SEASONAL HISTORY OF *CULEX TARSALIS* AND ASSOCIATED SPECIES IN LARVAL HABITATS OF THE TENNESSEE VALLEY REGION

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Observations on the seasonal occurrence of mosquitoes in the Tennessee Valley region indicate that *Culex tarsalis* Coq. has been found only in the fall of the year. Although it has never been found in abundance, its density and distribution vary from year to year. Based on U. S. Army light trap and adult resting station records, Carpenter (1945) recorded *C. tarsalis* only at Camp Tyson near Paris, Tennessee, in 1942, whereas they were found at various army installations in Alabama, Georgia, Kentucky, Mississippi, and Tennessee in 1943 though not at Camp Tyson. In 1944, adults were reported at one or more installations in the aforementioned states including Camp Tyson, Tennessee. Collections in adult resting stations on Kentucky Reservoir used in connection with the TVA malaria control program showed *C. tarsalis* widespread in September 1953 but represented only by a single collection in 1954.

Light trap collections by TVA in 1953 indicated that *C. tarsalis* was present during September in the main reservoir system extending through western Tennessee, northern Alabama, and east Tennessee between Chattanooga and Knoxville. One light trap in the floodplain of the French Broad River flowing through the foothills of the Smoky Mountains was negative for *C. tarsalis* in 1953, 1954, and the spring of 1955. Records of light trap catches from a trap at Hustburg, Tennessee, where Duck River broadly joins the Tennessee River, indicated a high of 67 females and 4 males on September 15, 1953, with 7 additional specimens captured in the ensuing two weeks. At Dayton, Tennessee, across the Cumberland Mountains from Hustburg, 6 female *C. tarsalis* were captured on September 14 and 16, 1953, collectively.

With the exception of one larval series in the Authority's collection from flooded hoofprints near Leighton, Alabama, by Pratt and Quinby in October 1944, no information has been available on the type of larval habitats used by *C. tarsalis* in the Tennessee Valley basin states. Because of its general connection with encephalitis and the increased interest in irrigation crops and pastures in the Tennessee Valley, efforts were made to determine the habitat type and larval associations of *C. tarsalis* as part of a two-year survey on insects of public health importance associated with TVA reservoirs. The results reported in this paper cover limited observations during three growing seasons, 1953–1955, although the larval habitats discussed were not found until the fall of 1954 or later.

HABITATS IN TENNESSEE. One of the areas selected for investigation was about the grounds of former Camp Tyson near Paris, Tennessee. Following the war, the camp site was acquired by a private company for the production of industrial clays. Most of the acreage, however, has been turned into pasture for livestock and quarter horses. Two of the breeding areas were associated with the old water system of the camp. The third was a grassy roadside ditch intermittently flooded by normal rainfall.

The first site, designated as the fireplug seep area, was a very shallow roadside drain thickly populated with millet, *Echinochloa crusgalli* (L.) Beauv.; fantail *Setaria geniculata* (Lam.) Beauv.; Bermuda grass, *Cynodon dactylon* (L.) Pers.; and with occasional panic grass, *Panicum dichotomi florum* Michx., and smartweed, *Polygonum pennsylvanicum* L. When first visited on September 9, 1954, a large series of *Psoro-*

