 3 weeks and caused a second hatch of *A. dorsalis* and *A. flavescens*. The adult POE shows similar characteristics for each of the 3 years. Adult emergence began 2 to 3 weeks after maximal larval density was reached. The adults reached maximal density within 2 to 3 weeks and then gradually decreased in numbers until the 35th to 38th week when mean weekly temperatures dropped to about 45° F. The anomalous situation in 1971 (Fig. 2) resulted from the disproportionately large numbers of *A. vexans* and *A. spencerii* following the heavy rains of the 30th week. Figure 4, which shows the summation of the 3 years sampling, probably gives a good indication of the seasonal occurrence of the POE which would normally be encountered at this sampling site.

Figures 1–3 show that appearance of the larval POF began in the 21st or 22nd week each year and excepting 1972 was present for 2 to 3 weeks after the flood plain dried (arrows on abscissae). The larvae were maintained for the additional 2 to 3 weeks in the sloping area of the outflow of the pond. In 1972 the drop in water level was so rapid, because of low rainfall, that there was no suitable habitat in the outflow. Also in 1971 the flood plain dried during weeks 27 to 29 and larval populations were minimal. A peak in larval density followed by a decline was reached 3 weeks after hatching began in 1970, 1971 and 1972; in 1971 a second peak occurred following heavy rains in the 30th week. In each year larval abundance of POF exceeded that of POE in maximum density and the totals of the 3 years (Fig. 4) exceeded in both density and duration. Overwintered females which gave rise to POF were collected in the traps 1 to 3 weeks before larvae occurred in the flood plains and when mean air temperatures were 45° F or above. The POF consisted of 85 percent or more *C. inornata* each year so that species largely set the trend in the graphs for that group. Maximum density of POF adults occurred when mean air temperatures were at the

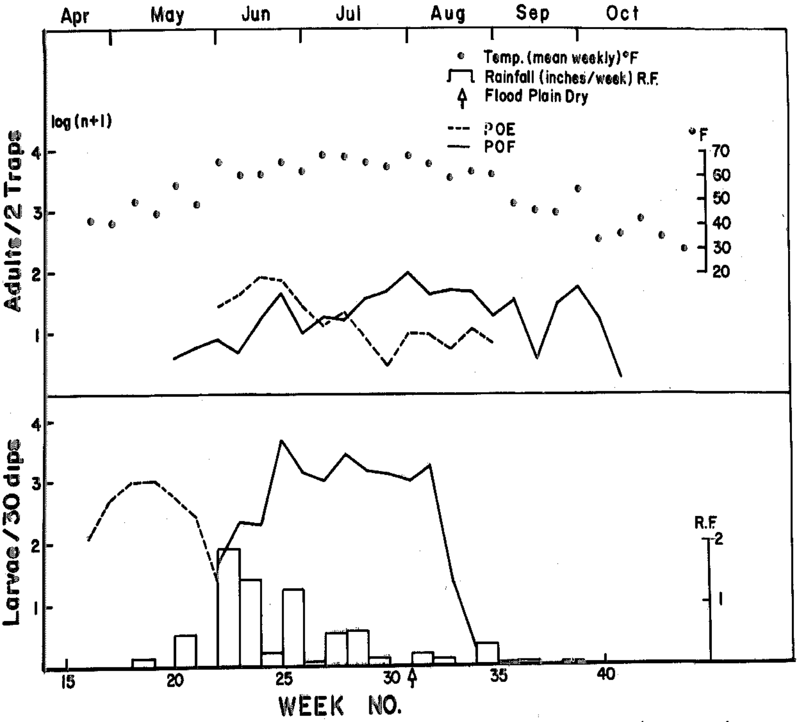

FIG. 1.—Seasonal pattern of abundance of mosquito larvae and adults near Saskatoon, Sask., 1970. POE—populations arising from overwintered eggs. POF—populations arising from overwintered females. Week No. 15—2nd week of April.

upper limits (60 to 70° F) each year; the heavy rains in the 30th week of 1971 enhanced greatest production of adults arising from greater larval populations. Adults of the POF were trapped from the 19th or 20th week until the 41st to 43rd week at which time freezing temperatures or snowfall inactivated them.

