MOSQUITO TRANSMISSION OF ARBOVIRUSES AT THE MEXICAN BORDER IN IMPERIAL VALLEY, CALIFORNIA 1972

DAVID BOWN [1] AND TELFORD H. WORK [2]

INTRODUCTION. This study was initiated in conjunction with the United States Department of Agriculture effort of 1972 to detect appearance of Venezuelan equine encephalitis (VEE) virus in the United States. The study site at the Alamo River crossing and the U.S.-Mexican border in Imperial County was selected because of its pertinent ecology and geographical location, contiguous with irrigated areas of Baja California and Sonora in Mexico.

The Alamo River is diverted from the Colorado River south of Algodones, Mexico, flowing west and eventually northward, crossing the U.S.-Mexico border 7.5 miles east of Mexicali. The Alamo receives most of its water as a result of excess irrigation run-off from an extensive Imperial County agriculture community (de Stanley, 1966).

Since 1967, several long-term studies have been undertaken in the Imperial Valley. These studies have been concerned with the ecological and seasonal distribution of mosquitoes, how mosquitoes may be involved in arbovirus transmission and what role vertebrates may play in this transmission (Knudsen, Work and Vanis, to be published).

Culex tarsalis, the notorious vector of WEE and SLE, is present and active during all months of the year (Chew and Gunstream, 1970). Since 1948, numerous cases of encephalitis in both humans and horses have been recorded in Imperial County (Magy, 1955). More than three hundred arboviruses have been isolated from mosquitoes in the Imperial Valley in separate studies conducted by the University of California and the State Department of Public Health.

In August 1971, monthly mosquito collections were initiated along a 1.4 mile length of the Alamo River between the Mexico border and Highway 98 in Imperial County, California. The objectives were to determine: (1) the mosquito species present (2) whether those mosquitoes were involved in the transmission of VEE or other arboviruses (3) what environmental factors may be involved in mosquito seasonality and relative abundance. The U.S. Department of Agriculture Emergency Programs Surveillance supported more frequent periodic collections which were carried out from January through December 1972. Mosquitoes collected were all identified, pooled and inoculated for virus isolation to detect any appearance of VEE virus.

Trap sites were selected as close as 10 feet from the edge of the river (site 1) to 90 feet (site 8). *Pluchea* (arrow weed), an abundant brush in Imperial Valley, grows at a higher elevation away from rivers. *Phragmites, Tamarix* and cattails are found in scattered clumps intermixed with *Distichlis* (saltgrass) along the river's edge.

MATERIALS AND METHODS. Mosquito collections were made monthly or biweekly using the standard CDC miniature light trap as described by Sudia (1967). Each trap was supplemented with a 2- to 3-pound block of dry ice contained in a paper bag placed 1 to 2 feet above the trap. Traps were started before sunset. Mosquito bags were collected after sunrise. The number of nights trapped varied from 3 to 7 with four to eight traps functioning per night.

---

[1] World Health Organization, Anopheles Control Research Unit, P.O. Boy 503, Kaduna, Nigeria.

[2] Professor of Infectious and Tropical Diseases, Center for the Health Sciences, University of California, Los Angeles, California 90024.

This research was supported partially by U.S. Pub. Hlth. Service Research Training Grant AI-132-12, and U.S. Dept. of Agr. VEE Cooperative Agreement 12-16-100-108.

TABLE 1.—Total number of mosquitoes collected and pools inoculated from Alamo River 1972.

