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Drosophila pseudoobscura of the Great Basin

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OBSERVATIONS ON THE HIBERNATION OF *CULEX TARSALIS* COQUILLETT IN UTAH VALLEY, UTAH

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INTRODUCTION

Culex tarsalis Coquillett is a common evening pest mosquito throughout the summer in most of temperate Western North America. Present evidence indicates this mosquito as the principal naturally infected vector of western equine encephalomyeltic (WEE) viruses. Certain interrelationships of WEE epidemiology and *tarsalis* bionomics are basically understood; however, in areas where winters are severe little is known of *tarsalis* hibernation, and the survival mechanism for WEE viruses is unknown.

If sufficient virus survives in the hibernating mosquito to infect vertebrate hosts upon spring emergence of the vector, an extremely important interrelationship between the two phenomena exists. The possibility that virus survives only in the vector during the winter is doubtful; however, a thorough understanding of *C. tarsalis* hibernation and its relationship to WEE survival must be developed before an accurate evaluation of the mosquito-WEE virus reservoir concept can be made.

The purpose of this study, conducted from 1 September 1959 to 20 May 1960, was to gather ecological information on the hibernation of *Culex tarsalis* in Utah Valley, and secondly to collect pools of hibernating *tarsalis* and determine the index of infection, if any by WEE viruses.

LITERATURE REVIEW

During the colder months (December and January) in California Reeves *et al.* (1948) Mortenson, (1953) and Loomis and Green (1959), observed *C. tarsalis* overwintering in tree stumps, hollow logs, brush piles and wild rodent burrows. In Colorado, small numbers of this species were observed to hibernate in rodent burrows (Bennington *et al.*, 1958). Hammon *et al.*, (1942), Smith (1955), Keener (1952) and Dow *et al.* (1956) reported *tarsalis* hibernating in food storage cellars in Washington, Montana, Western Nebraska and Northern Utah respectively. Blackmore and Winn (1956) collected 1,361 hibernating specimens from abandoned mines in Colorado. Investigation of abandoned mines in Northern Utah indicated the species did not successfully hibernate in these circumstances, although a few specimens were observed here during most of the winter (Dow *et al.*, 1956). Hibernation of this mosquito in rock piles at the base of volcanic outcrops in the Columbia River Basin was described by Rush *et al.* (1958). In Central Utah, Taylor (1959), reported *C. tarsalis* from talus slides and rock piles in the early spring, at the base of mountains surrounding Utah Valley.

Culex tarsalis has been identified as the principal vector of WEE viruses in many parts of the United States (Hess and Holden, 1958; Ecklund, 1960). Hammon *et al.* (1942) in discussing the possibility that viral infected *C. tarsalis* may serve as an overwintering mechanism for WEE viruses state, "Another factor favoring the interrelationship of *C. tarsalis* and the endemic situation is the habit of adult winter hibernation. In this manner infected individuals might pass through winter and reestablish the infection in vertebrate hosts the following spring". Several attempts have been made to verify this hypothesis, such as those by Hammon *et al.* (1945), Rush *et al.* (1958) in Washington; Hammon *et al.* (1945), Hammon and Reeves (1947), Reeves *et al.* (1958) in California; Keener (1952) in Western Nebraska and Blackmore and Winn (1956) in Colorado. A single isolation of WEE virus from hibernating *tarsalis* in Colorado (Blackmore and Winn, 1956) is the only positive evidence to support the theory; however, in California, where they do not enter true hibernation, the virus has been isolated in all winter months except December (Reeves *et al.*, 1958).

MATERIALS AND METHODS

Field Procedure

During September of 1959 a survey of one previously suspected and other possible hibernation sites was made, and four representative areas in Utah Valley were selected for extensive observation. These were: (1) American Fork Canyon in the Timpanogos Cave Quadrangle, (2) Landrock in the Saratoga Springs Quadrangle, (3) Rock Canyon in the Bridal Veil Falls Quadrangle, (4) Warm Springs Mountain in the Santaquin Quadrangle * (Figure 1).

Ecological data on the hibernation of *Culex tarsalis* were gathered during the fall and winter by weekly visits at Landrock and biweekly inspections at all other areas. Pre-hibernation observations were made by inspection of farm buildings, sweep-net collections from vegetation, and periodic probing excavations to determine date of entry into hibernation. Systematic excavations were conducted during the winter to determine presence and behavior of the species and to collect specimens for viral analysis. Detection of early spring emergence from hibernation was accomplished by excavation. To detect activity of emergent hibernators in the valley, light traps were established at the Mendenhall Ranch one mile north of Landrock, and at

*Topographic description of these sites was taken from United States Geological Survey Topographic Maps, 7.5 minute series, scale 1:24,000.

Goshen two miles west of the Warm Spring Mountain site. Weekly inspection of farm buildings in Goshen, American Fork and Landrock areas were conducted from 23 March to 20 April. Systematic surveys of typical larval habitats along the west shore of Utah Lake from Pelican Point to the Lehi pumping plant, Jordan Narrows and American Fork were conducted weekly from 28 March to 20 May to determine the appearance of larvae.

Field Materials

Weather Instruments. Continuous recordings of temperature and humidity were established at the Mendenhall Ranch near Landrock. Recordings of atmospheric temperature and relative humidity were accomplished by the use of a Bendix-Friez Hygrothermograph. Sling psychrometer readings were taken at various intervals to check accuracy of hygrothermograph readings. Soil temperatures were read weekly from a Taylor minimum-maximum thermometer suspended inside a cement pipe buried 21 inches in the soil with the top five inches of the pipe filled with insulation and soil.

During weekly excavations at Landrock, and biweekly excavations at other sites, air temperature and relative humidity were obtained by use of a sling psychrometer. During excavation at all sites the temperatures of rocks, upon which hibernating *C. tarsalis* were found, were measured by a Cole-Parmer Thermister.

