OBSERVATIONS ON THE BIONOMICS OF *MANSONIA* (*MANSONIOIDES*) *UNIFORMIS* (THEOBALD) AND *M.* (*M.*) *AFRICANA* (THEOBALD) IN GAMBELA, ILLUBABOR PROVINCE, ETHIOPIA[1]

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ABSRACT. *Mansonia uniformis* (Theobald) and *Mansonia africana* (Theobald) were found to be the most abundant anthropophilic mosquitoes in the environs of Gambela, Illubabor Province, Ethiopia. Both species were highly exophilic and exophagic, more abundant during the wet season than the dry season, and showed maximum biting activity during the hour following sunset. The potential of the two species as vectors of human disease is discussed.

During the course of an entomological assessment of malaria transmission in Gambela, Ethiopia (Krafsur, 1971), it was observed that *Mansonioides* spp. were the most prevalent of all mosquitoes caught biting human bait. In early darkness, in fact, the numbers of attacking *Mansonioides* were often so great as to make the efficient capture of all of them impossible. Despite the obviously vast numbers of *Mansonioides* relative to man, few were found resting indoors in early morning pyrethrum spray captures. Thus, in Ethiopia, much as elsewhere in Africa (Mattingly, 1957), the potential of disease transmission by *Mansonioides* is apt to be overlooked because of their resting behavior after feeding.

In view of their high man-biting rates, *Mansonia* (*Mansonioides*) *uniformis* (Theo.) and *M.* (*M.*) *africana* (Theo.) may prove to be vectors of considerable importance in Ethiopia. In Malaya, Wharton (1962) found that *M. uniformis* was a primary vector of *Brugia malayi* (periodic endemic filariasis). The same mosquito was shown to be the principal vector of *B. malayi* in Ceylon (Carter, 1950) and an important vector of *Wuchereria bancrofti* in New Guinea (van Dijk, 1958). Records exist of mature *W. bancrofti* infections in wild *M. africana* and *M. uniformis* (see Horsfall, 1955). On the other hand, Smith (1955a) found only very immature filarial forms in *Mansonioides* spp. on Ukara Island, Tanzania. Numerous arboviruses have been recovered from *M. uniformis* and *M. africana*. These include Wesselsbron, Ndumu, Spondweni, Pongola, chikungunya and West Nile from *M. uniformis* (Worth *et al.*, 1961; Schmidt, 1965; Taylor, 1967) and Bunyamwera, chikungunya, Pongola, Sindbis and Spondweni from *M. africana* (Worth *et al.*, 1961; Taylor, 1967). Experimental transmission of yellow fever virus has been achieved with *M. africana* (Phillip, 1930) but not with *M. uniformis* (Kerr, 1932). The host range of *M. uniformis* and *M. africana* includes birds as well as man (Smith, 1955b), permitting a hypothetical bird-man transmission cycle of locally prevalent arboviruses.

This report describes the population dynamics, relative prevalence, and man-biting behavior of *Mansonia* (= *Taeniorhynchus*) *uniformis* and *M. africana* in a lowland region of western Ethiopia.

METHODS

The present observations were made over the period Dec. 1967–Dec. 1968 in the small provincial town of Gambela and in much smaller groups of native huts all of which border the River Baro. The study region lies at about 525 m. in eleva-