	Jan.–Feb. 27–3	Feb. 13–19	March 13–19	April 18–24	May 9–15	June 8–12	July 17–19	July 29–31	Aug. 29–31	Sept. 13–15	Sept. 28–30	Nov. 1–3	Dec. 1–3	Dec. 28–31	Total
	..	*9	304	4379	11714	7746	961	690	722	1835	1556	47	285	14	30262
C. tarsalis	..	**1	20	93	249	167	20	15	18	42	37	3	9	2	677
	..	..	1	8	92	332	8	3	..	..	..	..	2	..	446
C. erythro.	..	..	1	2	16	12	1	1	..	..	..	..	1	..	34
	..	..	..	154	7250	19160	458	24	89	142	552	801	1225	..	29855
C. pip. quinq.	..	..	..	5	160	397	10	2	4	5	18	19	25	..	645
	..	..	1	55	345	..	..	..	11	..	..	..	..	..	412
Culex sp.	..	..	1	2	11	..	..	..	1	..	..	..	..	..	15
	7	45	32	11	60	36	..	..	..	..	3	30	31	16	271
C. inornata	1	3	5	2	15	7	..	..	..	..	1	2	2	2	40
	..	1	101	82	436	298	236	13	6	1	16	27	11	2	1230
A. dorsalis	..	1	6	2	20	10	5	1	2	1	2	2	1	1	54
	..	..	24	18	76	142	..	..	139	54	61	5	2	..	521
A. vexans	..	..	2	2	14	7	..	..	6	3	3	1	1	..	39
	..	..	..	..	..	..	21	..	..	..	3	..	..	..	24
A. nigro.	..	..	..	..	..	..	2	..	..	..	1	..	..	..	3
	..	..	..	..	..	..	91	44	..	..	..	..	..	..	135
Aedes sp.	..	..	..	..	..	..	4	2	..	..	..	..	..	..	6
	..	..	2	..	..	..	..	..	..	..	..	..	..	..	2
A. franciscanus	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1
	..	..	1	2	..	275	560	911	15997	1736	436	..	..	..	19918
P. confinnis	..	..	1	2	..	13	11	19	319	38	17	..	..	..	420
	7	55	466	4709	19973	27989	2335	1685	16964	3768	2627	910	1556	32	83076
Totals	1	5	37	110	485	613	54	40	350	88	79	27	39	5	1934
Trap Nights	25	51	52	51	52	38	19	12	19	16	21	18	13	18	405

* No. collected. ** No. pools.

Mosquitoes per trap night were computed by dividing the total number of mosquitoes collected at each site by the total number of traps that operated there without trap failure.

A truck trap 6 feet in length and 2′ x 6′ at the open end (Bidlingmayer, 1966 and Shimizu *et al.*, 1969) was used during most of the collection trips. Each truck run was made through the Alamo River collection area 15 minutes before dusk and 30 minutes after dusk at a speed of 2) or more miles per hour.

Mosquitoes collected with the truck trap and the CDC light traps were killed with dry ice, transferred to plastic containers and held on dry ice until returned to the laboratory.

There, mosquitoes were identified to species and pooled according to number collected and trap site. Pool size was standardized at 25 for *C. inornata* and 50 for all other species. Virus isolations were attempted in 2- to 4-day old suckling mice and in tissue culture using baby hamster kidney (BHK) cells. Isolations were identified with the hemagglutination inhibition (HI) microtiter techniques described by Clarke and Casals (1958).

RESULTS

In the calendar year of 1972, 83,076 mosquitoes were collected. Table 1 summarizes the catches by seasonal period and shows the numbers of pools into which they were sorted for inoculation for virus isolation. The influence of temperature and humidity parallels that determined in the previous more detailed studies elsewhere in Imperial Valley (Knudsen, *et al.*, to be published).

The mean temperatures and relative humidity for the collecting periods designated in Table 1 are shown in Table 2. A seasonal biphasic maximum in the *Culex tarsalis* population is noted for late spring and early fall, with a marked depression in mid-summer apparently due to excessive heat. Table 3 shows the relative numbers of mosquitoes collected according to species. It should also be noted that *Culex tarsalis* was collected in every period, indicating that it was active throughout the year. On the other hand, *Culiseta inornata* was recovered only in the cooler months of the year.

Yield from the truck trap is shown in Table 4 only to indicate that this method of collecting was relatively ineffective in this particular habitat at the time periods used.

Table 5 summarizes the isolations of western equine encephalitis (WEE), St. Louis encephalitis (SLE), and Turlock (TUR) viruses from mosquitoes collected from the eight established sites along the Alamo River within one mile of its entry into the Imperial Valley from Mexico through tunnels beneath the

TABLE 2.—Mean monthly temperature and relative humidity Alamo River 1972.