Light Trap. Standard New Jersey light traps were used to determine activity and population density of *C. tarsalis* during the spring.

Laboratory Procedure

Aspirator collections of mosquitoes taken from a given site, on a given date constituted a pool. Mosquitoes removed from the under surface of rocks during an observation were placed in sterile 10 dram glass vials, given a collection number and placed on ice until examined under the dissecting microscope. Specimens kept alive for periods of 24 hours to two weeks at 40°F were anesthetized with chloroform but not killed, and dissected in order to determine the presence of developing ova, undigested blood, and fat bodies. The amount of fat body present was determined by the relative distention of the abdomen. Pools of mosquitoes to be examined for virus were sealed in sterile glass vials and stored on dry ice until analyses were made.

Individual pools of frozen mosquitoes to be tested for virus were ground in porcelain mortars using mosquito diluent (10% normal rabbit serum in 0.85% NaCl plus 300 units of penicillin-G and 300 micrograms of streptomycin per ml.). The suspension was then placed in the refrigerator for two hours for antibiotic action and to allow coarse particles of mosquito tissue to settle. The suspension was then removed from refrigeration and the supernatant inoculated into a litter of four-day old albino Swiss mice. Each mouse received 0.05cc by intraperitoneal inoculation. Four days following inital inoculation of mosquito serum, brains from three mice of the original litter were harvested, pooled and passed serially to a new litter. All mice were observed fourteen days for signs of meningo-encephalitis, such as spastic muscular contractions and paralysis, followed by prostration and death; healthy mice were discarded at the end of the observaion period.

Laboratory Material

Mice. A strain of white Swiss mice (Rocky Mountain Laboratory Strain) was used in the attempt to isolate virus. This strain has been maintained at the Rocky Mountain Laboratory for 21 years. A mouse litter, as used in the isolation studies, consisted of six four-day old mice. During this investigation 46 litters of mice were used.

OBSERVATIONS

Field Observations

Description of hibernation habitats. Hibernation habitats included both artificial and natural talus slides at the base of mountains which surround the valley. Brief description of each site is given below.*

1. Timpanogos Cave Quadrangle, Wasatch Range, American Fork Canyon, Range 2 East, Township 4 South, Section 32, elevation 5,100 feet. Natural north facing limestone talus slope at the mouth of American Fork Canyon. Dominant vegetation was Currant (*Ribus cereum*) and Choke Cherry (*Prunus malanocarpa*).

2. Saratoga Springs Quadrangle, Lake Mountains, Range 1 West, Township 6 South, Section 2, Landrock, elevation 4,800 feet. East facing artificial limestone talus slope one and one half miles west of the west shore of Utah Lake. Dominant vegetation was Sage Brush (*Artemesia tridentata*) and Twisted Rabbit Brush (*Chrysothamnus spp.*).

3. Bridal Veil Falls Quadrangle, Cascade Range, Range 3 East, Township 6 South, Section 28, elevation 6,600 feet. Southwest facing natural feldspar talus slope about one mile east of the mouth of Rock Canyon. Dominant vegetation was Scrub Oak (*Quercus gambelii*).

4. Santaquin Quadrangle, Warm Spring Mountain, Range 1 East, Township 10 South, Section 8, Warm Spring Mountain, elevation 4,700 feet. West facing artificial limestone talus slope directly east of Goshen Ponds. Dominant vegetation was Rabbit Brush (*Chrysothamnus spp.*).

Pre-hibernation observations. *Culex tarsalis* were found to rest in vegetation near the hibernation site during warm afternoons (90°-74°F) in September and the first week in October. In the evening as the sun's

*Topographic description of these sites was taken from United States Geological Survey Topographic Maps, 7.5 minute series, scale 1:24,000.

rays left the valley and the atmospheric temperature decreased 4°-7°F the mosquitoes were observed to leave the vegetation, migrate to the talus slope and crawl under the upper rocks in the talus hibernation habitat. If specimens were disturbed in vegetation or during excavation they would fly away rapidly. During the cold and stormy weather in October and the first week in November 1959 this species, along with Anopheles freeborni, was observed under rocks at the upper part of the talus slope. When minimum temperatures fell below 40°F mosquitoes were no longer observed in vegetation but during the warm part of the day would appear on top of rocks at the hibernation site.

Blood engorgement, as noted in sweep-net collections, declined from 23% (11/47) to 4% (1/27) during September. October 17 was the last date an engorged specimen was collected. Abdominal fat bodies were first observed in specimens collected on 4 September. The number of mosquitoes showing fat bodies gradually increased from 2% (1/29) to 87% (29/33) during September and the first week in October. All specimens collected after 10 October showed extensive abdominal distention due to fat body development.

Ground temperatures during the pre-hibernation period, 1 September to 6 November, declined from 76° to 52°F expressing a 24 degree change in the period (Figure 2). Air temperatures fluctuated from a maximum of 90°F to a minimum of 26°F during September and October; the mean temperature decreasing from 68° to 36° (Figure 2). Relative humidity during the period ranged from 74% to 10% with little moisture falling during the entire fall.

Hibernation observations. Throughout Utah Valley Culex tarsalis entered hibernation between 1 and 7 November 1959 when atmospheric temperatures ranged between 60° and 15°F and relative humidity fluctuated between 12% and 83%. Hibernating specimens were found in talus slides clinging to the underside of rocks below the frost line and immediately beneath a layer of rocks moist with frost. Depth of hibernating specimens varied from one to five feet during the winter, however, at any one time mosquitoes were found to occupy approximately the same level within the hibernation habitats (Figure 3).

