OBSERVATIONS ON *ANOPHELES WALKERI* THEOBALD IN THE TENNESSEE VALLEY

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The mosquito, *Anopheles walkeri,* is more widely distributed, occurs in greater numbers, and bites man more readily in the Tennessee Valley than is generally known. It breeds in relatively permanent aquatic habitats containing emergent plants such as cattail, sawgrass, or lizard-tail. Although the larval habitat of *A. walkeri* and *Anopheles quadrimaculatus* may be essentially the same, the diurnal resting places of the adult mosquitoes vary so greatly that they are rarely taken together.

In past years, the importance of *A. walkeri* as a pest or as a possible vector of malaria in the Tennessee Valley may have been overlooked because the adults, which resemble *A. quadrimaculatus* superficially, have never been identified from specimens taken in barn collecting stations during TVA's routine inspection seasons from May through September. During the past 21 years, 166,518 mosquito station inspections have been made throughout the Valley and while over a million *A. quadrimaculatus* and numerous other anophelines have been recorded, no *A. walkeri* has ever been detected in these routine inspections.

During the summer months adults of *A. walkeri* show a strong preference for diurnal resting sites on emergent aquatic vegetation rather than in barns, nail kegs, or privy-type structures where other native anophelines are frequently found. In 1947, from approximately 40,000 anopheline adult mosquitoes collected in nail kegs around Blackwell Swamp, only one *A. walkeri* was detected, although they constituted about 30 percent of the anophelines taken in night collections (2, 3). In 1949 mosquitoes were collected from a series of privy-type resting shelters and nail kegs along the margin of Blackwell Swamp. From the total mosquitoes collected and identified, only one female *A. walkeri* was captured while 60,253 *A. quadrimaculatus,* 448 *A. crucians,* 289 *A. punctipennis,* and small numbers of fifteen culicine species were taken (5).

Although it appears that *A. walkeri* avoids resting in barns and other diurnal shelters frequented by *A. quadrimaculatus* during the hot, summer months, small numbers were found in barns during the cooler, fall months after routine inspections were terminated. An inspection of a barn about ⅞ mile north of Blackwell Swamp during August and September of 1948 yielded only *A. quadrimaculatus;* however, during a nocturnal visit on October 29, females of *A. walkeri* were observed biting in the barnyard, and several engorged specimens were found the next day randomly distributed within the barn. Subsequent inspections of this barn showed that engorged females continued to frequent this barn until November 23 when a final series of five engorged specimens were collected. Later collections were negative for *A. walkeri* although *A. quadrimaculatus* and *A. punctipennis* were found in about equal numbers.

By means of night-biting collections, *A. walkeri* in the Tennessee Valley was first detected in 1939 at Live Oak near Paris, Tennessee. The following year it was found at two other separate, but similar, ponded situations where the natural drainage of small streams had been blocked for several years by silt from the natural erosion.

In 1947, several night collections in the

Wheeler Reservoir area revealed *A. walkeri* to be present and abundant. The most favorable type of habitat in this area appeared to be where lizardtail, *Saururus cernuus* L., and waterwillow, *Decodon verticillatus* (L.) Ell., were the dominant emergent plants (3). One of the best collecting sites was at Blackwell Swamp, an old spring-fed tupelo gum swamp now largely cleared of trees. Extensive bands of lizardtail were present along the open margin and smaller stands had colonized the periphery of the old emergent tupelo stumps (Fig. 1). The adults of *A. walkeri* were commonly found resting during the day a few inches above the water level on the stems of lizardtail, waterwillow, and in the old tupelo stumps. Because of their leafy canopy and naked stems, these plants actually afford the resting mosquitoes more protection from the elements than the cattail type of vegetation with which they are usually associated.

Night collections appear to give the most reliable index to the density and distribution of *A. walkeri*. A technique for making night collections was first used in 1939, and, since that time, TVA entomologists have found it to be a very satisfactory method for detecting the presence of *A. walkeri* as well as other night-biting mosquitoes. This collecting method, which has been called the "parked car technique," may be used as follows:

"Drive an automobile to the collecting site just before or at sundown and park facing the breeding area; leave headlights on for the first five minutes after dark, then turn them off; open all doors and windows, and turn on overhead domelight. If only one collector, sit in back seat and expose the arms and legs as

FIG. 1. Old tupelo stumps and associated stands of frost-damaged lizardtail as viewed from the west margin of Blackwell Swamp near Triana, Alabama, October 19, 1948.

feeding surfaces. With flashlight, aspirator, and killing tube (or cages), collect the mosquitoes as they appear" (2, 3).