	Temp.	R. humidity
Jan.–Feb.	51.7	29%
Feb.	63.4	27%
March	74.0	26%
April	68.4	20%
May	80.9	15%
June	79.0	69%
July	91.8	30%
July	99.0	26%
Aug.	88.0	23%
Sept.	83.3	21%
Sept.	83.3	20%
Nov.	60.6	28%
Dec.	58.0	49%
Dec.	51.0	26%

TABLE 3.—Mosquitoes collected Alamo River 1972.

	No. coll.	% of total
C. tarsalis	30,262	36
C. pipiens q.	29,855	35
P. confinnis	19,918	23
A. dorsalis	1,230	1
A. vexans	521	.6
C. erythro.	446	.5
Culex sp.	412	.5
C. inornata	271	.3
Aedes sp.	135	.2
A. nigro.	24	.01
A. franciscanus	2	.002
Total	83,076	

TABLE 4.—Truck trap mosquito collections, Alamo River 1972.

	May **	June	July	Aug.	Nov.
C. tarsalis	42	4	0	8	9
C. erythro.	1	0	0	0	0
C. pip. quinq.	4	18	0	4	1
Culex sp.	4	0	0	0	32
C. inornata	0	0	0	0	2
A. dorsalis	9	0	2	8	13
A. vexans	1	0	0	16	2
P. confinnis	0	0	2	12	0

* No mosquitoes collected in truck trap in April or Sept.
** May represents an average for 3 nights.

All American Canal which parallels the International Boundary. With the exception of one SLE strain from a pool of *Aedes* species, all isolations were from *Culex pipiens quinquefasciatus* and *C. tarsalis* mosquitoes. While only one WEE virus was isolated from *C. p. quinquefasciatus* it is notable that 4 of the 29 strains of SLE virus came from rural catches of this species, which has been implicated in other areas as the vector in urban outbreaks of St. Louis encephalitis. No virus isolations were made from mosquitoes collected in the truck trap.

The arbovirus isolations tabulated here are comparable to those made elsewhere in the Imperial Valley between June and September in 1972, and in previous years, confirming that mosquito transmission of WEE, SLE and Turlock viruses is an annual occurrence.

These results also establish the sensitivity of mosquito virus isolations as a detector of arbovirus transmission in an area subject to surveillance. Lack of Venezuelan equine encephalitis virus isolations complements other evidence that this virus was not active in this geographical area in 1972.

SUMMARY. Monthly mosquito collections throughout 1972 in search of Venezuelan equine encephalitis (VEE) virus at the U.S.-Mexico border of Imperial Valley yielded 83,076 mosquitoes from 405 trap nights. Most numerous were *Culex tarsalis* (36 percent), *C. pipiens quinquefasciatus* (35 percent) and *Psorophora confinnis* (23 percent).

All mosquitoes were inoculated in 1934 pools for isolation of arboviruses. Viruses were recovered from early May to late September. There were 9 isolations of western equine encephalitis (WEE) virus, 29 of St. Louis encephalitis virus and 3 of Turlock. WEE virus appeared in June

TABLE 5.—1972 arbovirus isolations from mosquitoes collected at the California-Mexico border entry of the Alamo River into Imperial Valley.

Collection period	Mosquito species	Number collected	Number of pools	Isolations of			
				WEE	SLE	TUR	Total
May 8–15	*C. tarsalis*	11,714	249	0	0	1	1
	C. pipiens q.	7,250	160	0	0	0	0
June 7–12	*C. tarsalis*	7,746	167	1	5	2	8
	C. pipiens q.	19,160	397	1	2	0	3
July 16–19	*C. tarsalis*	961	20	2	13	0	15
	C. pipiens q.	458	10	0	2	0	2
July 28–31	*C. tarsalis*	690	15	5	5	0	10
	C. pipiens q.	24	2	0	0	0	0
	Aedes sp.	44	2	0	1	0	1
August 28–31	*C. tarsalis*	722	18	0	0	0	0
	C. pipiens q.	89	4	0	0	0	0
September 12–15	*C. tarsalis*	1,835	42	0	0	0	0
	C. pipiens	142	5	0	0	0	0
September 27–30	*C. tarsalis*	1,556	37	0	1	0	1
	C. pipiens q.	552	18	0	0	0	0
Total		52,943	1,146	9	29	3	41

and July while SLE virus appeared early in June to late September. There was no evidence of Venezuelan equine encephalitis virus activity in the border region of Southern California in 1972.