Hibernating specimens looked like adults newly emerged from pupation. They were quiescent and their abdomens were filled with fat bodies. During the last three weeks of hibernation specimens appeared about the same as those observed earlier in the study, however, excavation would disturb the mosquitoes and usually they would make some attempt to escape.

The temperature of rocks upon which hibernating C. tarsalis were found varied from 29° to 38°F over the hibernation period (Figure 3). Temperatures during the first 11 weeks of hibernation were fairly stable, fluctuations were only gradual and slight after the first two weeks of hibernation. Rock temperatures fluctuated irregularly from 30° to 38° F during March and returned within one degree of the temperature recorded the first week of hibernation.

Atmospheric temperatures outside the hibernation habitat the first 9 weeks varied from a high of 72° to a low of -16°F, the lowest temperature of the winter. During the next two months, January and February, the mean temperature fluctuated between 24° and 36°F. Minimum temperatures during this period remained well below freezing while the maximums were only 10°F to 16°F above the freezing point. In March atmospheric temperatures abruptly warmed to an average of 50°, however, minimum temperatures remained below freezing while afternoon temperatures soared into the high 60°'s F (Figure 2).

Soil temperatures reflected the change in atmospheric temperature, however, remaining 12°F warmer during the first 9 weeks of hibernation. Soil temperatures declined from 52° to 20°F during November, December and January with a gradual warming from 30° to 53°F recorded during February and March. During the last week of hibernation soil temperatures increased rapidly from 41° to 51°F thus becoming 13°F warmer than rock temperatures recorded for the last hibernating mosquitoes (Figure 3).

Collection of hibernating *C. tarsalis* for virus studies was begun on 2 January 1960 and continued weekly until spring emergence from hibernation was apparently complete (Table 1).

Emergence. Emergence from hibernation was first noted at Landrock on 22 March 1960. An immediate search of other sites indicated emergence had been general, as 21 hours of excavation failed to yield a single specimen. Outside atmospheric temperatures during the week of 22 March 1960 were at a minimum of 30°F and a maximum of 70°F suggesting that the species is able to endure below freezing temperatures out of the hibernation habitat. Light traps established at the Mendenhall Ranch and Goshen were negative during the first week, 20-26 March. Farm buildings near Landrock, American Fork and Goshen were also searched with negative results.

On 30 March three female *tarsalis* were collected in the Goshen light trap and on 2 April two were collected at the Mendenhall Ranch in a light trap. The abdomens of all five specimens appeared empty.

There was no indication of undigested blood, fat bodies or developing ova. A search of farm buildings throughout the valley failed to produce mosquitoes of this species. Inspection of typical larval habitats in American Fork and along the west shore of Utah Lake likewise proved negative for tarsalis, although Aedes dorsalis larvae were collected in shallow ponds 100 yards from the lake shore.

Engorged specimens were first collected in chicken coops at American Fork and Goshen during the first week of April, twelve to fourteen days following emergence. Four blood engorged mosquitoes were collected in American Fork on 4 April, and the following evening in Goshen three more were collected. Light trap collections during the week of 3 to 9 April produced two specimens in Goshen and one at the Mendenhall Ranch (Table 2). A thorough survey of larval habitats in Goshen Valley, American Fork and Landrock were negative for tarsalis; however, Aedes dorsalis larvae were becoming widespread.

Culex tarsalis larvae were first collected on 11 April in American Fork. Six third instar larvae were collected in a shallow pool, indicating larvae appeared sometime earlier but had not been observed. Light trap collections of three and five specimens were taken at Goshen and at the Mendenhall Ranch respectively during the week of 10 - 16 April.

During May, light trap collections were continued on a weekly basis. Results of tarsalis collections are shown in Table 2.

Atmospheric temperatures of below freezing were recorded throughout most of March and April. Maximum temperatures, for any one day, gradually climbed into the 70°'s F, with the average temperature fluctuating between 48° to $51^{\circ}F$ (Figure 2).

Soil temperatures fluctuated very little after the abrupt rise from $34^{\circ}F$ of March 5 to 51° at April 26 experienced just previous to emergence (Figure 3).

Laboratory Observations

Examination of dissected specimens from field collections of hibernating mosquitoes showed that hibernating C. tarsalis completely lacked developing ova or undigested blood. The abdomen of each specimen, however, was filled with fat bodies. In specimens collected and kept alive at $40^{\circ}F$ for twenty four hours and those kept alive at $40^{\circ}F$ for two weeks very little difference in amount of abdominal fat was noted. Seasonally, however, specimens collected during March showed less abdominal fat bodies than specimens collected in November and December.

Virological Observations. All litters of mice inoculated in the attempt to isolate WEE virus appeared healthy on the fourteenth day following inoculation. Virological results were recorded as negative (Table 1).

DISCUSSION

The hibernation habitat of Culex tarsalis is virtually unknown in most areas where winters are severe. Hibernation in artificial shelters has been described in food storage cellars (Keener, 1952; Smith, 1955; Dow et al., 1956), mine shafts (Blackmore and Winn, 1956; Dow et al., 1956) and sub-floor spaces (Rush et al., 1958). Present evidence, with exception of observations made in mine tunnels of Colorado (Blackmore and Winn, 1956), indicate that artificial shelters do not serve as principal hibernation sites. Following investigation of food storage cellars and mine shafts in Northern Utah, Dow et al., (1956) comment , "If Culex tarsalis overwinters successfully in mine shafts, it survives in spite of excessively high mortality. It seems more likely that the normal winter habitat is yet unknown." Investigation of natural habitats from which hibernation has been reported in California (Mortenson, 1953) revealed rodent burrows shelter a few specimens in Colorado (Bennington et al., 1958). At present, evidence seems to indicate rodent burrows are not a major hibernation habitat although more research is being done to accurately evaluate these sites. Realizing that the C. tarsalis hibernated long before artificial shelters played an important role in tarsalis bionomics, Rush et al.(1958)began a comprehensive search of the Columbia River Basin to locate natural hibernation habitats. They discovered the first major natural habitats in a cold northern climate and described them as rock piles at the base of volcanic outcrops. Taylor (1959) reported finding tarsalis in talus slides near the base of mountains surrounding Utah Valley during the early spring, but before detailed observations could be made emergence had been completed. Evidence gathered during the present study confirms Taylor's (1959) supposition that talus slopes at the base of the mountains are typical hibernation habitats for _C. tarsalis_ in Utah Valley.

