

BEHAVIOR OF *PSOROPHORA* SPP. AND *ANOPHELES QUADRIMACULATUS* INSIDE AND AROUND UNTREATED FARM BUILDINGS IN A RICE GROWING AREA

J. B. GAHAN, H. G. WILSON, AND D. E. WEIDHAAS

Entomology Research Division, Agr. Res. Serv., USDA, Gainesville, Florida 32601

The cultural methods currently used to grow rice in the vicinity of Stuttgart, Arkansas, are favorable to the development of large numbers of mosquitoes. *Psorophora* spp. primarily a combination of *Psorophora confinnis* (Lynch-Arribálzaga) and *Psorophora discolor* (Coquillett) predominate in June and July. While the rice fields are being alternately flooded and dried, tremendous populations of these floodwater species are produced. *Anopheles quadrimaculatus* Say is prevalent from May until after the rice fields are drained for the last time in the early part of September, but the population never reaches the heights attained by *Psorophora* spp. Throughout the latter part of August and the first part of September, when the rice fields remain flooded continuously, most *Psorophora* spp. disappear, and *A. quadrimaculatus* becomes the predominant species.

Although we have studied the effectiveness of insecticides applied as residual sprays in the area of Stuttgart by making hundreds of daytime inspections of buildings and have become familiar with the habits of adult mosquitoes in these structures between dawn and dusk, we knew little about the habits after dark. Therefore, during the summers of 1967 and 1968, we made a series of nighttime observations inside of and in the vicinity of some of the untreated buildings that we knew were used by adult *A. quadrimaculatus* as daytime resting places.

The present paper summarizes the information gained through the daytime observations made over the past 25 years and presents the results of the nighttime studies made in 1967 and 1968.

DAYTIME OBSERVATIONS

Psorophora spp. are usually scarce and seldom troublesome in buildings during the daytime. Often, when these insects are pestiferous outdoors during the hours immediately after dawn, considerable relief from their biting can be obtained by entering buildings, even those containing *A. quadrimaculatus*. In contrast, throughout the rice growing season, adult *A. quadrimaculatus* are prevalent in the daytime inside many of the farm buildings, particularly in structures used to house horses, cows, chickens, pigs, or dogs. They also inhabit some pump houses and storage sheds that do not house animals but are close to barnyards or pastures where animals are kept. We have seen more than 10,000 adults of this species at one time in a single stable or chicken house.

During the early part of the morning and on cloudy days when the temperature ranges in the 70's or the low 80's, the adults often sit on the underside of the roof or on the upper parts of the walls. At such times, they are easily disturbed, fly frequently, and sometimes feed if a host is available. As the temperature and light increase on hot sunny days, they gradually move down the sides of the walls into dark corners. At a temperature above 90° F., they seldom fly more than a few feet unless they are disturbed, and they usually are not interested in feeding; when the temperature in wooden buildings exceeds 100° F., they sometimes sit on the earthen floors. Adult *A. quadrimaculatus* are found on all types of wood or metal surfaces, but spider webs often are preferred resting places, perhaps be-

cause they are cooler than the wooden or metal walls during the warmest part of the day. The mosquitoes seldom are entrapped in the webs, and they leave any time they wish to fly. On cloudy, rainy, or cool days, flying and biting often continue inside the buildings throughout the day.

NIGHTTIME OBSERVATIONS

Most nighttime observations were made in and around 3 horse stables, a cow barn, and a potato storage shed, but 2 chicken houses and a tool shed were also investigated. The study was started August 1967 in the chicken houses, one horse stable, the cow barn, and the tool shed. Chickens were on the roosts in the chicken houses, but the other buildings did not contain animals at the time the observations were made. By August, most *Psorophora* spp. had disappeared so our observations were confined to *A. quadrimaculatus*. Since mosquitoes were rarely observed feeding on the chickens, those resting on the walls and ceilings were counted and classified as fed or unfed.