References

Bidlingmayer, W. L. 1966. The use of the truck trap for evaluating adult mosquito populations. Mosq. News 26 (2):139–143.
Bidlingmayer, W. L. 1967. A comparison of trapping methods for adult mosquitoes: species response and environmental influence. J. Med. Ent. 4 (2):200–220.
Chew, R. M. and Gunstream, S. E. 1970. Geographical and seasonal distribution of mosquito species in Southern California. Mosq. News 30 (4):551–562.
Clark, D. H. and J. Casals, 1958. Techniques for hemagglutination and hemagglutination inhibition with arthropodborne viruses. J. Trop. Med. & Hyg. 1 (5):561–573.
Knudsen, A. Bruce, Work, T. H. and Vanis, R. 1971. An analysis of mosquito collections made in a four year (1967–1971) period in the Imperial Valley, California. Presented An. Mtg. Ent. Soc. Am. Nov. 29–Dec. 2, 1971, Los Angeles, California.
Magy, H. I. 1955. A mosquito survey of Imperial Valley, Imperial County. December 1953–January 1955. St. Calif., Dept. Public Hlth., Bureau Vector Control. June 9, 1955 m-41 (mimeographed) 9 p.
Nelson, M. J. 1971. Mosquito studies (Diptera, Culicidae) xxvi, Winter biology of *Culex tarsalis* in Imperial Valley, California. Contributions Am. Ent. Inst. 7(6) 56 p.
de Stanley, M. 1966. The Salton Sea: yesterday and today Los Angeles. Triumph Press. 128 p.
Shimizu, Yasugoshi, M. Takahashi and S. Yabe, 1969. Use of the truck traps for the survey of mosquito population and the physiological age composition. Medical Zoology 20 (2).
Sudia, W. D. and Chamberlain, R. W. 1967. Collection and processing of medically important arthropods. U.S. Dept. H.E.W., P.H.S., C.D.C. Atlanta, Ga. 29 pp.

DOES ARIZONA NEED A MOSQUITO ABATEMENT PROGRAM?

JOHN L. McDONALD [1, 2]

When most of us think of Arizona, almost a common picture comes to mind. We visualize an arid land of mountains, plains, canyons and valleys. We visualize sand, clumps of grasses and cacti. What we never visualize is water.

If there is no water, then there can be no mosquitoes. A recent study by McDonald *et al.* (1973) revealed that there are at least 43 species of mosquitoes in Arizona. If there are mosquitoes, there must be standing water. Where is this water and where does it come from? Much of the water originally found or naturally occurring was found along the rivers. Naturally, the river areas became centers of the state's population. Irrigation has become rather concentrated along such rivers as the Verde, the Gila, the Colorado, and the Santa Cruz. Similarly located along these rivers are cities such as Phoenix, Coolidge, Tucson, Yuma, Wallton, and Gila Bend.

None of us has any illusions about the fact that man is the cause of many of his own problems with respect to mosquitoes. True, the white man did not bring all of Arizona's mosquitoes to Arizona, but he has intensified the problem. As early as 1871, Camp Goodwin, Arizona had to be moved to higher ground to avoid the malaria and mosquitoes which appeared near the original site.

Population growth in Arizona has been astronomical. In 1870 the population of the entire State was only 9,658 people. Since that time, the rate of population growth in Arizona has been faster every decade than the growth of the United

[1] Lt. U.S. Navy, Graduate Student, Department of Entomology, University of Arizona, Tucson, Arizona.

[2] The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.