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phora spp. were observed emerging, mainly *P. confinnis* (L. & A.) and *P. cyanescens* (Coq.), while mature larvae and pupae of *P. discolor* (Coq.) and *P. ciliata* (Fab.) were also collected. Rain in the early part of September caused excessive flooding of the area and the subsequent hatch of *Psorophora.* On September 22, larvae of *Culex tarsalis* were collected without associated species. By October 27, *C. tarsalis* was no longer found here, but *C. restuans* Theob. and *Anopheles punctipennis* (Say) had appeared. One species of moth fly, *Telmatoscopus furcatus* (Kin.) was reared from the seep in December, but mosquitoes were not found until February 24, 1955, when small larvae of *Culiseta inornata* (Will.) were seen beneath a thin layer of ice. At this time a large number of midge pupae, *Anatopynia guttularis* (Coq.) were present. In March, larvae of *Aedes vexans* (Meig.) and a midge, *Anatopynia dyari* (Coq.), appeared. Rains in mid-April hatched larvae of typical grassland *Psorophora* such as *P. confinnis, P. cyanescens,* and *P. ciliata* along with another series of *A. vexans* and a single representative of a typical salt-marsh species, *Aedes sollicitans* (Walk.). Of the several hundred larvae returned to the laboratory for rearing nearly all were *P. confinnis.* It was surmised that perhaps salt blocks left on the ground for livestock or perhaps dust from mined clay might have made conditions favorable for the development of *A. sollicitans.* Repair of the leak at the hydrant caused the site to go dry in the summer of 1955, although heavy rains late in July hatched a brood of *P. discolor, P. ciliata, P. confinnis,* and *P. cyanescens,* and in September, *P. ciliata* and *P. confinnis.* In neither case were larvae able to complete deevlopment before the pool went dry. Since the water table at this site was not replenished during the summer by seepage from the hydrant, fall rains in October and November were insufficient to maintain an aquatic habitat when *C. tarsalis* was expected to invade the situation as it did in 1954.

The second site, called a ditch (fig. 1), was a grass-lined roadside ditch whose lower end was more or less blocked by a secondary gravel road which permitted retention of water in the ditch for at least a month after heavy rains. No other source of water was provided. Marginal grasses were millet, fantail, and Bermuda grass, while emergent plants were panic grass, smartweed, and several clumps of *Juncus effusus.* The panic grass (*P. dichotomiflorum*) volunteered after the ditch went temporarily dry in August and September 1955. The ditch was first visited on September 9, 1954, when a large brood of *Psorophora confinnis* and *P. cyanescens* was emerging. Larvae of these floodwater species and adult *P. discolor, P. ciliata,* and *A. vexans* were also collected, but no *Culex* were found. When the ditch was again visited on October 5, larvae of *Culex tarsalis* (1), *C. pipiens* L. (7), and *P. confinnis* (8) were present in small numbers. Later collections on October 27 yielded *C. pipiens, Anopheles punctipennis,* and *A. quadrimaculatus* Say, but no *C. tarsalis* were seen. By December, only *A. punctipennis* and *Culiseta inornata* persisted. In March 1955, larvae of *A. vexans* and *C. inornata* were found. During May and most of June the ditch was dry. Light rains in July were sufficient to maintain productivity of *Culex erraticus* (D. & K.) and *A. quadrimaculatus* and occasional *Psorophora.* Pupae of *Culicoides crepuscularis* Mall., *C. haematopotus* Mall., and

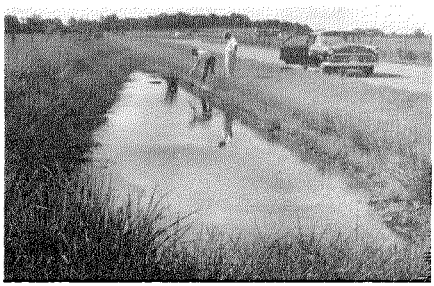

FIGURE 1. An intermittently flooded ditch at former Camp Tyson, Tennessee, where broods of *Culex tarsalis* were found in the fall of 1954 and 1955.

Dasyhelea grisea (Coq.) were found among the bases of emergent *Juncus* on July 7. The ditch was dry most of August and September. The ditch was flooded heavily in October, larvae of *P. confinnis, P. ciliata, P. cyanescens,* and *P. discolor* being observed on October 5, 1955. By October 11, *A. punctipennis* and *Culex salinarius* Coq. had shown up. Predominance of *Culex* was evident at the October 19 inspection when *C. pipiens* (90), *C. salinarius* (11), *C. tarsalis* (4), and *C. territans* Walk. (3) were represented (50 dips) along with *A. punctipennis,* a few straggling *P. ciliata,* and two larvae of *C. inornata.* On November 1 and 15, the same species of *Culex* were still present as in October and in addition *C. restuans* appeared. Of the 166 larvae and pupae reared in the November collections, the culicine species were as follows: *C. pipiens* (97), *C. salinarius* (22), *C. inornata* (21), *C. tarsalis* (13), *C. territans* (12), and *C. restuans* (1). Larvae of *C. inornata* were observed in abundance on November 15. Of the anophelines, *A. punctipennis* continued breeding heavily in November and *A. quadrimaculatus* was taken in small numbers on November 1 and 15. A final inspection on December 9, 1955, revealed larvae and one pupa of *C. inornata* in marginal grass beneath 1/4″ of ice.