In 1968, the horse stable and cow barn investigated in 1967 were used again. Also two other horse stables were studied. This year a horse was placed in each of the four buildings at least 2 hours before the first counts were made and was left there throughout the night. The potato shed was used without an animal in it. Also, in 1968, we determined the proportion of male and female *A. quadrimaculatus* in the buildings and classified the females as unfed, freshly fed, or gravid. When the infestation was less than 500-600, every adult *A. quadrimaculatus* that could be found was counted. However, when densities were high, the total was determined by counting 100 mosquitoes and estimating the number of similar samples in the buildings. If more than 150 mosquitoes were present, the classifications, male, female, unfed, freshly fed, or gravid, were determined by examining about 100 insects selected at random.

Also, in July 1968, *Psorophora* spp. were

so numerous in two of the horse barns that their presence could not be ignored. Since they were too numerous and too active to count, variations in their density from one visit to another were estimated by counting those sitting on 1 sq. ft. of the inside and outside walls.

Both years, observations were made every 1 or 2 hours throughout the night with flashlights to determine whether annoyance occurred continuously or was more prevalent during one portion of the night. Visits were started between 5 and 6 p.m. Central Daylight Time (CDT) and discontinued at 6 to 9 a.m. CDT the following morning. During the period of the studies, the sun set between 8:19 and 7:53 p.m. and rose between 6:12 and 6:32 a.m. CDT. Complete darkness occurred about 30 minutes after sunset and the first light of dawn appeared high in the sky about 30-45 minutes before sunrise.

DENSITIES OF *Psorophora* spp. IN 1968. No counts of *Psorophora* spp. were made in the stables on nights when no horse was present, but few if any *Psorophora* spp. were ever seen on the inside or outside walls at such times. Even when a horse was present, the density usually did not exceed 5 or 10 between 5:30 and 7:30 p.m. and those that were there were rarely seen on the horse. In the potato shed which had no host animal, no *Psorophora* spp. were found on either the inside or outside walls throughout the night.

However, when a horse was present, *Psorophora* spp. became very active at dark (about 8:50 p.m.), and large numbers entered both stables. By 10 p.m. thousands were sitting or flying inside and around these buildings. As shown in table 1, counts made on the marked areas of the two stables indicated that the density per sq. ft. of wall space was 26 and 34, respectively, on the outside and 74 and 113, respectively, on the inside.

Hundreds more were flying or feeding on the horses. The animals were bitten so extensively that they continually stamped their feet, shook their heads, and moved their tails. At times they shook their

TABLE 1.—Density of *Psorophora* spp. on the inside and outside walls of 2 stables containing horses in July 1968.

Time	Number of mosquitoes/ ft ² of wall	
	Inside	Outside
	Stable 1	
6:00 p.m.	0	0
8:00 p.m.	1	0
10:00 p.m.	74	26
12:00 p.m.	64	19
2:00 a.m.	59	34
4:00 a.m.	33	12
6:00 a.m.	0	0
7:00 a.m.	0	0
	Stable 2	
6:30 p.m.	0	0
8:30 p.m.	0	0
10:30 p.m.	113	34
12:30 a.m.	146	14
2:30 a.m.	98	19
4:30 a.m.	61	17
6:30 a.m.	25	0

entire bodies and threw mosquitoes in all directions. Favored places for feeding were the faces, necks, bellies, and legs. On one visit we counted 240 mosquitoes on the face and neck and more than 300 on the legs of a mare before she chased them, and our count represented less than the total present. Most of the mosquitoes present were *Psorophora* spp. but some were *A. quadrimaculatus*. The population in both stables remained heavy throughout the night, but by 2 a.m., the flying activity was reduced because many of the mosquitoes present had become engorged and sat quietly on the inside and outside walls or ceiling.

We believe that the *Psorophora* spp. were able to detect the presence of the horses without seeing them for we found hundreds sitting on the outside walls of both buildings. The horse could get no closer than 25 feet to one wall on which the mosquitoes were sitting, but there were cracks between the boards through which odors passed. The large number of unfed females sitting on the inside and outside walls of the building was interesting. One would expect that mosquitoes

in the process of locating a suitable host would fly directly to the animal, but large numbers alighted on the walls before feeding.

At dawn, most of the mosquitoes left and returned to daytime resting places in nearby vegetation.