The behavior of _tarsalis_ prior to hibernation was studied very closely in Colorado by Bennington _et al._ (1958). Summarizing their observations they comment, "...Culex tarsalis females from late summer and fall broods mate, take plant juice, and enter a diapause with respect to blood feeding to develop fat bodies." During the present study no attempt was made to distinguish between broods. In all specimens taken in sweep-net collections during September and the first week of October, a decline from 23% to 4% in number of specimens showing blood was noted. Fat body development increased from 2% to 87% during this same period with all female specimens collected after 10 October showing definite fat body development in the abdomen.

Present evidence indicates that _C. tarsalis_ does not go into hibernation engorged with blood. This supports the concept that it would be unlikely for mosquitoes to go into hibernation with a virally infected blood meal. The stimuli which caused the mosquitoes in this study to discontinue taking blood meals and develop abdominal fat bodies were not investigated; however, there was an observed correlation between this behavior and the decrease in minimum atmospheric temperatures.

Movement of _C. tarsalis_ in and out of the hibernation habitat during the fall appeared to be stimulated by temperature change. This phenomenon would seem to indicate decreasing minimum temperature is one of the factors stimulating hibernation. On days before true hibernation began specimens appeared in vegetation or on top of the hibernation site when atmospheric temperatures were above 40°F and disappeared into the rocks when temperatures fell below this. Movement in and out of the hibernation habitat is an observation new with this present study; however, it has been suspected in California (Reeves et al., 1958) where tarsalis are seldom found infected during the early winter but become infected during the hibernation period. Throughout the present study careful observation was made on warm days to detect any movement out of hibernation site after true hibernation began; indications are, however, that once tarsalis enters true hibernation they remain until spring.

Mosquitoes are not totally inactive during hibernation. After observaion of hibernating Culex apicalis in Massachusetts, Berg and Lang (1948) state, "There was a noticable activity among the mosquitoes throughout the study period, even during the coldest months....It was found that no mosquito occupied the same place for more than two weeks". Movement by tarsalis during the winter was observed in mine tunnels by Dow et al. (1956) and appeared to be correlated with fluctuations in temperature and relative humidity, at least in the early part of their study. Rush et al. (1958) found tarsalis in rock piles from one to four feet from the surface and found no correlation with depth and temperature because specimens were collected under different climatic conditions at the same site. In consideration of data from the present study it appears that movement to different depths within the talus slopes was stimulated by temperature changes in the talus habitat.

Mosquito hibernation temperatures remained rather constant throughout the winter as specimens moved within the site to maintain temperatures which were desirable (Figure 3).

The range of temperatures in which hibernation of *C. tarsalis* occurs is apparently wide (Figure 4). Dow *et al.* (1956) postulate, "If the source of this energy is food stored in the body and if this supply must last through the winter, the species should best survive in natural shelters where it would be inactivated by the cold and not trapped by the heat." Previous workers studying hibernation in artificial shelters found *C. tarsalis* hibernating in temperatures above freezing. Rush *et al.* (1958) during observations of rock piles in the Columbia River Basin state, ". . .there is little doubt that at least part of the rock-pile population was occasionally exposed to below-freezing, if not below zero temperatures." Data gathered during the present study indicates *C. tarsalis* hibernate at temperatures near freezing (29-38°F), and when temperature changes occurred within the habitat they responded by moving deeper or nearer the surface of the talus slope to find suitable conditions.

The principal factor stimulating spring emergence from hibernation appears to be a continued increase in temperature within the hibernation habitat. Bennington *et al.* (1958) and Bennington and Sherman (1960) present evidence which indicates *C. tarsalis* females emerge from hibernation shortly following the spring soil temperature inversion. Dow *et al.* (1956) state, " . . . it appears that increasing out-door temperatures might have increased the temperatures within the tunnel so that *C. tarsalis* were forced out of its shelter." Data gathered during the present study indicate that a rise in temperature within the hibernation habitat and not atmospheric temperature alone stimulates emergence from hibernation. Keener (1952) observed that emergence did not occur until daily minimum temperatures were maintained above freezing; however, in Washington (Rush et al., 1958) found that tarsalis emerged when minimum temperatures were in the 20°'s F and maximum in the 60°'s F. During the spring of 1960 emergence occurred in Utah Valley during a period when atmospheric temperatures ranged from 18°-64°F, near the same range described by Dow et al. (1956) in Northern Utah, which was 12°-55° F.

Observation during the first month following emergence seem to indicate that C. tarsalis females are inactive for nine to eleven days immediately following emergence from hibernation. Rush et al. (1958) observed engorgment to begin eight to ten days following emergence and Taylor (1959) collected specimens on the fourteenth day following emergence. Considering third instar larvae were collected twenty one days following detection of emergence and seven days after collection of the first engorged specimens it appears either blood feeding began earlier than 4 April or the mosquitoes began emergence earlier than 20-21 March 1960. Data presented by other investigators (Rush et al., 1958; Taylor, 1959) indicate a period of about ten to fourteen days must elapse before blood feeding begins, thus indicating that emergence in Utah Valley during 1960 began about two weeks before it was detected.

The failure to isolate WEE viruses from the limited number of hibernating specimens examined is not significant when considered alone. These data do, however, add to accumulating evidence that Culex tarsalis does not serve as the principal mechanism for the survival of WEE viruses during the winter months.

