

ABANDONED MINES AS OVERWINTERING SITES FOR MOSQUITOES, ESPECIALLY *CULEX TARSALIS* COQ., IN NEVADA¹

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INTRODUCTION. Since *Culex tarsalis* is considered the principal vector of western encephalitis (WE) in the West, much emphasis has been placed on discovering the sites of overwintering females. Hibernation of females in loose rock at bases of volcanic outcrop and in manmade rock piles in Washington was reported by Rush *et al.* (1958). Loomis and Green (1955) reported females of this species throughout the winter in rodent burrows in the San Joaquin Valley of California, whereas Keener (1952) observed them overwintering in Nebraska in food-storage cellars. Price *et al.* (1960) reported on a 3-year survey in Minnesota of many sites, including 27 caves, and found only a few present and none after November 27. In Colorado, Blackmore and Winn (1956) found many females present in abandoned mines, but they did not clearly state whether these populations overwintered successfully. Dow *et al.* (1956) observed small numbers of *tarsalis* in two abandoned mines in northern Utah but concluded that the mines were probably not suitable as hibernation quarters.

This study was initiated since some observations in abandoned mines in the late fall and winter of 1959-60 indicated the continued presence of substantial numbers of *tarsalis* females as well as other species.

METHODS. In early November 1959, several abandoned mines were checked for mosquitoes. Nineteen additional mines were examined in December with fewer mines visited monthly through March 1960. The mines were located within approximately a 5-mile radius of historic Virginia City at elevations ranging from about 5,000 to 6,200 feet. The mines examined

were selected because of their accessibility and proximity to roads. This area (Virginia City-Silver City-Gold Hill) is undermined with innumerable tunnels, shafts, and pits. Shafts were not checked because of the danger involved in their examination. The mines varied in length from approximately 20 feet to more than a quarter of a mile in length and most of the tunnels were about 6 to 7 feet in height. Some mines contained large and small pools of water whereas others contained only seepage droplets of water on the walls and ceilings; many other mines were devoid of moisture.

Examination was done by flashlight. Periodically a sample of the mosquitoes was collected and identified in the laboratory. In 1959-60, temperature and relative humidity readings were taken with an aspirator-type psychrometer only in one month—January 1960. Generally, readings were taken in positive mines (mosquitoes present) as follows: just inside the mine entrance, in the immediate vicinity of the first *tarsalis* female, adjacent to other females, and then beyond the last ones if the mosquitoes did not occur at the end of the mine. In negative mines (no mosquitoes present), readings were taken just inside the mine entrance and at various intervals within.

In 1960-61, 16 mines were surveyed beginning in November 1960. Most were the same ones checked the year before. An additional five mines were checked in December 1960. All 21 mines were investigated monthly through February 1961, and then twice in March 1961. Temperature and relative humidity readings were taken monthly with a battery-operated psychrometer in a manner similar to that of the previous year. Searching for mosquitoes was done as in the previous year.

¹In cooperation with the Nevada Agricultural Experiment Station, Reno, Nevada.

Some light-intensity readings were also recorded near females, as well as in portions of mines not containing mosquitoes, and in negative mines.

RESULTS. As shown in Table 1, only three species of mosquitoes were observed overwintering in abandoned mines throughout the two seasons. In 1959-60, *Culex tarsalis*, *Anopheles pseudopunctipennis franciscanus* McCracken, and *A. freeborni* Aitken comprised 93, 6, and 1 percent, respectively, of the total mosquitoes observed. The numbers of *tarsalis* seen in any one mine ranged from 0 to 145. Substantial numbers of *tarsalis* females were still present in late February (102 in one mine) whereas the mine populations were greatly reduced in early March. These reductions occurred after 2 days (March 5 and 6) when the temperature in the general area rose above 50° F. The lowest outside temperatures (° F.) recorded at Virginia City by the U. S. Weather Bureau were as follows: November, 27°; December, 12°; January, 4°; February, 11°; and March, 20°.

In 1960-61, *Culex tarsalis*, *Anopheles pseudopunctipennis franciscanus*, and *A.*

freeborni comprised 88, 11, and 1 percent, respectively, of the mosquitoes present during the observation period (Table 1). The highest number of *tarsalis* recorded in any mine was 75. In general this species was less abundant and *A. pseudopunctipennis franciscanus* more abundant than in the previous year. During the same month in the two observation periods, several mines contained almost exactly the same numbers and species. A sharp drop in numbers of *tarsalis* females was noted in mid-February. For several consecutive days prior to the February sampling, the temperature exceeded 50° F. Few *tarsalis* were present in March. The coldest outside temperatures (° F.) recorded by the U. S. Weather Bureau for Virginia City were as follows: November, 20°; December, 10°; January, 17°; February, 15°; and March, 20°. During both 1959-60 and 1960-61, *tarsalis* females were observed in 112 of 178 times that all mines were visited. None of the samples of the overwintering mosquitoes were blood-engorged and all possessed fat bodies.