On one occasion, the potato storage shed and a nearby stable were used to study the effect on *Psorophora* spp. of transferring a horse from one location to another. At 6:15 p.m., the horse was inside the stable, and 125 *Psorophora* spp. were feeding on her; only 2 other *Psorophora* spp. were in the building. At 8:15 p.m., we counted 215 on the outside of the stable, 112 feeding on the horse, and only 1 flying or resting on the inside walls. (Although the sun had set by this time, visibility was still good.) By 10:15 p.m., about 1.5 hours after dark, the number of *Psorophora* spp. on the outside had risen to 85/sq. ft. and the number inside was 150/sq. ft. During these same periods, we found only one on the inside and none on the outside of the walls of the unoccupied potato storage shed, even though mosquitoes were plentiful in the area, and there was considerable biting occurring outdoors after dark.

At 10:15, the horse was moved from the stable to one corner of the potato storage shed. Subsequently, the infestation rapidly increased in the vicinity of the storage shed and decreased in and around the stable. By 10:30 p.m., the count of *Psorophora* spp. showed 26/sq. ft. on the outside of the potato shed near the horse's head; also, mosquitoes were starting to collect on 3 sides of the building. Ten minutes later, the count had increased to 45/sq. ft. near the horse's head, and mosquitoes were found on all parts of the building. By 10:50, the count had reached 52/sq. ft. near the horse's head. In contrast, the infestation inside the stable decreased 77 percent within 15 minutes after the horse was removed and dropped another 47 percent in the next 15 minutes. Most *Psorophora* spp. that remained sat quietly and made no effort to find the horse. The experiment was

discontinued at 11 p.m. because the horse was being badly bitten.

Two nights later, the same transfer was made after several thousand *Psorophora* spp. had collected in the stable. Within one minute after the horse was moved to the potato shed, the mosquitoes on two walls of the stable were dusted with a yellow phosphorescent powder. Ten minutes after the transfer, we found dusted mosquitoes sitting on the outside wall of the potato shed or feeding on the horse, when an examination was made with an ultraviolet light. The number of dusted mosquitoes reached a peak of 23 on the horse within 20 minutes and then started to decrease. By 11 p.m., only 3 were on the horse, and none were on the potato shed. Thus, though some mosquitoes that left the stable found the horse again, they were only a small fraction of the total population that came to the new location. At 11 p.m., there were still dusted mosquitoes inside the stable and on weeds around the stable but many less than before the removal of the horse.

DENSITIES OF *Anopheles quadrimaculatus* IN 1967 AND 1968. In the buildings we examined in 1967 that contained no animals, we found adult *A. quadrimaculatus* resting during late afternoon. As darkness approached, the females left gradually, and during the early hours of the night, the population decreased rapidly and it remained low until dawn. However, all adults left only one of the four sites studied. In that stable, 104 and

119 *A. quadrimaculatus* were present at 4:30 and 5:30 p.m., respectively, on August 17, 1967. The mosquitoes started to leave between 5:30 and 6:30 p.m., and the count was below 10 by 10:30 p.m. and reached zero between 5 and 6 a.m.

In the tool shed and cow barn, which contained no animals but were on farms with animals housed nearby (studied July 27, 1967 and August 7, 1967, respectively), infestations ranged from 83 to 434 during the late afternoon. *A. quadrimaculatus* started to leave between 7 and 8 p.m., and counts were as low as 4 to 43 by 10:30 p.m. The number present then continued to decrease slowly throughout the remainder of the night but never reached zero.

Table 2 summarizes the results obtained in 1968 in the unoccupied potato storage shed. The data presented are an average of three series of observations made the nights of July 23-24, August 19-20, and August 21-22. On two occasions between 6 to 6:30 p.m. and 8 to 8:30 a.m. and on one occasion between 8 to 8:30 p.m. and 6 to 6:30 a.m., the number of *A. quadrimaculatus* present exceeded 1,000. Since totals of this magnitude were conservative estimates rather than actual counts, the size of the infestations were not determined accurately. However, many mosquitoes that had used this shed as a daytime resting place left before dusk, and a high proportion had disappeared by 10-10:30 p.m. The exodus continued at a slow rate throughout the remainder of

TABLE 2.—Density of *Anopheles quadrimaculatus* in an unoccupied potato shed, July and August, 1968.