A third breeding site at Camp Tyson known as the seep (fig. 2) was not discovered until the latter part of May 1955. It consisted of about 100 feet of grassy roadside ditch which had been continually wetted for some time by water seeping from a surface outlet of the local water system. Beds of mud plantain (*Heteranthera reinformis* R. & P.), a plant somewhat similar to watercress in appearance and growth habit, were well established in the ditch where the seep water was entering. Farther down the ditch the bottom had become heavily colonized by panic grass (*P. dichotomiflorum*) and *Paspalum* sp. The depth of the water ranged from 3–4″ over the bottom of the ditch. In the panic grass area where vegetation greatly retarded water flow, a rather thick rust-colored layer of flocculent organic matter was present. This medium appeared to be particularly favorable for the production of *C. salinarius* affording it protection from excessive surface temperature and predators.

FIGURE 2. Beds of mud plantain in a seep at former Camp Tyson, Tennessee, where *Culex tarsalis* was found breeding in the fall of 1955.

At the time of the initial inspection on May 18, only larvae of *C. restuans* were found. In June, July, and August, the predominant anopheline was *A. punctipennis,* the principal culicine, *C. salinarius,* and the only floodwater species, *P. confinnis.* The larvae of *P. confinnis* were associated with hoofprints near the issuance of seep water and were incidentally the only *Psorophora* species ever taken in this seep area. This hoofprint area was generally populated with millet. The collections of June 24 and July 7 and 13 revealed the presence of a punkie, *Culicoides variipennis* (Coq.), which becomes very abundant in brackish water in the western states and has also been recently collected in enormous numbers from brackish water at Saltville, Virginia. Pupae of this punkie were collected both in the *Heteranthera* and *Panicum* areas of the seep, and adults were swept from marginal fantail and Bermuda grass during the day. The pupae ranged from 1–3 per dip in vegetation. Other heleids appearing in summer collections included *Bezzia glabra* (Coq.) on June 24, *Dasyhelea grisea* on July 7 and 13, and *Bezzia setulosa* (Lw.) on July 13.

In July and August, *C. pipiens* also appeared but was never numerous compared to *C. salinarius*. Larvae of *A. quadrimaculatus* did not invade the seep until September and were still present until October 5 but not thereafter. Two heleids, *Culicoides crepuscularis* and *Stilobezzia coquilletti* K., were taken on September 2. The pupae of *C. crepuscularis* were very frequent and were taken principally in the shallow flooded panic grass area. Large numbers of tendipedid larvae (5+ per dip) in the genus *Pentaneura* and one specimen of *Tendipes fulvipilus* (Rempel) were detected breeding in the flocculent organic matter of the panic grass area in September. *Culex restuans,* normally a cool weather species, was not collected after its spring appearance until the first week in September. Larvae of *C. tarsalis* were collected in the seep for the first time on September 30 in both the mud plantain (*Heteranthera*) and panic grass zones. Subsequent collections on October 5, 11, and 19 showed *C. tarsalis* present in association with *A. quadrimaculatus, A. punctipennis, C. pipiens, C. restuans, C. salinarius,* and *C. territans.* Collections on November 1 and 15 showed larvae of *C. pipiens, C. restuans, C. salinarius, C. tarsalis, C. territans,* and *A. punctipennis* still present. In the October collections, culicine species reared from the seep were represented numerically as follows: *C. pipiens* (40), *C. salinarius* (15), *C. tarsalis* (12), *C. territans* (3), and *C. restuans* (3). The collections for November 1 and 15 showed the following distribution for the culicine larvae and pupae: *C. pipiens* (63), *C. salinarius* (10), *C. restuans* (6), *C. tarsalis* (2), *C. territans* (2), and *Culiseta inornata* (1). From these field collections it appears that two broods of *C. tarsalis* were developed from the late September to mid-November portion of the 1955 growing season at Camp Tyson, Tennessee. Larvae of *C. inornata* were collected for the first time at this site on November 15, 1955. A final collection on December 9 revealed only larvae of *C. salinarius* (4) and *C. inornata* (2) beneath thin ice in a clump of *Paspalum* flooded to a depth of 4 inches.