The temperature and relative humidity data for both seasons are given in Table 2

TABLE 1.—Mosquitoes observed in abandoned mines from November 1959 to March 1960 and November 1960 to March 1961, near Virginia City, Nevada

Date observed	Number of mines visited	Number of mines with mosquitoes	Species			Average number per mine
			<i>Culex tarsalis</i>	<i>Anopheles</i>		
				<i>pseudo-punctipennis franciscanus</i>	<i>freeborni</i>	
1959						
Nov.	2	2	37	0	5	21.0
Dec.	21	14	309	27	4	16.2
1960						
Jan.	16	10	236	22	0	16.1
Feb.	8	5	139	1	0	17.5
March	10	4	25	0	0	2.5
Nov.	16	14	270	14	2	17.9
Dec.	21	18	283	39	2	15.4
1961						
Jan.	21	17	233	36	4	13.0
Feb.	21	14	113	20	3	6.5
March 8	21	11	37	4	0	1.9
March 30	21	3	2	0	1	0.1

and show an excellent correlation between the presence of *tarsalis* females in the mines and relative humidity. Positive mines consistently possessed higher relative humidities than did negative mines. Within a positive mine, relative humidity readings were considerably higher in the immediate vicinity of *tarsalis* females than in those portions uninhabited by this species. Relative humidities in some positive mines ranged up to 100 percent. Lesser differences were observed in the temperature readings taken in positive and negative mines. Females were never noted in portions of mines with temperatures above 60° F., and were usually absent just inside the entrances where temperatures usually averaged about 48–49°. Mosquitoes were seldom noted farther than several hundred yards within the mines since in general temperatures tended to increase from the entrance toward the end of the mines.

The greatest numbers of *tarsalis* females and *Anopheles* spp. were generally observed on ceilings of abandoned mines, with relatively few along the sides. The *Anopheles* spp. were especially prone to fly at a slight disturbance; *tarsalis* females were not so easily disturbed but could be induced to fly within the mines. During winter months some females were also seen leaving the mines. Light intensities did not appear to be an important factor in

the presence or absence of *tarsalis* females nor in their particular placement.

DISCUSSION. Conditions for true hibernation as proposed by Blackmore and Winn (1956), that is, accumulation of fat body, absence of feeding and males, outside temperatures prohibitive for survival, and quiescence, were generally present for *tarsalis* populations in the abandoned mines. As mentioned previously, some *tarsalis* were prone to fly when disturbed and thus were not always completely quiescent. If temperatures in the vicinity of female *tarsalis* were adversely affecting the successful overwintering of these populations in the mines, surely the females would have sought the coolest portions, which were those adjacent to the entrance and near the floors. Our many observations indicated that this did not happen. Our readings undoubtedly represent the highest daily temperatures occurring in abandoned mines since these mines were always checked from about 10 a.m. to 3 p.m. and cooler temperatures must prevail during the remainder of the day.

The writer prefers to believe that in early March of 1960 and early February of 1961 the reductions that occurred in overwintering *tarsalis* populations as well as in *Anopheles* spp. were caused by the mosquitoes leaving the abandoned mines for lower elevations and not by mortality. In Utah, Dow *et al.* (1956) reported sim-

TABLE 2.—Mean temperatures (° F.) and relative humidities (R.H.) of abandoned mines in relation to the presence or absence of female *Culex tarsalis*

Date observed	Negative mines (no mosquitoes)		Positive mines (with mosquitoes)						
	Temperature	R.H.	Immediate vicinity of females		Females absent		Average		
			Temperature	R.H.	Temperature	R.H.	Temperature	R.H.	
1960									
Jan.	50	41	50	66	51	64	50	65	
Dec.	49	39	52	63	52	52	52	58	
1961									
Jan.	53	32	51	57	51	41	51	51	51
Feb.	54	40	51	64	51	55	51	51	60
March	51	41	49	60	51	57	50	58	58
Average	53	39	51	62	51	54	51	58	58

ilar reductions in February and blamed them on mortality but admitted that increased temperatures might have forced the mosquitoes to leave.

The first breeding of *tarsalis* in the general area of the adjacent valleys was noted on April 15, 1959, April 6, 1960, and April 8, 1961. During the unaccounted-for time between their departure from the mines and breeding, the females must have had some temporary resting site. Overwintering mosquitoes were undoubtedly much fewer than normal during these two winters since the paucity of snow pack in the mountains in 1958-59 and 1959-60 greatly reduced both permanent and temporary breeding sites.

SUMMARY. A 2-year survey of abandoned mines indicated the presence of only three species of overwintering female mosquitoes: *Anopheles freeborni*, *A. pseudopunctipennis franciscanus*, and *Culex tarsalis*. During each of the 2 years *tarsalis* represented 93 and 88 percent, respectively, of the total mosquitoes observed in the mines. During both years a sharp reduction in *tarsalis* occurred in early March and February but was attributed to an exodus from the mines rather than mortality. The maximum number of *tarsalis* females noted in any one mine during 1959-60 and 1960-61 was 145 and 75, respectively.

Temperatures were slightly lower and relative humidities much higher in mines where mosquitoes were present than in those where no mosquitoes were found. Average temperatures were also slightly lower and relative humidities somewhat higher in portions of the mines where *tarsalis* females were present than in those parts where they were not.

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The **FLORIDA ANTI-MOSQUITO ASSOCIATION** Annual Meeting will be held on April 29th and 30th and May 1st and 2d, 1962 in Silver Springs, Florida.

The Annual Meeting of the **VIRGINIA MOSQUITO CONTROL ASSOCIATION** will be held on February 23d in Norfolk or vicinity. Details are lacking at the time of this writing.