DISCUSSION. There was little quantitative agreement between the results from the light trap samples of adult populations and dipping samples of larval populations except that popuation peaks for larvae were associated with later population peaks for adults. The species taken in the adult and larval samples showed slight qualitative agreement also except for *C. inornata* and *A. flavescens*. *A. vexans* and *A. campestris*, which ranked second and third respectively as adults, were taken as larvae in only 1 year out of the 3 (1971) and then in incidental numbers. *A. earlei* was taken each year in the light traps but no larvae were found. This indicates that the breeding area was not optimal for these species, that those adults caught came from other locations, and that had we relied on larval sampling only we would have had a poor indication of the species present in the general area. On the other hand, this may indicate that the latter three species are readily attracted to light traps and are probably represented in the samples at a level of abundance higher than warranted.

The results from samples of adults and larvae show that there were two rather well-defined populations at the site studied. The population arising from overwintered eggs is the one that would be most easily

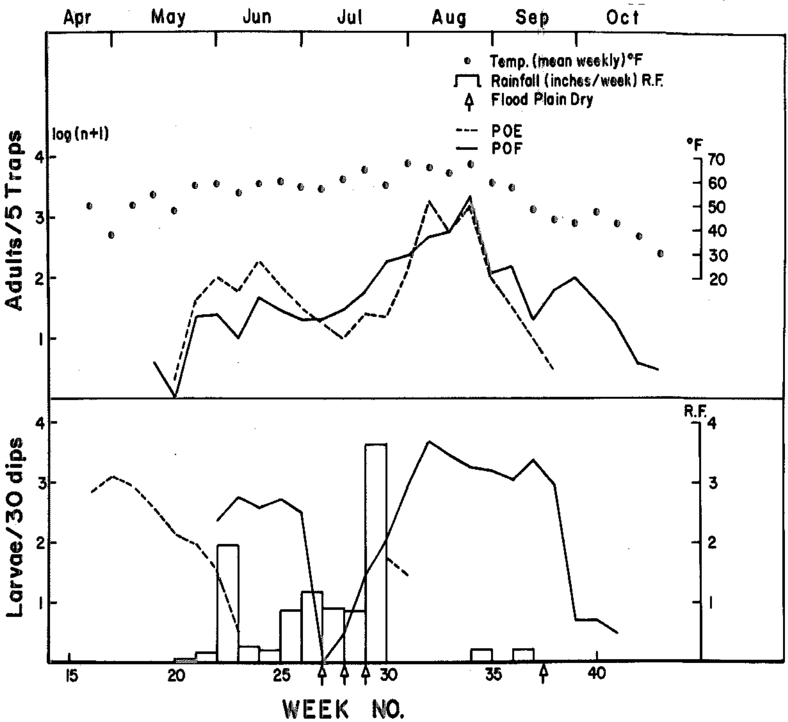

FIG. 2.—Seasonal pattern of abundance of mosquito larvae and adults near Saskatoon, Sask., 1971. POE—populations arising from overwintered eggs. POF—populations arising from overwintered females. Week No. 15—2nd week of April.

controlled by conventional methods of larviciding or pupiciding. For larviciding POE species the equipment should be readied by week 15 (second week of April) and the first application made before the population peaks in week 17 or 18. The first pupicidal application should be made not later than week 20. Successful control of the early larval population by either method could conceivably eliminate the mosquitoes of the POE group in all years except those with extremely heavy rainstorms as in 1971. Under conditions similar to 1971 a second treatment would be required about week 30 (within 7 days after reflooding).

Control of the POF group is complicated because of the multivoltine habits of the species in this group. Egg laying begins about the end of the larval period of the POE group and continues until late in the season when moisture conditions are favorable, so the larvae could not be killed with the same insecticidal treatment employed for the POE. Larvicidal control of the POF could be attained only by repeated applications to the flood plain at the site at regular intervals. Under similar conditions in urban areas this procedure may be acceptable providing insecticides are used that have no deleterious side-effects but in rural areas with sparse setttlement the excessive costs would be difficult for the residents to bear.