It has been thought that *C. tarsalis* might invade small pooled areas in stream beds during seasonal drought in the fall. Since adults of this species had been collected from a barn adjacent to Jonathan Creek near Hardin, Kentucky, during the fall of 1954, dipping records were made at Jonathan Creek in 1955. While stream pools were negative, a seepage area draining through a hog lot into the creek was discovered on October 10. At this time larvae and pupae of *C. pipiens, C. restuans, An. punctipennis, An. quadrimaculatus,* and one specimen of *Ae. vexans* were present in grassy hoofprints about the seepage area. The collection (50 dips) of November 1 showed *C. tarsalis* (1) present with *C. territans* (4), *C. pipiens* (20), *C. restuans* (25), and one pupa of *C. salinarius.* Larvae of *A. punctipennis* (47) were most abundant. Small numbers of *C. inornata* (8) were recorded also. By November 15, no further breeding of either *C. tarsalis* or *C. salinarius* was detected, though the other species found on November 1 were still active. On December 9, only two larvae of *C. inornata* were present in a deep pool where the seep water entered the creek.

Isolated pools in stream beds near Camden and Hustburg, Tennessee, have also been sampled for *C. tarsalis* but with negative results.

HABITATS IN ALABAMA. The appearance of *C. tarsalis* in light trap collections at Florence, Alabama (McFarlands Bottom) during October 1953 prompted inspection of likely productive sites in the reservoir basin during 1954 and 1955. Larvae of *C. tarsalis* (34) were first found in a construction pit near the grassy margin of the reservoir on September 17, 1954, in association with *C. pipiens* (85), *C. salinarius* (2), *A. quadrimaculatus* (7), and *A. punctipennis* (10). Inspection of polluted pools in an arm of Cypress Creek adjacent to the construction pit showed only *C. pipiens, C. restuans,* and *A. punctipennis* present on October 8. A subsequent collection from these pools on November 22

showed larvae and pupae of *C. tarsalis* (6) with *C. restuans* (5), *C. pipiens* (17), *C. inornata* (2), *An. punctipennis* (2), and *Ae. vexans* (1). Inspection of the Cypress Creek arm the following week, however, showed all the associated species to be present except *C. tarsalis*.

In 1955, the polluted arm was sampled heavily during the fall, but no specimens of *C. tarsalis* appeared in the thousands of culicine larvae reared, nor were any adults found in the light trap. An extremely heavy *C. pipiens* population was present and required larviciding in the latter part of October and November. Two species of midges, *Tendipes fulvipilus* and *T. decorus* (Joh.), were also very frequent in the polluted reservoir area.

DISCUSSION. In examining the records of captures by light trap at army installations in the Southeastern States in the early 1940's and in considering our own records, it is of interest that such wide variation occurs from year to year in the distribution pattern of *C. tarsalis*. For instance, specimens were captured at only one army installation (Camp Tyson, Tennessee) in 1942; however, adults appeared in light traps at 21 other installations in Tennessee and five other Southeastern States in 1943 but not at Camp Tyson. The collection of *C. tarsalis* in anopheline resting habitats inspected by TVA on Kentucky Reservoir in western Tennessee showed adults present in thirteen widely scattered locations in 1953, but in only one in 1954. The seasonal observations of habitats used by *C. tarsalis* at former Camp Tyson, Tennessee, during the past two seasons suggest that the degree and regularity of late summer and fall precipitation may be a strong factor in determining the extent of the annual appearance of this species at least in the Tennessee Valley watershed. Heavy rains early in September 1954 filled in the fireplug and ditch areas sufficiently to produce a heavy fall brood of *Psorophora* sp. and a subsequent series of *C. tarsalis* three and four weeks later. In 1955, however, while the same sequence was repeated at the grassy ditch, drier soil at the fireplug area after the leak was stopped in midsummer supported water for only a few days and even the *Psorophora* did not have time to emerge. Inability of fall rain to maintain sufficiently favorable breeding sites such as intermittently flooded ditches and seep areas for a month or so in the fall could therefore influence the persistence of a species generally evident only during the latter part of the growing season.