In actual practice, many more specimens are captured from the interior surfaces of the car (*i.e.,* windshield, rear window, doors, and upholstery) than from the human bait. The open doors and interior of the car furnish the mosquitoes suitable temporary stopping places before and/or after they feed, and most of them are usually captured before they succeed in taking blood. This technique takes into consideration several characteristic reactions of *A. walkeri* including a marked attraction to light, a suitable host, and a period of flight at dusk.

From the records on 6,140 specimens thus obtained, from September 1948 to August 1949 it appears that *A. walkeri* was active well into the fall and tolerates a considerably wider temperature range than *A. quadrimaculatus* (6). On October 17–18, frost killed the emergent lotus and most of the tall lizardtail, the normal diurnal resting sites for *A. walkeri.* The reasons for an unusual surge of activity noted in collections in late October of 1948, and the occurrence of the species in barns in October and November are not clearly understood, but such activity could be related to the winter kill of vegetation normally used for diurnal resting sites, thus forcing the mosquitoes to seek other types of shelter along the wooded shoreline, and closer to the collection site. Further, the cooler temperatures may have influenced the adult mosquitoes to rest longer in the car, where they were caught more readily. It is also quite possible that a buildup of emerging adults occurred during the cold period previous to the October peak and conditions were not favorable for adult flight activity until the end of October.

As a part of TVA's malaria control program, Blackwell Swamp was dewatered after July 1949 and anopheline production in this area was virtually eliminated. Although collections were continued here throughout the remainder of 1949, these negative data are not presented because, after this drastic ecological change in the mosquito breeding grounds, the results are not comparable to data previously collected to show the seasonal occurrence of this species.

Females of *A. walkeri* showed a secondary feeding peak at dawn along the swamp margin, but it was not nearly so marked as in the early evening. Feeding in bright sunlight was also observed for this species. On October 19, 1948, at least four females entered the parked car on the west side of the swamp and attempted to feed on man during the 1100–1200 hour period.

Adults were captured on several occasions in the open and in barns approximately 5/8 mile from Blackwell Swamp without the factor of attraction to light. One collection two miles distant was negative. At Reelfoot Lake, Tennessee, specimens of *A. walkeri* were recovered in traps at a town about 2 miles from the nearest breeding area, but these mosquitoes may have been influenced by light along the way. Release and recovery of marked specimens for a more accurate determination of the flight pattern were attempted; however, only small numbers of marked individuals were released and none were recovered (1).

Along the swamp margin at Reelfoot Lake *A. walkeri* made short interrupted flights. In the late afternoon hours it has been seen pausing on the upper leafy surfaces of buttonball as it moved from one group of plants to another (6). Such series of short flights appeared to be a normal pattern of dispersal, but, of course, this type of visual observation could not be made for long flights. Other workers observed that *A. walkeri* does not often fly out to the center of a lake "because there is no food to be had there" (1). They operated a light trap from a boat located on open water about 100 yards from the marshes and caught only 3 *A. walkeri,* while simultaneous collections at an equal distance ashore yielded 141 *A. walkeri.*

On October 28, 1948, approximately 1,400 female *A. walkeri* were captured on the west bank of Blackwell Swamp and they were released from the opposite east

bank the same evening (2,000 hrs.) after they had been thoroughly dusted with rhodamine B.* A flashlight was set up across the swamp on the original capture site with the thought that it might possibly attract the dyed adults back across approximately 1,000 feet of water surface which was broken by stumps, lizardtail, and lotus. A parked car collection the early part of the next evening (Oct. 29) showing the number of dyed specimens recaptured per 15-minute collecting period is presented in table 1.

TABLE 1.—Parked car collections of female *A. walkeri* on west bank of Blackwell Swamp, Wheeler Reservoir, October 29, 1948

Time (CST)	*A. walkeri*	+ Rhodamine B
1630–1700	511	33
1700–1730	636	36
1730–1800	416	34
1800–1830	218	11
1830–1900	79	4
1900–1930	38	0
Total	1,898	118

A subsequent collection of 304 *A. walkeri* at this same collection point on November 3 yielded two more dyed specimens making a total of 120 or 8 percent of the marked individuals released. Therefore, at Blackwell Swamp, this species returned to its original location across water, but whether it came in short or long flights is unknown (6). In one night collection (August 26, 1947), 29 female *A. walkeri* were taken during a three-hour period at Cane Landing which was approximately 1,100 feet across the open water of the Tennessee River from Blackwell Swamp, the nearest known breeding grounds of *A. walkeri* (4).