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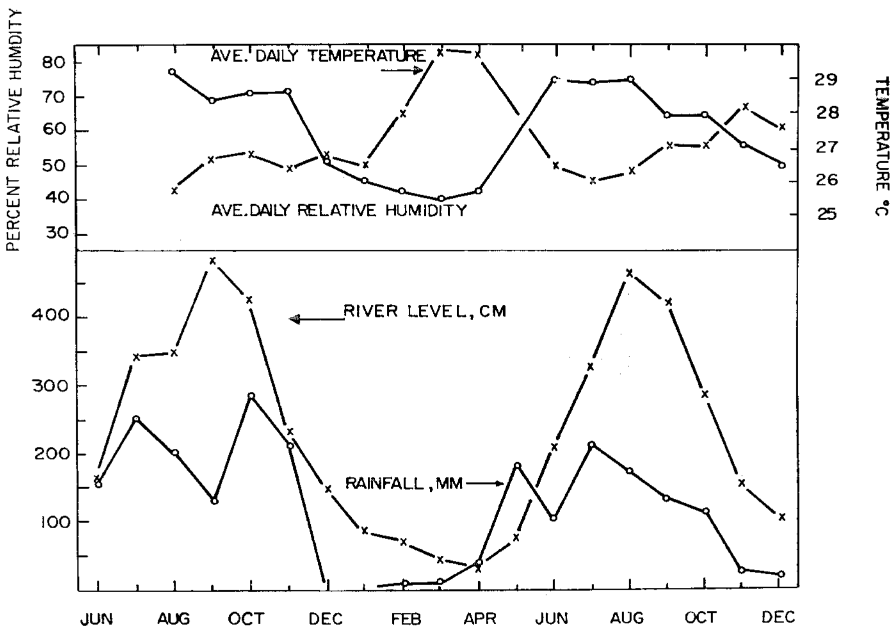

Fig. 1.—Climatic conditions in Gambela, June 1967–Dec. 1968.

tion in western Ethiopia (approximately 8° 15′ N by 34° 35′ E) at the foot of the highlands to the east. The area is a savanna with well-marked semiannual wet and dry seasons (Fig. 1). During the wet season, areas immediately adjacent to the River Baro flood, forming temporary swamps. Numerous small, seasonal streams are present throughout the region.

The inhabitants live in single-room huts of grass and mud. No domesticated animals are kept with the exception of chickens and very few dogs.

Man-mosquito contact was estimated by two methods. Native huts were sprayed in early morning with 0.6 percent pyrethrum aerosol and the knocked-down mosquitoes removed with forceps from sheets spread beforehand on the floor. Such "space-spray" collections were made in six huts daily, no individual hut being sampled more often than once monthly. The results were expressed as the number of each species per hut per day.

To sample mosquitoes attempting to bite human bait, three men were stationed in a hut while three others were placed outdoors nearby in the open. Each collector, a member of the locally-predominant tribe, was provided with an aspirator and flashlight. Of each team of three, two men actively collected while one member slept within immediate reach. Sleeping was for 4-hour periods in rotation. The catch was begun at 1800 and stopped at 0700 hours. In the latitude of Gambela, sunset was at about 1830 and sunrise at ca. 0630 hours. Mosquitoes biting or landing on any of the human baits were aspirated and placed into small holding cages which were changed hourly by a full-time supervisor. Catches were sorted by location (indoors and outdoors) and hour of capture for later identification.

Two typical native huts in different locations in Gambela were employed for the all-night catch, each hut being used once weekly and occupied at other times by a native family.

RESULTS

PYRETHRUM-SPRAY CATCHES. Indoor-resting *Mansonioides* were captured in low densities throughout the study period; the results are expressed as values of "hut density" (mosquitoes per hut per day) (Table 1). Virtually all specimens were freshly engorged, and no gravid were found. Males were occasionally found. In order to compare directly the magnitude of indoor-resting populations with those caught biting man (Fig. 2), values of hut density were converted into estimates of bites per man per night. This was done by dividing the estimated average number of human occupants per hut (3) into yearly averaged values of hut density (Dec. '67–Nov. '68). Thus, expressed as bites (mosquitoes) per man per day, annual averages of 0.017 *M. uniformis* and 0.043 *M. africana* were recovered resting indoors in Gambela. Directly measured yearly average indoor values of bites per man per night of 8.15 *M. uniformis* and 11.93 *M. africana* (see Fig. 2) suggested that the actual densities of these species were 479-fold and 277-fold greater, respectively, than the comparable values derived from estimates of indoor-resting collections. *Mansonioides* are therefore highly exophilic, and the number of bites suffered by the inhabitants of the study region must be enormous.