CONCLUSIONS

On the basis of this study the following conclusions are presented:

1. *Culex tarsalis* began preparation for hibernation during the early fall by a decline in blood feeding and subsequent development of abdominal fat bodies indicating blood engorged specimens do not enter hibernation.

2. Evidence from this study supports Taylor's (1959) contention that talus slopes and rock piles are typical natural hibernation habitats of *Culex tarsalis* in Utah Valley. The present study found hibernating specimens to occupy a level in the hibernation habitat below the frost line and directly beneath a layer of rock moist with frost.

3. Hibernating mosquitoes remained outside the hibernation habitat during the fall when atmospheric temperatures were above 40°F. During warm afternoons in late September and October *tarsalis* was observed to migrate to the slope apparently as a response to decreasing atmospheric temperatures.

4. True hibernation began during the first week of November when atmospheric temperatures ranged from 15° to 60°F. Hibernation during this study appeared to be stimulated by continued decreases in minimum atmospheric temperatures.

5. Hibernating *tarsalis* morphologically appeared as adults newly emerged from pupation. The abdomen of each specimen was filled with fat bodies; however, there was no indication of developing

ova or undigested blood.

6. Data gathered during this study indicate that tarsalis hibernates in natural shelters at temperatures near freezing (29°-38°F). When temperature changes occurred within the habitat the mosquitoes moved deeper or nearer the surface in the talus slope to find conditions suitable for hibernation.

7. Emergence from hibernation was first observed on 22 March. Emergence appeared to be stimulated by increasing temperatures within the hibernation habitats.

8. Larvae first appeared in American Fork on 11 April 1960.

9. Emergent hibernators do not actively seek a blood meal for ten to fourteen days following emergence.

10. Twenty three pools (212 mosquitoes) of hibernating Culex tarsalis collected during this study were not infected by western equine encephalomyelitic (WEE) viruses.

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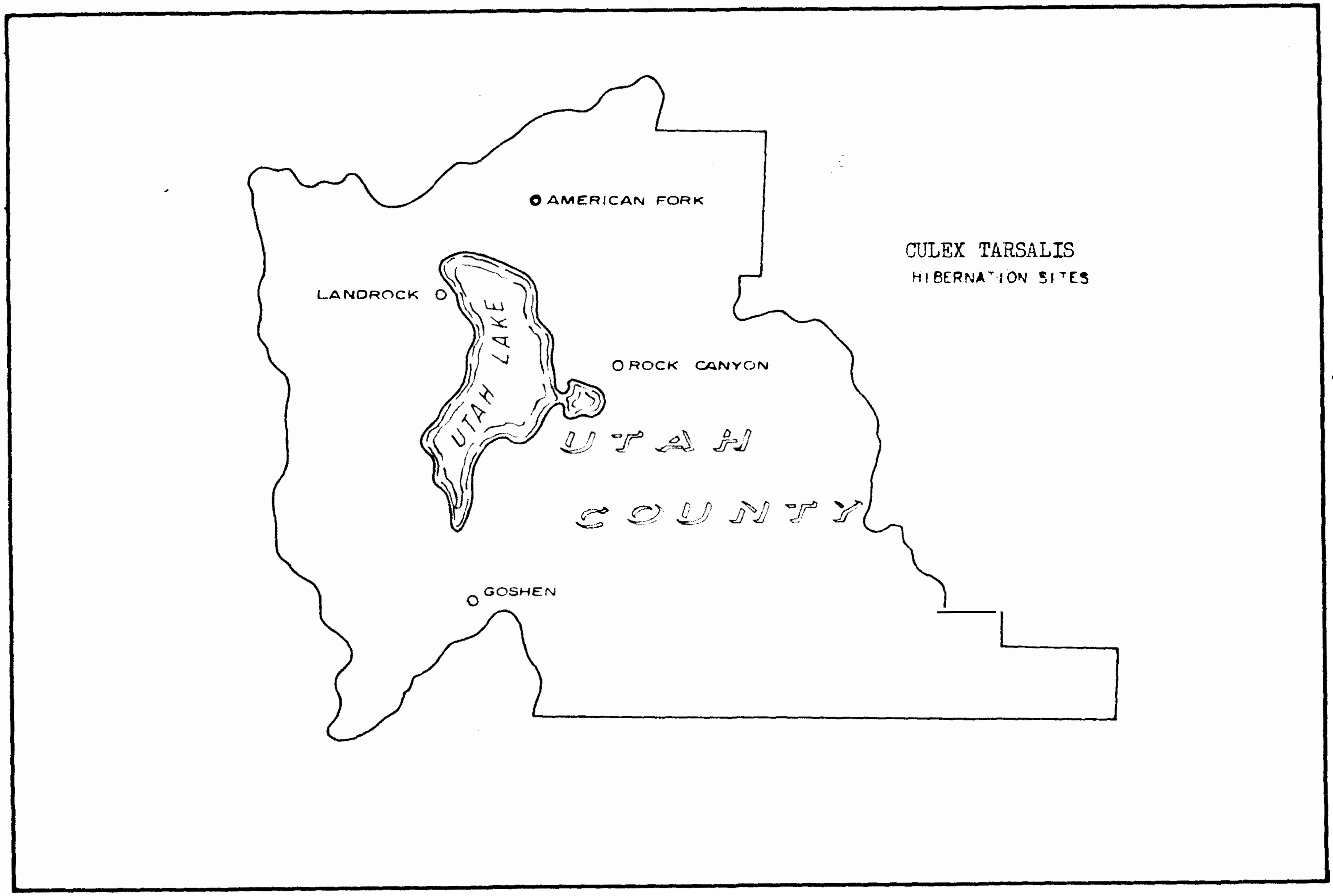

FIGURE 1. HIBERNATION SITES STUDIED IN PRESENT INVESTIGATION.