Limited observations at Reelfoot Lake indicated that during the spring and fall *A. walkeri* was captured more frequently on man than in a nearby light trap run concurrently with the biting collections (7). It was also observed that *A. walkeri* was active primarily at ground levels when paired biting collections on man were made at ground, 30-ft., and 75-ft. elevations on the margin of the cypress forest (8). These biting collections were made without the use of lights. Where light traps have been operated simultaneously at the base and atop a 100-foot bluff, catches of *A. walkeri* have been considerably more plentiful at the base of the bluff (1).

In recent years, TVA's malaria control operations, especially shoreline topography changes, dewatering, and water level management, have eliminated many situations which at one time appeared to be optimum breeding places for *A. walkeri*. Only occasional specimens are now recovered, and these are found in relatively permanent pooled areas not materially affected by the seasonal recession phase of the reservoir operation or in swampy areas apart from the main reservoir but within the Tennessee River watershed.

The following is a record of the occurrence of *A. walkeri* in the Tennessee River watershed. The site, or condition under which collected, is indicated by the following abbreviations: B=barn; C=parked car; BM=biting man in open; L=larva; P=pupa; RP=resting on plant stem; and RK=resting in nail keg.

TENNESSEE. Paris, VII–17–39 (BM–8), V–17–40 (BM–15), VI–5–40 (C–4), VI–52 (BM–6); Bruceton, V–31–40 (C–1); Camden, VI–13–51 (C–1).

ALABAMA. Triana, VII–16–47 (C–1), VII–17–47 (C–13), VIII–47 (RK–1), IX–28–48 (C–88), IX–29–48 (C–85), X–1–48 (C–9), X–4–48 (L–5), X–10–48 (L–3), X–12–48 (P–1), X–13–48 (C–231) (RP–4), X–19–48 (C–4) (BM–1), X–20–48 (C–10) (L–2), X–21–48 (C–181), X–27–48 (C–673) (L–2), X–28–48 (C–1456) (B–3), X–29–48 (C–1903), XI–3–48 (C–304), XI–7–48 (B–1), XI–9–48 (C–15) (B–1), XI–10–48 (B–1), XI–17–48 (B–3) (C–14), XI–18–48 (B–2), XI–23–48 (B–5), XI–29–48 (RP–1), XII–13–48 (C–12), XII–14–48 (C–22), V–16–49 (C–1), VI–

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14–49 (C–3), VI–22–49 (C–57) (RK–1), VI–27–49 (C–42), VII–5–49 (C–94), VII–18–49 (C–6), VII–25–49 (C–829), VII–27–49 (C–4), VIII–15–49 (C–2), VIII–23–49 (C–3), VIII–30–49 (C–1), IX–19–49 (C–1); Decatur, VII–21–47 (C–4); Redstone Arsenal, VII–24–47 (C–5); Mooresville, VII–24–47 (C–1); Somerville, VIII–5–47 (C–57), VIII–26–47 (C–18) (BM–11); Smithsonia, X–15–48 (C–1), X–20–49 (C–7), X–24–49 (C–1); Greenbrier, VIII–26–49 (C–3), VIII–29–49 (C–1), IX–14–49 (C–2), X–17–49 (C–1), XI–30–49 (C–1), VIII–4–55 (BM–1).

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Literature Cited

1. BANG, F. B., QUINBY, G. E., and SIMPSON, T. W. 1943. Studies on *Anopheles walkeri* Theobald conducted at Reelfoot Lake, Tennessee, 1935–1941. Am. J. Trop. Med. 23:247–273.

2. Malaria Control Division. 1948. Significant developments in TVA's malaria control program through 1947. Health and Safety Department, Tennessee Valley Authority, pp. 47–48.

3. SMITH, G. E. 1948. The occurrence of *Anopheles walkeri* Theobald in the Tennessee Valley. (Unpublished TVA report.)

4. SMITH, G. E. 1948. Studies on the flight dispersion of *Anopheles quadrimaculatus*, Blackwell-Buckeye area, Wheeler Reservoir, 1947. (Unpublished TVA report.)

5. SNOW, W. E. 1949. Studies on portable resting stations for *Anopheles quadrimaculatus* in the Tennessee Valley. J. Nat. Mal. Soc. 8:336–343.

6. SNOW, W. E. 1951. A preliminary review of the mosquitoes of the Tennessee Valley region, pp. 165–180. (Unpublished TVA report.)

7. SNOW, W. E., and PICKARD, EUGENE. 1954. Observations on the seasonal activity of some night-biting Diptera. J. Tenn. Acad. Sci. 29:17–22.

8. SNOW, W. E. 1955. Observations on the seasonal activity of blood-sucking Diptera with special reference to vertical distribution in bottomland forest. Ann. Ent. Soc. Am. 48:512–521.