Hut densities (mosquitoes per hut per day) of both *Mansonia* species were higher in the river villages than in Gambela (Table 1). For the period of Dec. 1967 to Nov. 1968, the mean hut density of *M. uniformis* and *M. africana* in Gambela was, respectively, 0.05 and 0.13 mosquitoes per hut per day, while in the river villages values of 0.18 and 0.26 mosquitoes/hut/day were obtained. Thus, *M. uniformis* densities were more than three times as great, and *M. africana* were twice as prevalent in the river villages than in Gambela. These observations may be explained by the facts that the human population of Gambela is much more dense than the river villages, while at the same time available breeding sites relative to

TABLE 1.—Indoor-resting densities of *Mansonia uniformis* and *M. africana* in Gambela and nearby villages.

	Gambela			River Villages		
		Hut density[a]			Hut density[a]	
Period	No. huts sprayed	*uniformis*	*africana*	No. huts sprayed	*uniformis*	*africana*
Dec. '67	108	0	0.02	36	0.11	0.14
Jan. '68	108	0.06	0.05	42	0.25	0.45
Feb.	102	0.02	0.04	33	0.09	0.27
Mar.	96	0	0.02	32	0.37	0.37
Apr.	78	0.03	0	34	0.21	0.71
May	114	0.04	0.05	32	0.34	0.28
June	96	0.08	0.06	36	0.31	0.28
July	96	0.05	0.18	46	0.04	0.28
Aug.	114	0.08	0.11	63	0.17	0.06
Sept.	90	0.01	0.22	46	0.11	0.11
Oct.	108	0.11	0.47	42	0.29	0.24
Nov.	96	0.10	0.31	38	0	0.16
Dec.	60	0.08	0.25	16	0.56	1.19
Average	1266	0.052	0.135	496	0.194	0.292

[a] hut density = mosquitoes collected per hut per day

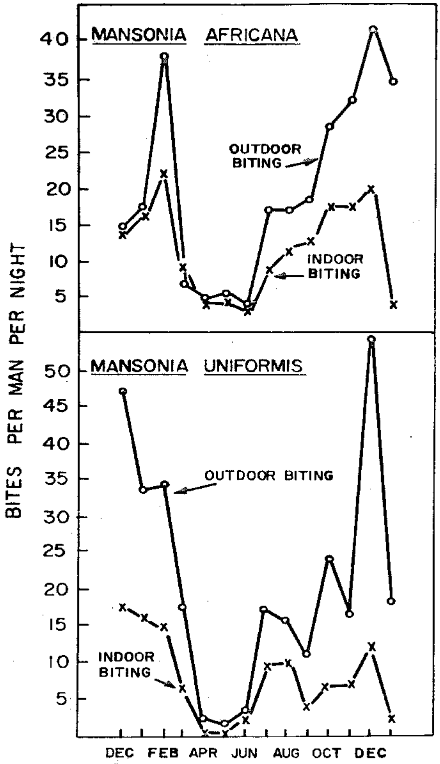

FIG. 2.—Seasonal distribution of *Mansonioides* taken at 3 human baits indoors or 3 baits outdoors expressed as bites per man per night.

the human population are much greater in the river villages.

SEASONAL DISTRIBUTION. *Mansonioides* indoor-resting collections (Table 1) were seasonally distributed much as were the results of the man-biting catches (Fig. 2). In general, both *M. africana* and *M. uniformis* were more abundant during the wet season than during the dry season. However, maximum population densities of both species were observed early in the dry season. The dynamics of *M. uniformis* and *M. africana* populations were not alike in the early dry season of 1968; thus, *M. uniformis* populations peaked in December, while those of *M. africana* peaked two months later, in February. A similar disparity between the dynamics of the two species was not observed in the following year.