Larviciding or pupiciding is the method of control to be preferred but adulticiding may be required where larval control was omitted or was ineffective. Adulticiding

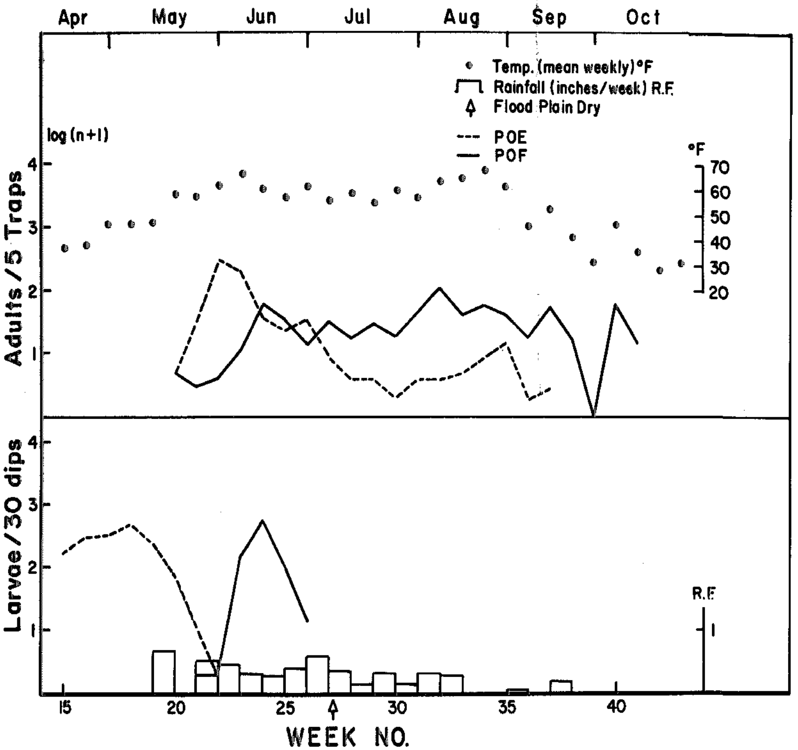

FIG. 3.—Seasonal pattern of abundance of mosquito larvae and adults near Saskatoon, Sask., 1972. POE—populations arising from overwintered eggs. POF—populations arising from overwintered females. Week No. 15—2nd week of April.

would be of doubtful practicability except as an emergency measure to prevent or control epidemics of arboviruses or for short-term relief of mosquito nuisance at outdoor activities. Adult control is difficult because the mosquitoes have to be struck with the insecticide so applications would have to be repeated each time a new brood of adults emerged. The mobility of the mosquitoes, as shown by the light trap collections, requires area control and the size of the area depends upon the distance that adults disperse from the breeding source. Shemanchuk *et al.* (1955) showed dispersion of 6.6 miles from the point of emergence so an area at least 13 miles in diameter would have to be treated to control the adults from a single breeding source.

Thus, in rationalizing a control program it would seem advisable to sample the adult populations with light traps to determine the species present in the general area, sample all larval habitats that are suitable for production of these species to determine the particular breeding areas and apply larvicides or pupicides to control the larvae in these breeding sources. Adulticiding would be useful only in an emergency or for short-term relief from mosquito nuisance.

Literature Cited

Carpenter, S. J. and W. J. La Casse. 1955. The mosquitoes of North America (North of Mex-