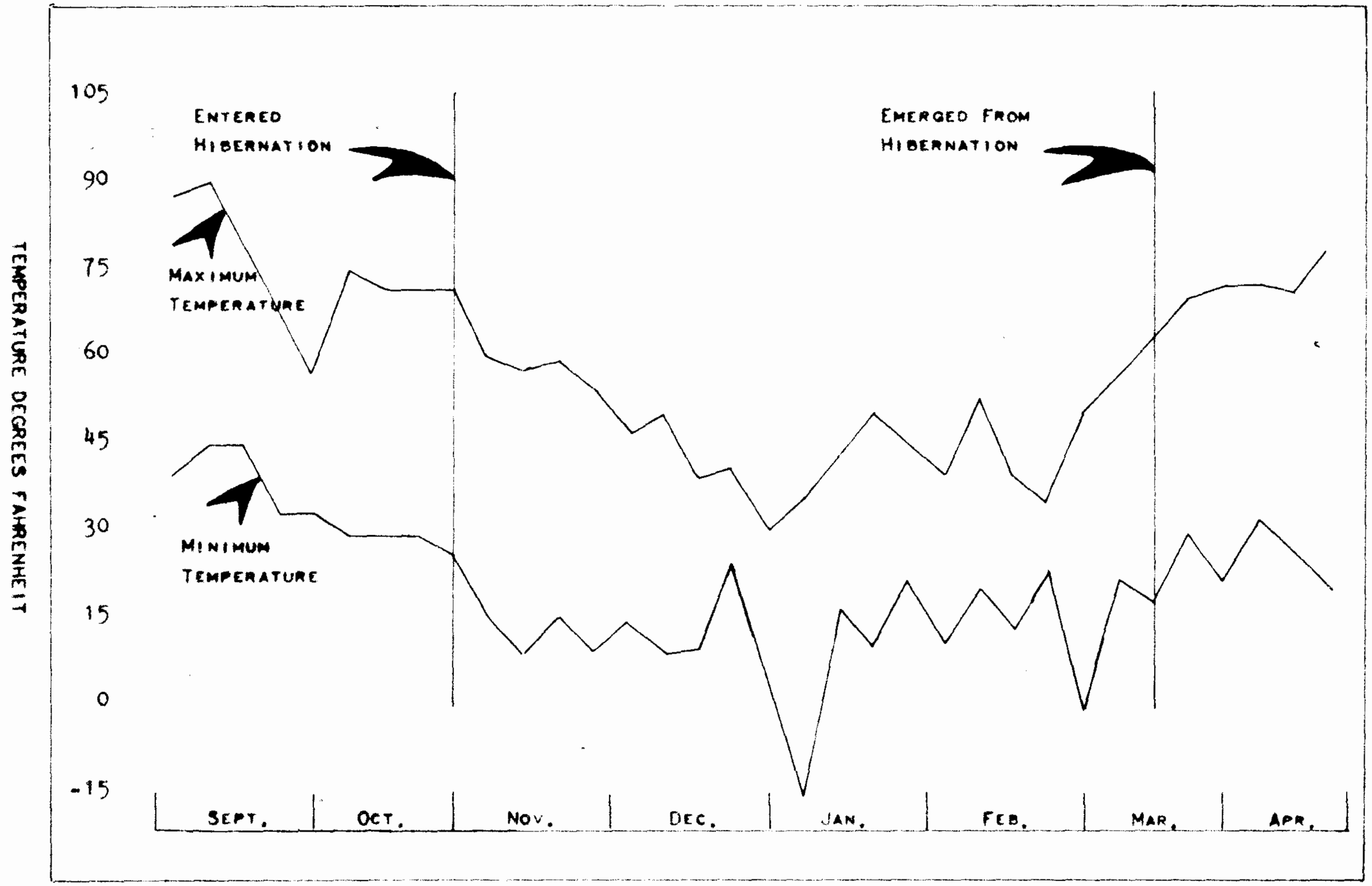

Figure 2. Maximum and minimum atmospheric temperatures taken at the Mendenhall Ranch one mile north of Landrock during months indicated, 1959-1960.