Minimal population densities were recorded in the last (and driest) month of the dry season and in the first two months of the wet season. In July, the third month of the wet season, populations of *Mansonioides* began to increase until values of forty to sixty bites per man per night were recorded in December.

It was not altogether clear which environmental factors were principally responsible for the seasonal population dynamics. Because of the dependence of *Mansonioides* larvae on certain aquatic plants, a correlation between population density and river level (Fig. 1) might be established. The correlation is a tenuous one, periods of greatest abundance (July–Dec.) having occurred when the river rose to its maximum level and thereafter declined precipitously. Minimal populations of *Mansonioides* were observed when the river was at its lowest point (in April, Fig. 1) or beginning to rise due to rains in the highlands nearby (May and June). The latter observation may suggest that flooding and washing out of breeding sites, particularly the aquatic plants that *Mansonioides* larvae depend on, may be important in maintaining small early wet season populations. On the other hand, permanent and semi-permanent swamps exist which may have supported breeding. Because no plant or larval surveys were carried out, further speculation would be unwarranted.

RELATIVE ABUNDANCE OF THE TWO *Mansonioides* SPECIES. Indoor-resting *M. africana* were recovered more frequently than *M. uniformis* in both Gambela, by a factor of 2.6, and in the river villages, by a factor of 1.5. Approximately 1.5 times as many *M. africana* as *M. uniformis* (Table 2; 3781/2550=1.5) were taken in Gambela by the all-night indoor human bait capture method. On the other hand, human bait captures staged outdoors resulted in more *M. uniformis* than *M. africana*. By adding together the indoor and outdoor man-biting catch results, totals of 9,800 *M. africana* and 9,184 *M. uniformis* (Table 2) suggest that these species were actually almost equally prevalent.

RELATIVE INDOOR AND OUTDOOR BITING AND RESTING BEHAVIOR. Exophagic feeding behavior was demonstrated when *Mansonioides* were given equal opportunity to attack human bait indoors and outdoors. Thus, over the 14-month study period, an average of approximately 39 percent of the total *M. africana*, and 28 percent of *M. uniformis* were taken biting indoors (Table 2). It is interesting that

Only very minor differences were observed in the biting cycle of *M. africana* and *M. uniformis*, the overall picture being virtually identical (Fig. 3). In both species, biting activity was minimal in the hour during which sunset occurred (1800–1900), but the principal peak followed in the next hour, between 1900 and 2000 hours. A secondary peak of aggressive activity was recorded between 2200 and 2300, activity thereafter declining in a more-or-less linear fashion. A small, perhaps insignificant, tertiary peak of biting occurred between 0100 and 0200.

The "cycles of aggressivity" described above are in close agreement with those of Hamon (1963) in Upper Volta, Surtees

TABLE 2.—The total numbers and associated statistics of *Mansonia* species biting human bait indoors and outdoors in Gambela, Dec. 1967–Jan. 1969.

	M. africana		*M. uniformis*	
	In *	Out *	In *	Out *
Total no. caught	3781	6019	2550	6634
No. man-nights	312	312	312	312
Avg. bites/man/night	12.1	19.3	8.2	21.3
Ratio, outdoor biting / indoor biting	1.6		2.6	
Percentage biting indoors	38.6%		27.7%	

* 3 men in each location 1800–0700 hrs.

the relative proportions biting indoors and outdoors were not constant over the study period. Nearly equal numbers of *Mansonioides* were taken indoors and outdoors when populations were minimal (March–June). Thereafter, the relative proportions biting outdoors increased as the total biting population increased (Fig. 2). These observations suggest a density-dependent relationship and one of epidemiological significance.

BITING CYCLE. Records of the relative proportions biting in any one hour of the period 1800–0700 hours strongly suggested that the time of attack of indoor-biting and outdoor-biting *Mansonioides* was closely similar. For this reason, the indoor and outdoor human bait-capture results for each species were combined in the graph shown as Figure 3.