Time	Total number of mosquitoes	Percent of females present	Percent of females that were—		
			Gravid	Freshly engorged	Unfed
6-6:30 p.m.	>790	74	78	1	21
8-8:30 p.m.	>448	87	71	0	29
10-10:30 p.m.	87	99	83	1	16
12-12:30 a.m.	67	100	94	0	6
2-2:30 a.m.	36	100	97	0	3
4-4:30 a.m.	27	100	93	0	7
6-6:30 a.m.	>427	80	75	11	14
8-8:30 a.m.	>1,000	55	76	2	22

the night. Also before dark, 13-26 percent of those present were males, but after dark, males were rarely seen. A vast majority of the females in this building during the daytime was either gravid or unfed. Gravid females predominated during the nighttime, but many left. The only time freshly engorged females comprised more than 1 percent of the mosquitoes was after dawn when the insects were seeking daytime resting places, and many gravid and unfed females, as well as males, came into the building.

The situation was quite different in buildings that contained animals. In most cases, the number of mosquitoes present during the daytime was much higher than in buildings without animals, but densities of *A. quadrimaculatus* usually decreased shortly before dark as they did when animals were not present. Then at dusk or soon thereafter, this trend reversed, and the population began to increase again.

Thus, in a chicken house studied in 1967 that contained 12 roosting chickens after dark, the count dropped from 1,054 to 427 between 6 and 8 p.m. This trend had reversed by 9 p.m. (15 minutes after

dark) and by 10 p.m. the infestation had increased to 975. Throughout the remainder of the night the counts made at 2-hour intervals ranged from 763 to 1,086.

In another chicken house that contained 140 chickens after dark, the count dropped from 1,067 to 947 between 5 and 6 p.m., and then increased to 1,259 by 7 p.m.; thereafter, through the rest of the night, it ranged from 973 to 1,335.

The results obtained July 23-24, 1968 in 2 stables each containing a horse are shown in table 3. In one stable, only 101 *A. quadrimaculatus* were found at 6 p.m. (We believe this count would have been much higher if the horse had spent the previous night inside the building instead of in the pasture.) In the other barn, more than 2,000 *A. quadrimaculatus* were present at 6 p.m. The infestations in both buildings started to decrease more than an hour before dark and were quite low at 10 p.m. However, sometime between 10 p.m. and midnight, the populations began to increase again, and they continued to rise throughout most of the remainder of the night. Unfed mosquitoes began entering before dark (between 6 p.m. and 8 p.m.), and

TABLE 3.—Density of *Anopheles quadrimaculatus* in two stables containing horses, July 23-24, 1968.

Time	Total number of mosquitoes	Percent of females present	Percent of females flying or resting that were—		
			Gravid	Freshly engorged	Unfed
Stable 1					
6:00 p.m.	101	98	100	0	0
8:00 p.m.	57	100	91	0	9
10:00 p.m.	21	100	0	38	62
12:00 midnight	79	100	1	38	61
2:00 a.m.	157	100	2	66	32
4:00 a.m.	225	100	0	88	12
6:00 a.m.	546	99.6	3	76	21
7:00 a.m.	682	99.3	13	78	9
Stable 2					
6:00 p.m.	>2,000	86	95	1	4
8:00 p.m.	>1,000	100	89	4	7
10:00 p.m.	12	100	25	17	58
12:00 midnight	98	99	6	56	38
2:00 a.m.	177	100	10	62	28
4:00 a.m.	126	100	8	70	22
6:00 a.m.	>2,000	98	52	48	0

some feeding occurred at that time, but most feeding in both buildings occurred after dark. By 4 a.m., 70-88 percent of those present were freshly engorged, but this proportion decreased after dawn when gravid and unfed females came in to find a daytime resting place. Males were scarce during the night but were found easily between dawn and dusk.

It was interesting to us that some unfed females left the buildings in the evening even though a suitable host was present. Apparently, some females leave daytime resting stations in response to stimuli that result in a general pattern of dispersal, and responses to host-seeking stimuli follow this general pattern.