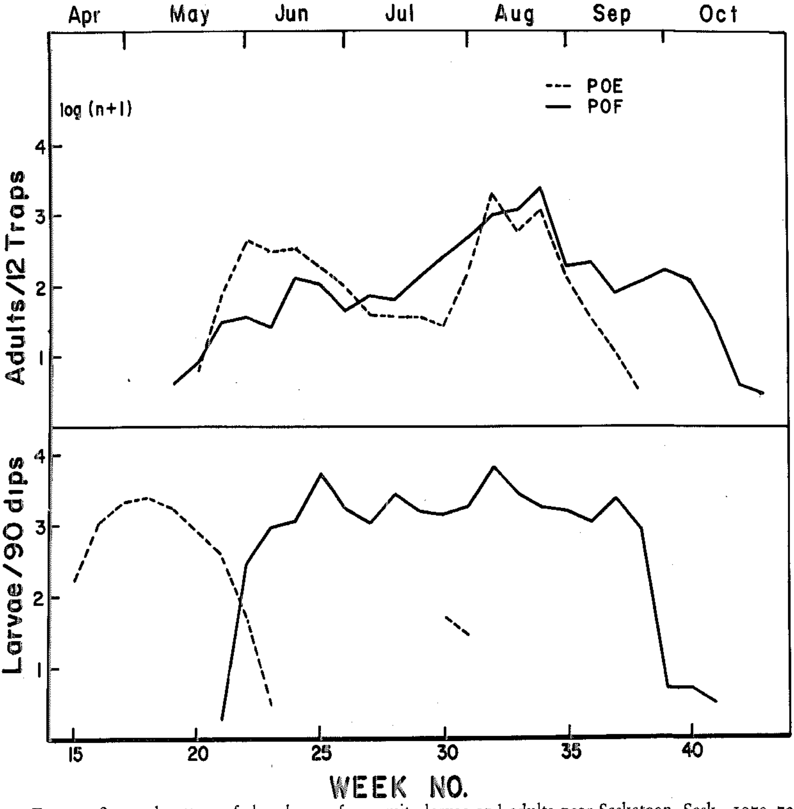

FIG. 4.—Seasonal pattern of abundance of mosquito larvae and adults near Saskatoon, Sask., 1970–72. POE—populations arising from overwintered eggs. POF—populations arising from overwintered females. Week No. 15—2nd week of April.

ico). University of California Press, Berkeley. 360 pp.
Husbands, R. C. 1969. An improved technique of collecting mosquito larvae for control operations. Calif. Vector Views 16:67–69, 72.
McLintock, J. and J. G. Rempel. 1963. Midsummer mosquito abundance in Southern Saskatchewan. 1963. Mosq. News 23(3):242–249.
McLintock, J., A. N. Burton, H. Dillenberg and J. G. Rempel. 1966. Ecological factors in the 1963 outbreaks of western encephalitis in Saskatchewan. Can. J. Public Health 57:561–575.
Mitchell, J., H. C. Moss and J. S. Clayton. 1944. Soil survey of Southern Saskatchewan. Soil Survey Rept. No. 12, Univ. of Saskatchewan, Sask.
Rempel, J. G. 1950. A guide to the mosquito larvae of Western Canada. Canadian J. of Res., D, 28:207–248.
Rempel, J. G. 1953. The mosquitoes of Saskatchewan. Canad. J. Zool. 31:433–509.
Shemanchuk, J. A., F. J. H. Fredeen and A. M. Kristjanson. 1955. Studies on flight range and dispersal habits of *Aedes flavescens* (Müller) (Diptera: Culcidae) tagged with radio-phosphorus. Canad. Ent. 87:376–379.
Stewart, W. W. A. 1970. A modified CDC light trap. Mosq. News 30(2):188–191.

MOSQUITO ACTIVITY IN TEXAS DURING THE 1971 OUTBREAK OF VENEZUELAN EQUINE ENCEPHALITIS (VEE). I. VECTOR POTENTIAL FOR VEE IN THE TEXAS RICE BELT REGION[1]

J. K. OLSON AND W. H. NEWTON[2]

Department of Entomology, Texas A&M University, College Station, Texas 77843

INTRODUCTION. The VEE Control Task Force, organized to suppress the outbreak of Venezuelan equine encephalitis (VEE) in Texas during 1971, involved personnel and expertise from a wide variety of governmental and scientific disciplines (Spears, 1972). The Department of Entomology at Texas A&M University contributed to the control effort by providing the VEE Vector Control Staff with current information on the relative size and species composition of adult mosquito populations in the regions of Texas most seriously affected by the epidemic. This information was obtained by means of an adult mosquito surveillance program initiated in May, 1971. Our surveillance program was designed to complement similar activities of other agencies concerned with the study and control of the 1971 VEE outbreak and eventually included 38 Texas counties.

One phase of the Texas A&M mosquito survey program was devoted to the assessment of adult mosquito activity in the Texas rice belt (Fig. 1) and extended from 22 July to 4 August 1971. Most of the land upon which rice is grown is in the northern half of a vegetational area of Texas designated by Gould (1969) as the "Gulf Prairies and Marshes Area." As Gould's designation implies, this area is quite level and drainage is relatively slow; thus, there are numerous habitats, in addition to those occurring in the ricelands proper, which have the potential for supporting large mosquito populations. At least 50 species of mosquitoes are known to occur in this region of the state (Hill *et al.*, 1958); and by the time that we began our survey of the rice belt, ten of these species had already been incriminated as being involved in the 1971 VEE outbreak in northern Mexico and in the lower Rio Grande Valley of Texas

[1] This research was conducted in cooperation with the Agricultural Research Service, U. S. Department of Agriculture and approved for publication as TA 10532 by the Director, Texas Agricultural Experiment Station.

[2] Assistant Professor and Extension Entomologist, respectively.