On the other hand, the condition of certain relatively permanent aquatic habitats may determine their suitability for invasion by *C. tarsalis* in the fall. Streams and ditches normally free flowing in spring and early summer frequently pool out and gradually go dry in the fall. Seasonal recession and cyclical fluctuation of Pickwick Reservoir in connection with the malaria control program of TVA reduced water elevation in the polluted arm of Cypress Creek at Florence to the bottom of the ditch by October 1954. Pools left just above the receding reservoir water did not become productive of *C. tarsalis* until late in November, though *A. punctipennis, C. restuans,* and *C. pipiens* were found as early as the first week in October and persisted through November. Larvae of *C. tarsalis* were first taken in the bottom of a sewer line construction pit near the polluted ditch on September 17 so they were available for invasion of the polluted ditch at a much earlier period than when finally found there on November 22. Because of the large number of *C. pipiens* present, it is possible that they may have been present earlier but not readily detected.

SUMMARY. Records of light trap collections at army installations and adjacent to TVA reservoirs show that wide variations occur from year to year in the distribution pattern of *C. tarsalis*. Larvae collected from grassy seeps and intermittently flooded ditches at former Camp Tyson near Paris, Tennessee, in 1954 and 1955 substantiate previous observations east of the Mississippi River that *C. tarsalis* occurs in the fall of the year generally

from late August to late November with a peak in September. In 1955, evidence of at least two broods during this period was obtained. In the larval habitat, *C. tarsalis* was usually associated with *C. pipiens* and *A. punctipennis* though frequently with *C. restuans, C. salinarius,* and *C. territans.* In intermittently flooded ditches, millet (*Echinochloa crusgalli*), fantail (*Setaria geniculata*), and Bermuda grass (*Cynodon dactylon*) were the principal plants encountered, whereas in grassy seeps they constituted the marginal vegetation along with the emergent forms such as mud plantain (*Heteranthera reniformis*), panic grass (*Panicum dichotoiflorum*), and *Paspalum* sp.

The degree and regularity of late summer and fall precipitation sufficient to maintain temporary habitats may be an important factor in determining the extent of the annual appearance of this species. At Florence, Alabama, larvae of *C. tarsalis* invaded excavation pits in a sewer line construction area in September 1954, but were not found in nearby polluted backwater pools of a lateral drain on the Cypress Creek arm of Pickwick Reservoir until November of the same year. In general, *C. tarsalis* favored small pooled areas such as grassy ditches, seeps, hoofprints, and polluted pools rather than large bodies of fresh or polluted water of a more permanent nature. It was not found in leafy pools of rocky stream beds.

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The "Operational and Scientific Notes" section, which follows, is a new section begun with Vol. 16, No. 1, of *Mosquito News.* It is designed to accommodate short contributions which have to do with field operations or observations on the one hand, or laboratory techniques on the other. Items in these categories can therefore be included while they are still of current interest, whereas longer items frequently have to wait for several issues when there is a backlog of longer, more formal papers.

Attention is also called to the "News and Notes" section which is compiled by Austin Morrill. Austin has made this section one of the departments to which many of our members turn first, to learn what has been going on and who has been doing what. A glance at this section in this issue will indicate what type of items we like to have for it and how they are handled. News and Notes should be addressed directly to Austin Morrill. The Operational and Scientific Notes should be addressed to the editorial office in Albany, N. Y.