It became obvious that gravid females moved to some extent at night while their eggs were developing. All or a majority of the mosquitoes in the buildings at 6 and 8 p.m. were carrying eggs, but after dark, many left, and throughout the middle of the night, gravid females comprised only a small percentage of the population. Undoubtedly, some females left to lay their eggs, but probably all of them did not since many mosquitoes entering at dawn were heavily laden with eggs. We

believe a portion of the females spent the night outdoors in vegetation where the temperature was more favorable than indoors and where heavy dews furnished the high humidity and water needed for survival. No extensive survey was conducted, but engorged females were seen sitting on bushes near the stables.

After the farmers discontinued the drainage of rice fields and *Psorophora* spp. became scarce, tests were made in another 2 stables that contained one horse each to find out if *A. quadrimaculatus* continued to enter throughout the night. Each time the density was checked, all the adult mosquitoes were removed from the walls and ceilings with a vacuum cleaner. Thus, those present during the next observation period presumably had been in the buildings no longer than 2 hours. No moon was shining, and the minimum temperature for the night was 73°-75° F. One building was studied the night of August 19-20, 1968 and the other the night of August 21-22, 1968.

As shown in table 4, *A. quadrimaculatus* continued to enter both buildings throughout the night; more than 1,000 were present each time a count was made.

TABLE 4.—Effect of removal of females every 2 hours on density of *A. quadrimaculatus* in untreated buildings at various times throughout the night, August 19-22, 1968.

Time	Total number of mosquitoes	Percent of females present	Percent of resting females that were:			Mosquitoes on horse	
			Gravid	Freshly engorged	Unfed	Number	Percent of total
Barn with horse							
5:30 p.m.	853	98	86	3	11	3	0.3
7:30 p.m.	140	100	60	5	35	5	4
9:30 p.m.	>1,000	100	1	2	97	80	<7
11:30 p.m.	>1,000	100	3	9	88	32	<3
1:30 a.m.	>1,000	100	4	3	93	37	<4
3:30 a.m.	>1,000	100	2	7	91	47	<4
5:30 a.m.	>1,000	100	5	18	77	57	<5
7:30 a.m.	>2,000	99	40	28	32	34	<2
6:00 p.m.	>1,000	62	59	3	38	11	>1
8:00 p.m.	>1,000	95	13	4	83	39	>4
10:00 p.m.	>1,000	100	8	47	45	98	>9
12:00 midnight	>1,000	100	3	57	40	20	>2
2:00 a.m.	>1,000	100	2	93	5	64	>6
4:00 a.m.	>1,000	100	7	92	1	113	>12
6:00 a.m.	>1,000	100	12	84	4	47	>4
8:00 a.m.	>1,000	78	32	57	11	0	0

They came in so rapidly that neither stable could be entirely emptied of mosquitoes while it was being vacuumed. Some mosquitoes that entered must have come from adjoining buildings where they had been resting because gravid females were present during most of the observation periods. However, during the night they represented only a small proportion of the total.

The amount of feeding done in the two buildings varied considerably. In one, more than 50 percent of the mosquitoes observed between 10 p.m. and midnight and above 90 percent of those seen between 2 and 4 a.m. were freshly engorged; shortly after dawn when gravid and unfed adults came in to rest during the daytime, the proportion that had fed dropped. In the other stable, most of the mosquitoes found throughout the night had not fed. An explanation for the difference in feeding in the two buildings was not readily apparent. The stable where the rapid feeding occurred was much the smaller of the two, and the mosquitoes may have found the horse more easily. Also this building was located within 50 feet of a rice field so it probably had a higher humidity than the other stable which was at least one-fourth mile from the nearest rice field.

Throughout this study, also, the *A. quadrimaculatus* that entered the buildings at night often rested on the walls and ceilings for some time before feeding on any animal, a behavioral pattern similar to that noted earlier for *Psorophora* spp.

The results also indicated that many *A. quadrimaculatus* entering these stables during the night found other daytime resting places than the building in which they fed. If all had remained, the mosquito counts at dawn would have been at least 5,000-7,000, but an infestation of this magnitude was never found in either building. Some engorged adults that we saw outside the stables or on nearby vegetation when the only host in the vicinity was the horse inside were undoubtedly leaving for other resting places.

The rapidity with which adult *A. quad-*

rimaculatus changed their daytime resting places was investigated by dusting a fluorescent dye along the walls of a cow barn on September 10, 1968 at 10:15 a.m. while about 4,000 *A. quadrimaculatus* were resting there (at least 40 percent of the mosquitoes were colored with the dye). Cows from a herd present in a surrounding pasture, entered and left this building *ad libitum*. Treated mosquitoes were found for the next 5 nights inside this building when examinations were made after dark with an ultraviolet lamp. However, the number of dyed mosquitoes was only a small percentage of the 1,500-2,000 *A. quadrimaculatus* present in the building each night, and the number remained above 100 for less than 59 hours: 356 dyed mosquitoes were counted the night after the treatment, the number decreased to 131 the second night, to 9 the third night, to 2 the fourth night, and to 1 the fifth night. Also, between 73 and 140 resting mosquitoes were collected each morning from the cow barn and examined under the ultraviolet lamp. The proportion that were dyed dropped from 19 percent at 24 hours posttreatment to 1 percent after 96 hours.

DISCUSSION. The rice growing area of Arkansas has both advantages and disadvantages for a study of this type. The conditions necessary to produce tremendous populations of mosquitoes are present throughout much of the summer, and as a result, the densities of *A. quadrimaculatus* and *Psorophora* spp. are high enough so that many conclusions can be based on extremely large samples. There can be no doubt, therefore, that adult *A. quadrimaculatus* find buildings excellent daytime resting places for they use them extensively. Buildings that house animals are preferred, but unoccupied structures are also used if animals are in the vicinity. Adults of this species remain quiescent throughout most daylight hours on hot sunny days but continue to fly frequently and feed indoors on cloudy, rainy, or cool days. Many females leave their daytime resting places and start feeding before dark, but others sit quietly

until after nightfall. Unfed females come into stables or barns containing animals throughout the night and feed, but most of them ignore unoccupied buildings. When they are fed, they often leave again and seek other resting places. The males leave buildings about dark and are seldom seen indoors again until the following morning. A high proportion of the gravid females also spend the night outdoors. *Psorophora* spp. come into buildings that contain animals after dark and cause serious annoyance, but they seldom use such places during the daytime.

On the other hand, the densities at the site of this study were frequently so high and the mosquitoes were so active that actual counts were subject to considerable error. When the number present was greater than 200 or 300, it was seldom possible to complete a count before one or two mosquitoes flew and disturbed others. Also it was impractical to make accurate counts where the infestations were as high as the 1,500 to 2,000 mosquitoes often found in the buildings studied. With such conditions, evaluations had to be based on estimates. Thus, though *Psorophora* spp. were extremely abundant, even an estimate of the total present would have been extremely inaccurate: so the evaluations had to be based on counts made on areas as small as 1 sq. ft. of wall space.

Our results agree with those obtained by Tarzwell and Fisk (1947) in a study conducted on the nighttime behavior and resting habits of *A. quadrimaculatus*. They found this species entered buildings at dusk both before and after treatment with DDT. Before treatment, the number resting in a barn increased progressively throughout the night, and many rested on the walls or ceilings for considerable periods before as well as after feeding.

SUMMARY

A study was made to determine the activities of adult *Psorophora* spp., primarily a combination of *P. confinnis*

(Lynch-Arribálzaga) and *P. discolor* (Coquillett) and *Anopheles quadrimaculatus* Say in buildings near Stuttgart, Arkansas.

During the daytime, *Psorophora* spp. were scarce, but *A. quadrimaculatus* was prevalent inside many farm buildings. *Anopheles quadrimaculatus* was most numerous in structures that housed horses, cows, chickens, pigs, and dogs, but it also was found in unoccupied buildings close to barnyards or pastures where animals were kept. Early in the morning and on cloudy days, adult *A. quadrimaculatus* often rested on the underside of the roofs or on the upper parts of the walls, but as the temperature increased on hot days, they gradually moved down the sides of the walls, seldom flew more than a few feet, and lost their interest in feeding. They rested on any type of wood or metal but often preferred spider webs. On cloudy, rainy, or cool days, flying and feeding tended to continue throughout the daytime inside the buildings.

At dark, *Psorophora* spp. entered two stables that contained horses and were serious pests throughout the night. Thousands were flying or feeding throughout the night, and the animals present were bitten so frequently they could not stand still, but by 2 a.m., flying and feeding activity was reduced. At dawn, most *Psorophora* spp. left the buildings and returned to daytime resting places in the vegetation. The mosquitoes could detect the presence of an animal without seeing it. When a horse was transferred from a stable to an unoccupied shed, the population of *Psorophora* spp. increased at the new location, but only a small proportion of the mosquitoes present followed the horse from the stable.

As dark approached, *A. quadrimaculatus* started leaving buildings regardless of whether the structures were unoccupied or housed animals. The exodus continued throughout the night if no animals were present. However, when an animal was present, the population began to increase again at dusk or soon thereafter and reached densities above 1,000 in some

places. Unfed female *A. quadrimaculatus* began entering buildings containing animals and feeding before dark; however, most feeding occurred after dark. The influx continued throughout the night, but many left before morning. Unoccupied buildings were ignored at night. Males as well as females rested in buildings during the daytime. However, a high proportion of the gravid females and

most of the males spent the night outdoors. Most, but not all adult *A. quadrimaculatus* changed their daytime resting sites from one day to another.

Literature Cited

TARZWELL, C. M., and FISK, F. W. 1947. Observations on the nighttime resting and biting habits of anopheline mosquitoes in DDT-treated and -untreated buildings. Pub. Hlth. Reports 62: 84-94.

EFFECT OF RESIDUAL APPLICATIONS OF BAYGON® AND CARBARYL ON THE ACTIVITIES OF MOSQUITOES IN BUILDINGS¹

J. B. GAHAN, H. G. WILSON, AND D. E. WEIDHAAS

Entomology Research Division, Agr. Res. Serv., USDA, Gainesville, Florida 32601

Baygon® (*o*-isopropoxyphenyl methylcarbamate) and carbaryl are two insecticides that have attracted considerable attention as possible replacements for the DDT and dieldrin used in residual spray programs against anopheline mosquitoes in malaria control programs. LaBrecque *et al.* (1960), Gahan *et al.* (1961), and Schoof *et al.* (1962) found these two materials promising in laboratory tests. Later, Smith and Hocking (1963a, 1963b) and Gahan *et al.* (1964) reported that Baygon produced at least several months' control of free flying mosquitoes in buildings that contained natural infestations of either *Anopheles gambiae* Giles or *Anopheles quadrimaculatus* Say. Both groups of investigators found carbaryl much less effective, and Smith and Hocking (1963b) observed that many mosquitoes entering huts treated with carbaryl were irritated by the chemical and escaped before they made lethal contact. Gahan *et al.* (1964) reported that after adults of *A. quadrimaculatus* entered at dawn into buildings

sprayed with either of these insecticides and rested on the treated surfaces, Baygon eliminated them all within 1 or 2 hours after sunrise whereas carbaryl, a much slower acting material, often failed to eliminate them by noon or even by late afternoon.

In field studies made to evaluate new insecticides as residual treatments against natural infestations of *A. quadrimaculatus* we have used the absence of resting adults during the daytime as an indication of the effectiveness of a compound. This method of evaluation has allowed us to eliminate from further consideration many compounds that lose their toxicity too rapidly to be highly effective residual sprays. However, malarial parasites require 7 or more days to complete their developmental cycle in the mosquito before the disease can be transmitted to other hosts (Young, 1960), so fast action and prevention of all biting are not required characteristics for insecticides used as residual sprays in malaria eradication campaigns. (The characteristics are still desirable because they help those conducting such campaigns to obtain cooperation from the beneficiaries.)

¹ Mention of a pesticide in this paper does not constitute a recommendation of this product by the USDA.