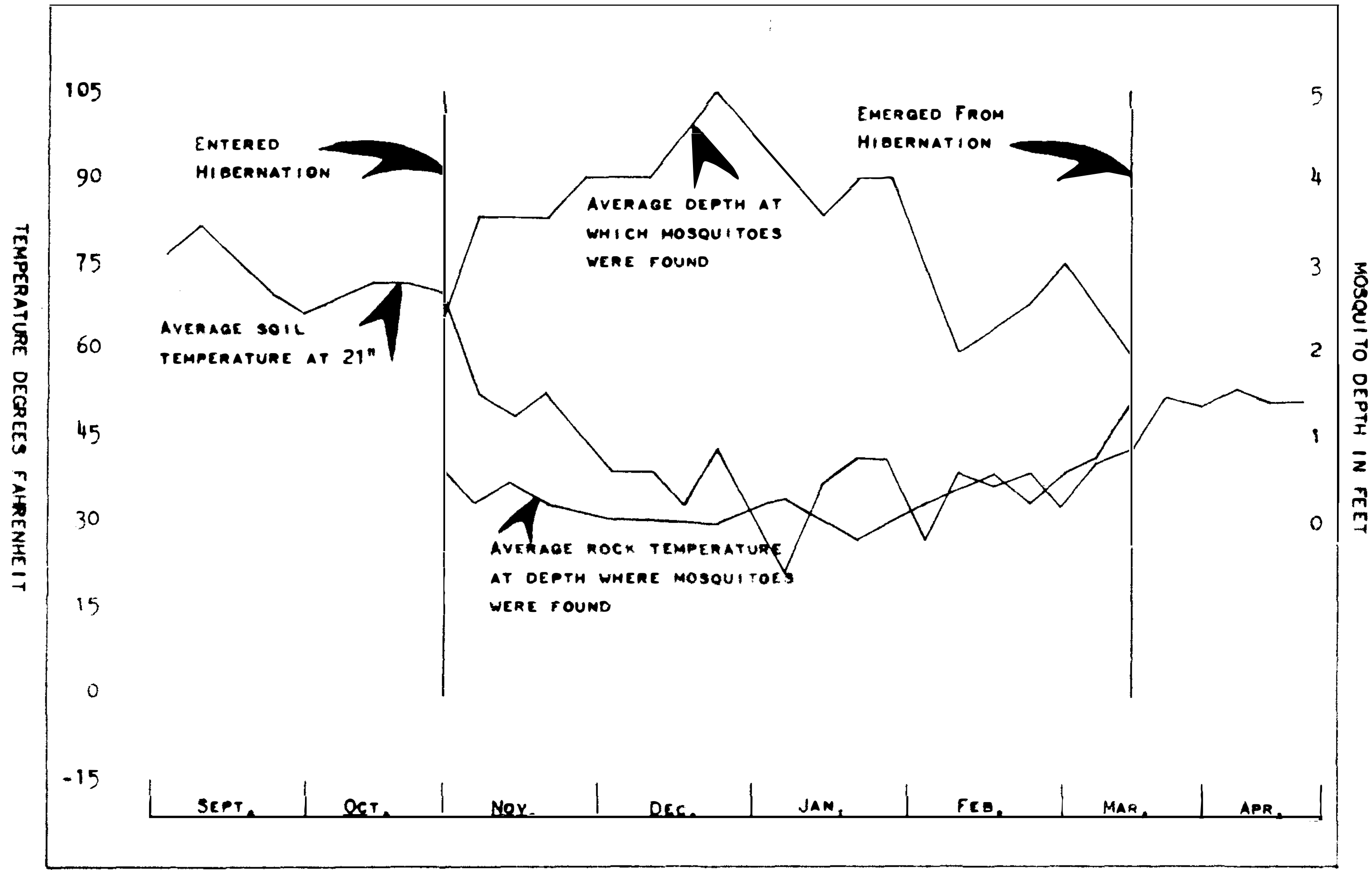

FIGURE 3. INTERRELATIONSHIP OF AVERAGE SOIL TEMPERATURE AT THE 21-INCH LEVEL, AVERAGE MOSQUITO-ROCK TEMPERATURE AND DEPTH OF HIBERNATING SPECIMENS.