(1970) in Kenya, and Wharton (1962) in Malaya. Similar biting cycles among *M. uniformis* and *M. africana* were reported by Haddow (1945) in Uganda and by Hamon (1963).

DISCUSSION

Both species of *Mansonia* were observed resting indoors in low frequency, while human-bait captures suggested that the actual densities were very much higher. In Gambela, averaged over the period December to the following November, biting catches indoors showed *M. uniformis* to be about 480 times as prevalent, and *M. africana* about 280 times as prevalent than indicated by the indoor-resting collections for the same period. Thus, most indoor-biting *Mansonioides* leave the

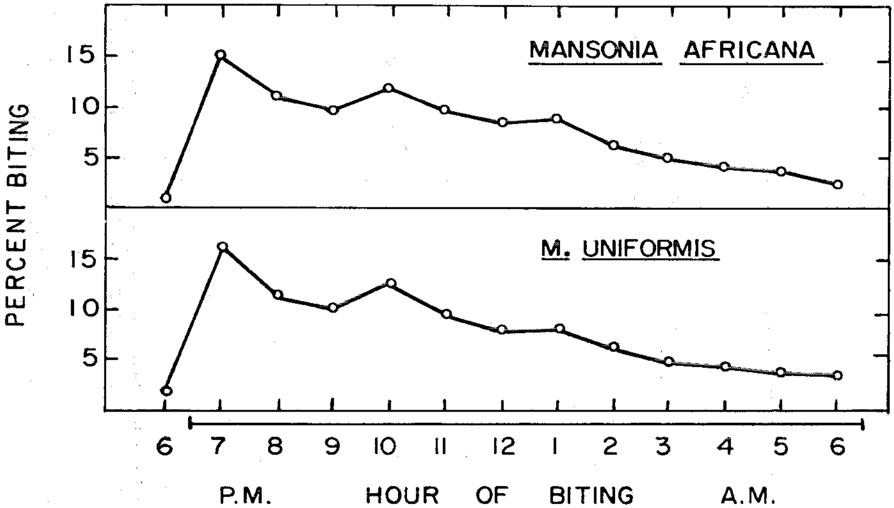

Fig. 3.—The biting cycles of *Mansonioides* in Gambela, Dec. 1967–Jan. 1969.

site of feeding by the following morning. When given equal choice of feeding indoors or outdoors, *M. africana* was more prone to indoor biting than was *M. uniformis*. Considered together, these observations show that *M. africana* is less exophagic and exophilic than *M. uniformis*, clearly an important difference in behavior between the two species. Lewis (1947) found that *M. africana* was more common in huts in Sudan although *M. uniformis* was probably the predominant *Mansonioides* species overall. Similar observations were made in Kenya and Uganda (Haddow, 1942, 1945).

The fact that, among *Mansonioides*, the relative proportions biting indoors decreased as total populations increased is difficult to explain. Clearly, the phenomenon was not related to climatic factors since it was observed in both the wet and dry seasons. The finding is epidemiologically significant because it suggests that people indoors in the early evening are at less of a risk than those remaining outdoors during periods of greatest *Mansonia* abundance. Elliot (1968) showed that the relative proportions biting indoors increased directly with population densities of *Anopheles gambiae* Giles in Africa and *An. albimanus* Weidemann, *An. nuneztovari* Gabaldon and *An. darlingi* Root in Colombia. Thus, *Mansonioides* differ fundamentally from these anopheline species.

Of considerable epidemiological importance is the fact that a large proportion of the total biting population of *Mansonioides* attacked man outdoors soon after sunset. This happens to be the period when most inhabitants are outdoors cooking and socializing with other villagers. The very high man-biting rates suffered by the inhabitants demonstrates the disease transmission potential of these species, notwithstanding the rather low life expectancy (Gillies, 1963) and probable low infection rates resulting from such longevity.

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