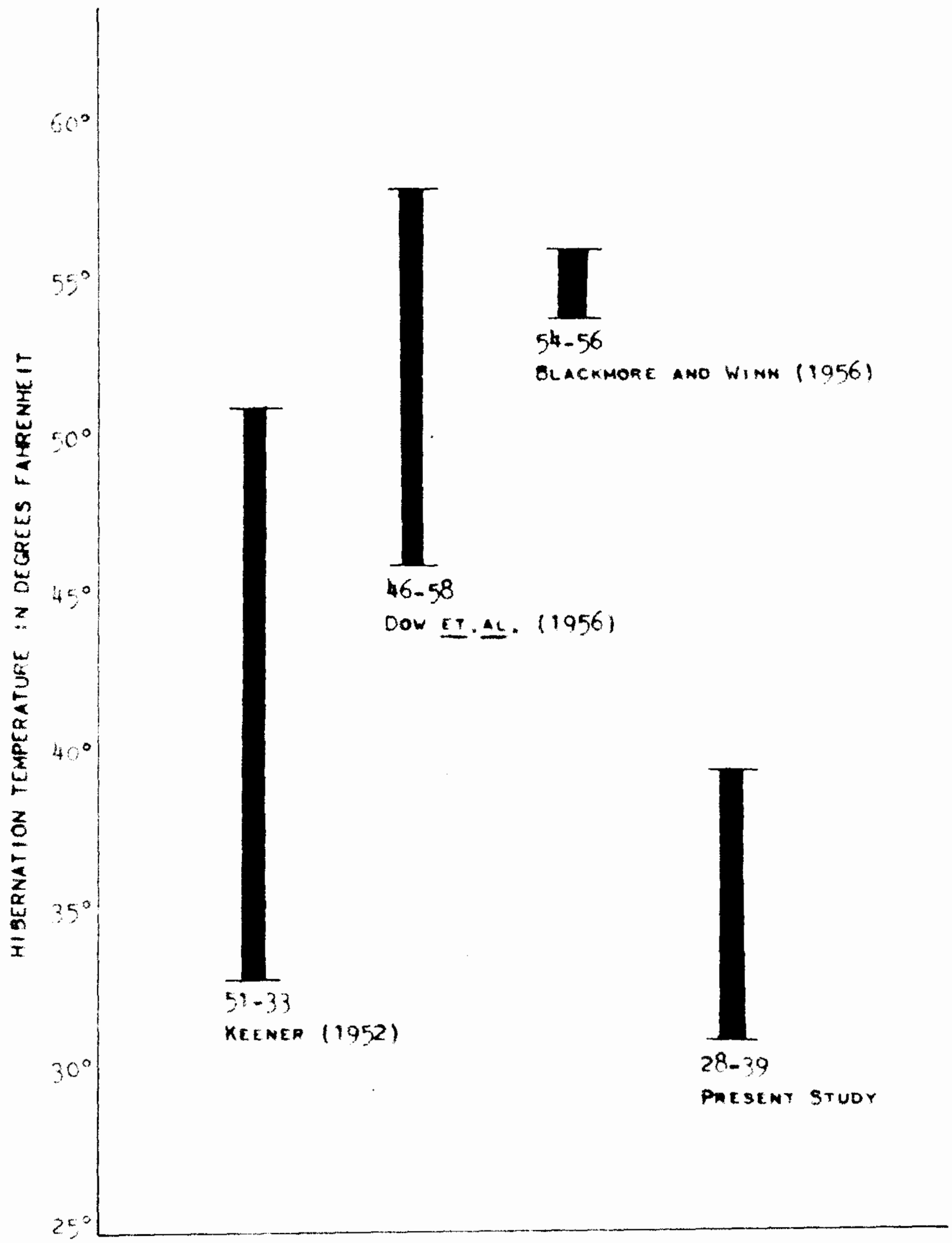

FIGURE 4. COMPARISON OF HIBERNATION TEMPERATURES RECORDED BY OTHER INVESTIGATORS AND PRESENT STUDY.

Table 1. Collections of Hibernating *C. tarsalis* indicating number of specimens per collection, number of pools and virus isolation results for each pool

DATE	LOCATION	NO. SPECIMENS	NO. POOLS	VIRUS ISOLATE
2 Jan	Landrock	7	1	-
9 Jan	Landrock	8	1	-
9 Jan	Rock Cyn	7	1	-
9 Jan	Warm Sp. Mtn.	7	1	-
16 Jan	Landrock	9	1	-
16 Jan	Warm Sp. Mtn	10	1	-
23 Jan	Landrock	9	1	-
30 Jan	Landrock	10	1	-
6 Feb	Landrock	10	1	-
6 Feb	Rock Cyn.	10	1	-
6 Feb	American Fork Cyn.	9	1	-
13 Feb	Warm Sp. Mtn.	9	1	-
13 Feb	Landrock	12	1	-
13 Feb	Rock Cyn.	8	1	-
20 Feb	Landrock	7	1	-
20 Feb	Warm Sp. Mtn.	13	1	-
27 Feb	Landrock	11	1	-
27 Feb	Rock Cyn,	9	1	-
7 Mar	American Fork Cyn.	10	1	-
7 Mar	Rock Cyn.	11	1	-
14 Mar	Landrock	7	1	-
14 Mar	Warm Sp. Mtn.	9	1	-
20 Mar	Landrock	10	1	-

Table 2. Light trap collections of C. <u>tarsalis</u> at Goshen and the Mendenhall Ranch 1960.

DATE	NUMBER COLLECTED	LOCATION
30 March	3	Goshen
2 April	2	Mendenhall Ranch
3-9 April	1	Goshen
3-9 April	2	Mendenhall Ranch
10-16 April	3	Goshen
10-16 April	5	Mendenhall Ranch
17-23 April	1	Goshen
17-23 April	2	Mendenhall Ranch
24-30 April	0	Goshen
24-30 April	1	Mendenhall Ranch
1-7 May	1	Goshen
1-7 May	0	Mendenhall Ranch
8-14 May	2	Goshen
8-14 May	3	Mendenhall Ranch
15-20 May	8	Goshen
15-20 May	10	Mendenhall Ranch

OBSERVATIONS ON THE HIBERNATION OF *CULEX TARSALIS* COQUILLETT IN UTAH VALLEY, UTAH

An Abstract of a Thesis

Presented to the

Department of Zoology and Entomology

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Dennis W. Trent

September 1960

ABSTRACT

The mosquito Culex tarsalis is the principal naturally infected vector of western equine encephalitic (WEE) viruses. Certain interrelationships of WEE epidemiology and tarsalis bionomics are basically understood; however, in areas where winters are severe little is known of tarsalis hibernation and the overwintering mechanism for WEE is yet unknown. An understanding of the interrelationship of these two phenomena is essential to an accurate evaluation of the mosquito-WEE virus overwintering reservoir concept. The purpose of this study was to gather ecological information on the hibernation of Culex tarsalis in Utah Valley, and secondly to collect pools of hibernating tarsalis and determine the index of infection by WEE virus.

Four representative talus slopes in Utah Valley were selected for extensive study during the fall, winter and early spring periods. Systematic observations were made during the fall and winter to determine behavior and presence and to obtain specimens for viral analysis. Detection of early spring movement from hibernation was accomplished by excavation and light trap collections.

During the fall tarsalis remained outside the hibernation habitat when atmospheric temperatures were above 40°F and moved to occupy a position under top rocks of the site when temperatures fell below 40°F. The number of specimens showing blood engorgement declined from 23% to 4% during the fall with a subsequent increase in fat body development from 2% to 87%. These date seem to indicate that C. tarsalis

does not enter hibernation in an engorged condition.

True hibernation began during the first week of November when atmospheric temperatures ranged from 15°F to 60°F and appeared to be stimulated by continued decrease in atmospheric temperature. Hibernating specimens were found clinging to the underside of rocks below the frost line and directly below a layer of rocks moist with frost. Females appeared as newly pupated adults, the abdomen of each specimen filled with fat bodies; however, there was no indication of undigested blood or developing ova. Tarsalis hibernated at temperatures near freezing (29° 38°F) and moved deeper or nearer the surface of the talus slope to maintain suitable hibernation conditions.

Emergence from hibernation was detected on 22 March and appeared to be stimulated by increasing temperatures within the hibernation habitat. Light trap and chicken coop collections indicate tarsalis apparently does not seek a blood meal for approximately fourteen days after emergence from hibernation. First larvae were collected on 11 April 1960.

Twenty three pools (212 mosquitoes) of hibernating C. tarsalis were analyzed for WEE virus. The failure to isolate WEE virus from this limited number of specimens is not significant when considered alone; however, these dat do add to accumulating evidence suggesting C. tarsalis does not serve as the principal overwintering mechanism for WEE virus.

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Approved: