Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1968, **38**, 239-253

Studies on Man–Vector Contact in Some Malarious Areas in Colombia

R. ELLIOTT [1]

The frequency of man-biting by mosquitos depends upon the amount of contact between man and mosquito, which in turn depends upon the behaviour patterns of both. In order to examine these relationships in an area with a high incidence of malaria, a study was made in 1965 of the nocturnal movements and of mosquito biting habits in five localities in the malarious area of Colombia that were in the thirteenth or fourteenth cycle of biennial DDT spraying.

The populations were classed into five age- and sex-groups, i.e., men and women over the age of 15 years, boys and girls from 5 to 15 years, and children under 5. A number of differences in the habits of these groups were discovered in relation to time spent indoors or outside, but close to, the house.

The habits of the four main anopheline vector species were studied in relation to human activities. For three of the species (A. albimanus, A. darlingi, A. nuneztovari) *it is suggested that a low relative importance of outdoor biting is caused not by a density-dependent factor but by an anopheline gonotrophic cycle or by relative humidity or both. The fourth species* (A. punctimacula), *common only at one locality, displayed a complex pattern of biting behaviour with, however, a much greater frequency of outdoor biting than in the other species.*

It is considered that in these localities malaria is probably transmitted mainly inside sprayed houses by vectors that are susceptible to the insecticides in use but which are not sufficiently reduced in numbers or in life-expectancy to interrupt the transmission of the parasite.

The man-biting rate, defined as the index of actual incidence of contact between man and mosquito, can be estimated from catches of biting mosquitos on human bait, but Garrett-Jones [2] has pointed out that, in the past, such catches have often been made in places and at times when members of the human population are not normally at risk, thus placing difficulties in the way of estimating the true amount of man-mosquito contact. Recognizing that the man-biting rate must have both an indoor and an outdoor component, and wishing to calculate the relative importance of each, he found that short catches made in the evening hours gave no idea of the total nightly quantity of biting, while catches made through the night simultaneously or alternately indoors and outdoors present an artificial situation since outdoor baits remaining outside the houses after the normal hour of retirement of the majority of people may attract larger or smaller numbers of mosquitos than the indoor baits. In dealing with observations made in this way in Mexico and in some African countries, he decided to ignore the outdoor component of biting after the hour at which the people were overwhelmingly inside their houses, so that in calculating the number of bites per person per night, three elements were taken into account:

(1) the number of bites per person outdoors from sunset to bedtime;

(2) the number of bites per person indoors from sunset to bedtime;

(3) the number of bites per person indoors from bedtime to dawn.

The man-biting rate was then calculated by adding (3) to the mean of (1) and (2). Those mosquitos found biting human baits outdoors between normal bedtime and dawn were disregarded since they would

[1] WHO/PAHO Entomologist Advisor, National Malaria Eradication Service, Republic of Colombia.

[2] Garrett-Jones, C. (1964) *A method for estimating the man-biting rate* (unpublished working document WHO/Mal/450). A limited number of copies of this document are available to persons officially or professionally interested on request to Distribution and Sales, World Health Organization, 1211 Geneva, Switzerland.

ordinarily have been obliged to seek a meal inside a house or else from an animal host. The night-catch observations described below were carried out in relation to the observed habits of the human population being studied, as recommended by Garrett-Jones (*op. cit.*).

SITE OF OBSERVATIONS

The observations on human and anopheline behaviour were made during the year 1965 at five localities in the malarious area of the Republic of Colombia, all of which lie less than 200 metres (656 ft) above sea-level, with rainfall between 200 cm and 400 cm (79 in–157 in) annually, and which are more fully described elsewhere.[1] At four of them the main activity is mixed farming in areas cleared from tropical forest; the people thus engaged rise early in the morning, often before dawn, and are usually indoors and in bed by 21.00 hours; at Turbo the main occupation is work in commercial banana plantations, and the daily round starts and finishes an hour later. Houses include those built of wood and adobe, the roofs are mainly thatched but some have corrugated iron roofs. At Turbo, however, regular employees occupy concrete or brick cottages, though transient workers live in very roughly constructed shelters. In general, and especially when the spraying of insecticide is considered, the majority of houses are poorly constructed. The walls are often incomplete and present many openings; they are frequently altered or rebuilt, thus destroying sprayed surfaces.

During the year of observations, the thirteenth and fourteenth twice-yearly cycles of house-spraying with DDT were in progress, using 2 g/m² of technical DDT applied as 75% water-dispersible powder. The coverages obtained were, respectively, 73% and 84% at El Pescado, 89% on both cycles at Rio Fuego, 100% on both cycles at Puerto Reyes and Turbo, and 94% on the fourteenth cycle at Las Arañas. The biting incidence fluctuated in the villages in a manner that could not be correlated with the passage of the spraying teams through them. However, there was no evidence of physiological resistance to the insecticide in 1965 or thereafter, and considerable evidence of continued susceptibility.

[1] Elliott, R. (1967) *The biting cycles of some anopheline mosquitos of Colombia* (unpublished working document WHO/Mal/67.600). A limited number of copies of this document are available to persons officially or professionally interested on request to Distribution and Sales, World Health Organization, 1211 Geneva, Switzerland.

METHODS

Human habits

The population under observation was classed into five groups: men and women over 15 years of age; boys and girls from 5 to 15 years; and children under 5 years. Between the hours of 18.00 and 06.00 during the period of study, the inhabitants of the selected houses were observed and the location of each person in the household was noted every half-hour. A classification of their activities was made according to the following scheme: (1) away from the house, (2) near but outside the house, (3) inside the house; (2) and (3) were subdivided according to whether the person was sleeping, resting or active.

Habits of mosquitos

The observations on the biting by mosquitos were made by 3-man teams of collectors led by entomological technicians, but about 10% of the work was professionally supervised. Collectors were stationed inside the houses from 18.00 to 06.00 hours, and in the peridomestic areas (location (2) from 18.00 to 21.00 hours (22.00 hours at Turbo) and again from 05.00 to 06.00 hours (except at Turbo where very few people were about before 06.00 hours). The collectors acting as bait sat with their legs exposed from knee to ankle and caught mosquitos which were biting them and occasionally those biting local volunteers. Collectors were moved around the various stations on a shift system.

In general, 8–10 catches per month were made but public holidays or transport difficulties sometimes reduced the number. The number of human baits used at any one time never reached half the minimum number of 8 persons recommended by Garrett-Jones (*op. cit.*) although the rest of his criteria are reasonably well satisfied.

OBSERVATIONS OF HUMAN HABITS

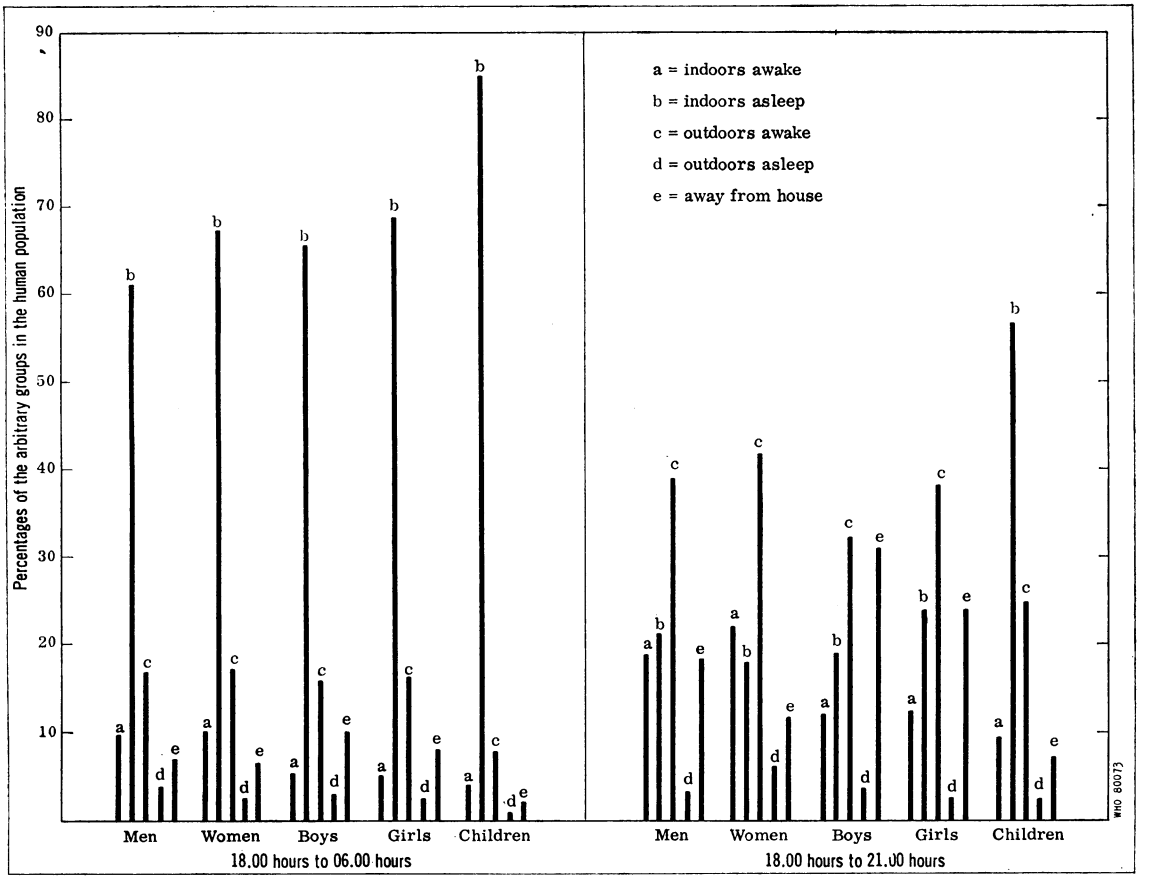
The sample shown in Fig. 1 contains rather too few children to be typical, it also has the disadvantage that the number of individuals was less than the numbers suggest since some families were observed repeatedly. However, the information does bring out certain variations in the habits of the different age- and sex groups in the population.

Habits of men

The greatest part of the night is spent sleeping inside the house (61% of the time between sunset and dawn). About 20% retire early, before 21.00 hours, then there is a steady rise to 85% by 23.00 hours. At all times there are some men awake and

FIG. 1

NOCTURNAL DISTRIBUTION AND ACTIVITIES, BY AGE-GROUP AND SEX, OF THE HUMAN POPULATION IN THE FIVE LOCALITIES STUDIED



moving about indoors. The percentage of men indoors and awake drops from 23% at sunset to 7% by 22.00 hours; over the whole night it accounts for 10% of the time of the men under observation. The habit of sleeping in the peridomiciliary area, in hammocks slung under the eaves, etc., accounts for only 4% of the time. Up to 20.30 hours 40%–45% of the men are outside the house but still in the peridomiciliary area, and just over 20% are away from the house altogether. Both these categories are much reduced after midnight, but at all hours of the night there were some men outside. In the morning, men began to rise at 04.00 hours and 53% were up by 06.00 hours, although only 10% had left for work by that time. Between 04.00 and 06.00 hours the number of men in the peridomiciliary area increased from 3% to 30%.

Habits of women

The women behaved quite like the men in the early part of the night, although rather more were in or near the house. The habit of sleeping in the peridomiciliary area seems actually commoner among women in the early part of the night, but this is a matter of a short nap and few women remain outside after 20.30 hours, and none after 23.00 hours. Over the whole night, the women spent 77% of their time inside the house compared with 71% for the men, and 4% away from the house compared with 7% for the men. The time spent in the peridomiciliary area was similar for men and women, 19% against 21%. The women in this sample rose a little later than the men in the morning and as, one would expect, fewer of them left the house. On the whole, these observations do not indicate any great

excess of exposure to outdoor biting of men compared with women.

Habits of boys

Boys seemed to spend the first hours of the night away from the house more than the other groups, but all returned by 23.00 hours; they also slept later in the morning than the men, but otherwise followed the habits of their elders quite closely. The distribution of their time between indoors and outdoors was the same as for the men, but the boys spent less time (19%) immediately outside the house, and more time away from it (10%) than either men or women.

Habits of girls

The girls spent more time away from the house in the early evening than their elders, but rather less time than the boys; like the boys, they went to bed earlier than the men, but they rose earlier than the boys in the morning. A few slept in the peridomiciliary area. As regards the whole period, they were intermediate between women and both classes of males as to the time spent in the house and away from it; they spent the same time in the peridomiciliary area as women.

Habits of children

Children under 5 years old constitute the only group with really different habits: they leave the house completely even less than women, and are all indoors and in bed by 22.00 hours; 89% of their time is spent indoors, 85% of it sleeping. They also rise later than the other groups.

This study has not demonstrated differences in the habits of the sexes and the age-groups as great as might have been anticipated. Fig. 1 shows the percentages of the members of each group found in each of the five locations between 18.00 and 06.00 hours and between 18.00 and 21.00 hours.

OBSERVATIONS ON HABITS OF MOSQUITOS

Seasonal densities

The seasonal densities have been worked out as monthly man-biting rates on an individual of "average" habits. This hypothetical person is expected to receive half the incidence of indoor

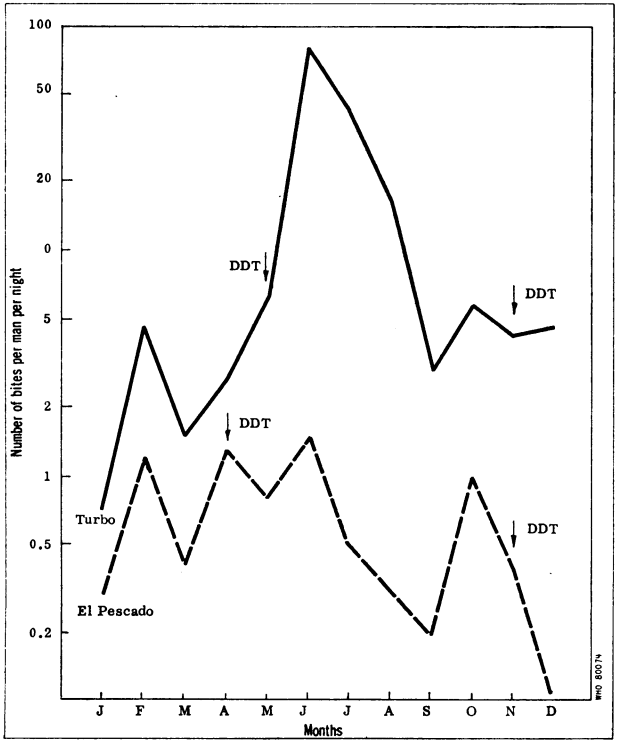
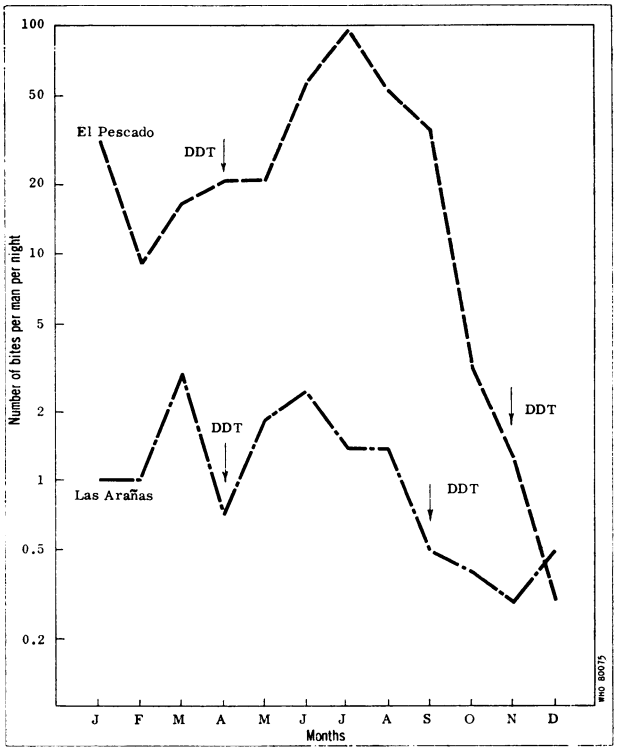


FIG. 2
SEASONAL VARIATION OF BITING-DENSITY IN *ANOPHELES ALBIMANUS* AT TURBO AND EL PESCADO IN 1965 [a]

[a] The arrows indicate DDT spraying.

FIG. 3

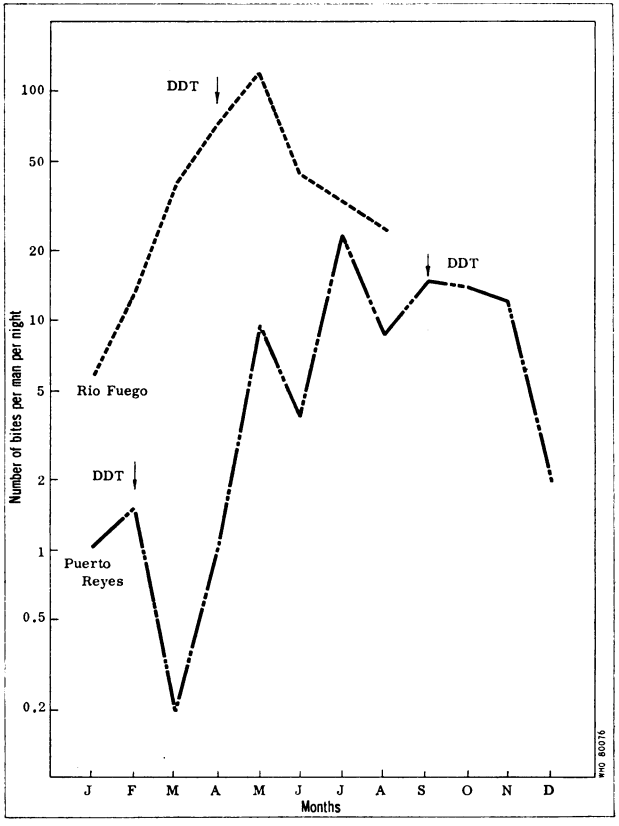
SEASONAL VARIATION OF BITING-DENSITY IN *ANOPHELES DARLINGI* AT EL PESCADO AND LAS ARAÑAS IN 1965 [a]



[a] The arrows indicate DDT spraying.

FIG. 4

SEASONAL VARIATION OF BITING-DENSITY IN *ANOPHELES NUNEZTOVARI* AT RIO FUEGO AND PUERTO REYES IN 1965 [a]



[a] The arrows indicate DDT spraying.

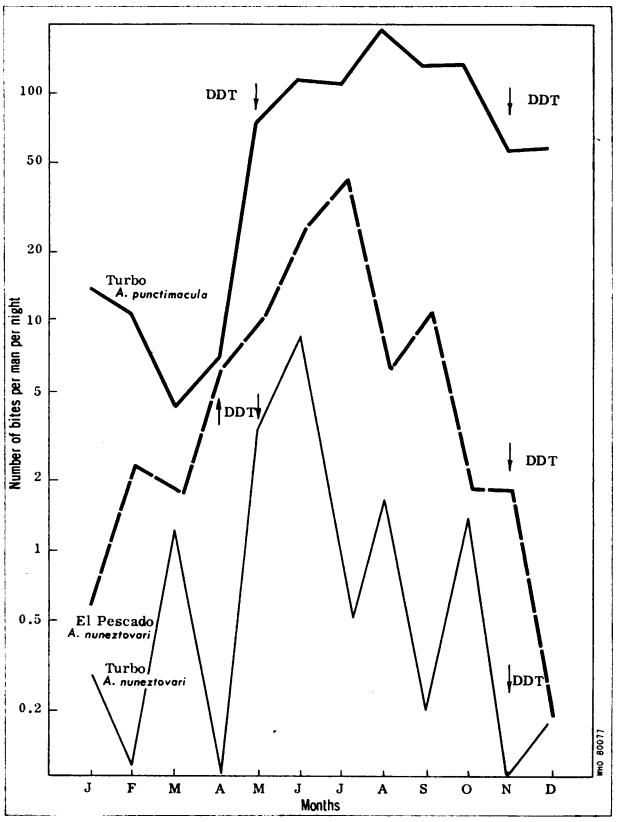


FIG. 5

SEASONAL VARIATION OF BITING-DENSITIES IN *ANOPHELES NUNEZTOVARI* AND *A. PUNCTIMACULA* AT TURBO AND EL PESCADO IN 1965 [a]

[a] The arrows indicate DDT spraying.

biting and half that of outdoor biting that takes place during the morning and evening periods when some of the people are available indoors and outdoors, as well as the whole incidence of indoor biting in the intervening period when nearly everyone is indoors.

In Fig. 2–5 the monthly man-biting rates derived from observations on four vector species are plotted on a logarithmic scale. The monthly variation in the biting density for *Anopheles albimanus* at two localities is shown in Fig. 2; at El Pescado the species showed a low level throughout the year. At Turbo, however, for the 3 months from June to August, it showed over 10 bites per man per night.

A. darlingi at El Pescado (see Fig. 3) showed 3 months of high density (over 40 bites per night) between June and August, 5 of moderate density, (between 10 and 40 bites per night) in January, March–May, and September, and 4 of low density, (below 10 bites per night) in February and October – December. At Las Arañas the density of biting was low throughout the year.

The seasonal densities of *A. nuneztovari* (see Fig. 4 and 5) show a peak in May at Rio Fuego; at Puerto Reyes and El Pescado there are peaks in July, and at Turbo a peak in June. The Rio Fuego densities may be separated into three periods, a low-density period in January and February with less than 10 bites per night; 4 months of medium density in March and June–August with between 10 and 40 bites per night; and a high-density period in April and May. The last 4 months of 1965 could not be studied in this area. At Puerto Reyes, two periods may be considered to occur; one of high density from July to September with a mean biting rate of over 10 per night, and a low-density period over the rest of the year. At El Pescado, similarly, a high-density period of May–July may be compared with a low density period in the remaining months. At Turbo, also, the main contrast is between two periods, the June peak and the remaining 11 months.

The seasonal variation in the density of *A. punctimacula* at Turbo can conveniently be considered in three periods: 4 months of low density (below 20

bites per night) in February–April; 3 months of moderate density (between 20 and 100 bites) in May, November and December, and 5 months of high density (over 100 bites) from June to October. The peak density fell in August, in the centre of this period, as can be seen in Fig. 5.

Times and situations of man–mosquito contact

The monthly man-biting densities described above represent the means of the numbers of bites per night on persons exemplifying two types of human behaviour, one exposing himself to maximum outdoor biting and the other to indoor biting only. In studying the biting cycles of insects it is usual to divide the night's catch into hourly percentages for graphical representation. The outdoor and indoor components of biting may be shown by plotting the hourly indices outdoors (O) and indoors (I) for those hours when contact occurs in both situations. In Fig. 6–10, the two indices are calculated to the base of the mean expressed as 100%.

Human contact in A. (Nyssorhynchus) albimanus *Wiedemann (Fig. 6)*

At Turbo, during the June–August peak, outdoor biting was higher than indoor through the whole period of evening exposure; the peak of biting occurred after this, however, in the hour before midnight, and biting continued at a gradually reducing rate until dawn. A person receiving full outdoor exposure would suffer 1.16 bites, against 1.0 on a person indoors the whole time. During the rest of the year the mean density was much lower, with about 4 bites per night instead of 64, and outdoor biting was even higher in comparison with indoor, especially in the last two hours of the evening period (Fig. 6B). After this peak at 20.00 to 22.00 hours biting declined, but rose again to a pre-dawn peak not seen in the period of high density; in the last hour, indoor biting was fractionally higher than outdoor. The ratio of bites received by a person with maximum outdoor exposure to those received

FIG. 6

MAN-VECTOR CONTACT IN *ANOPHELES ALBIMANUS*

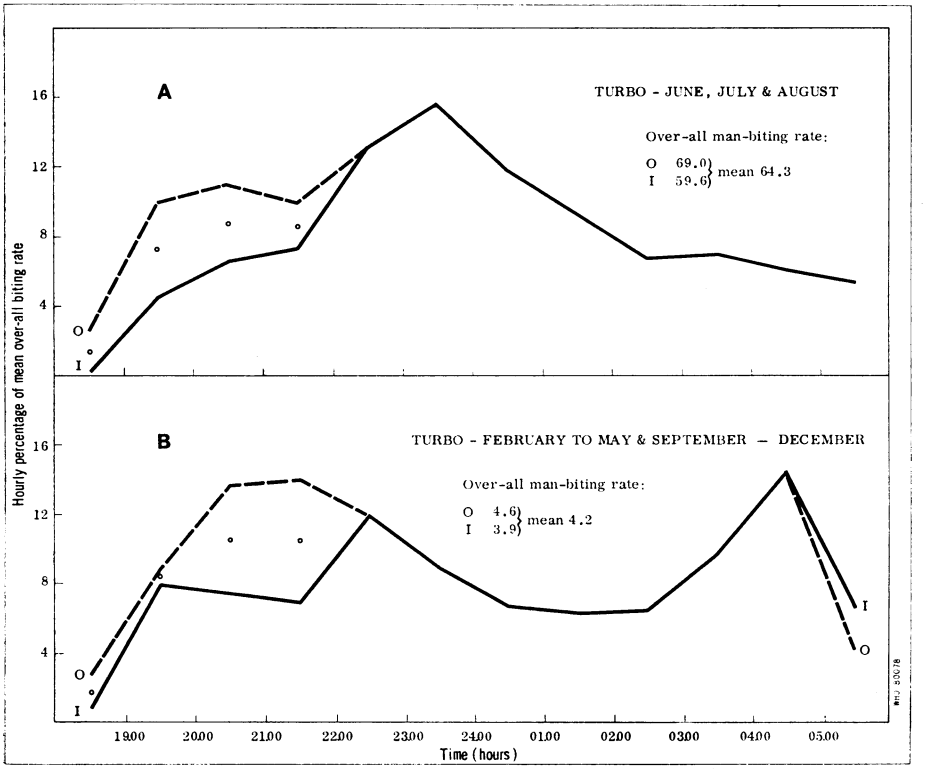
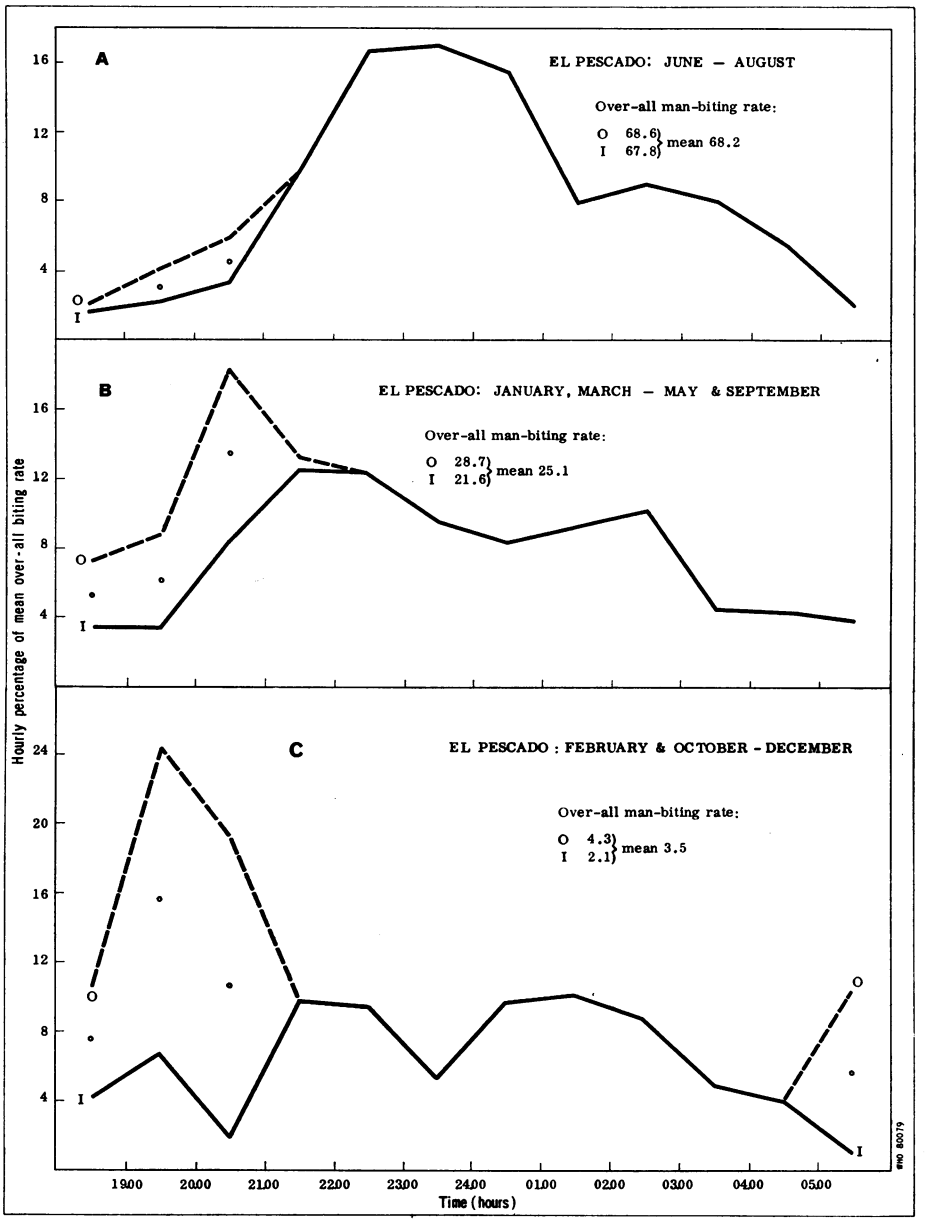


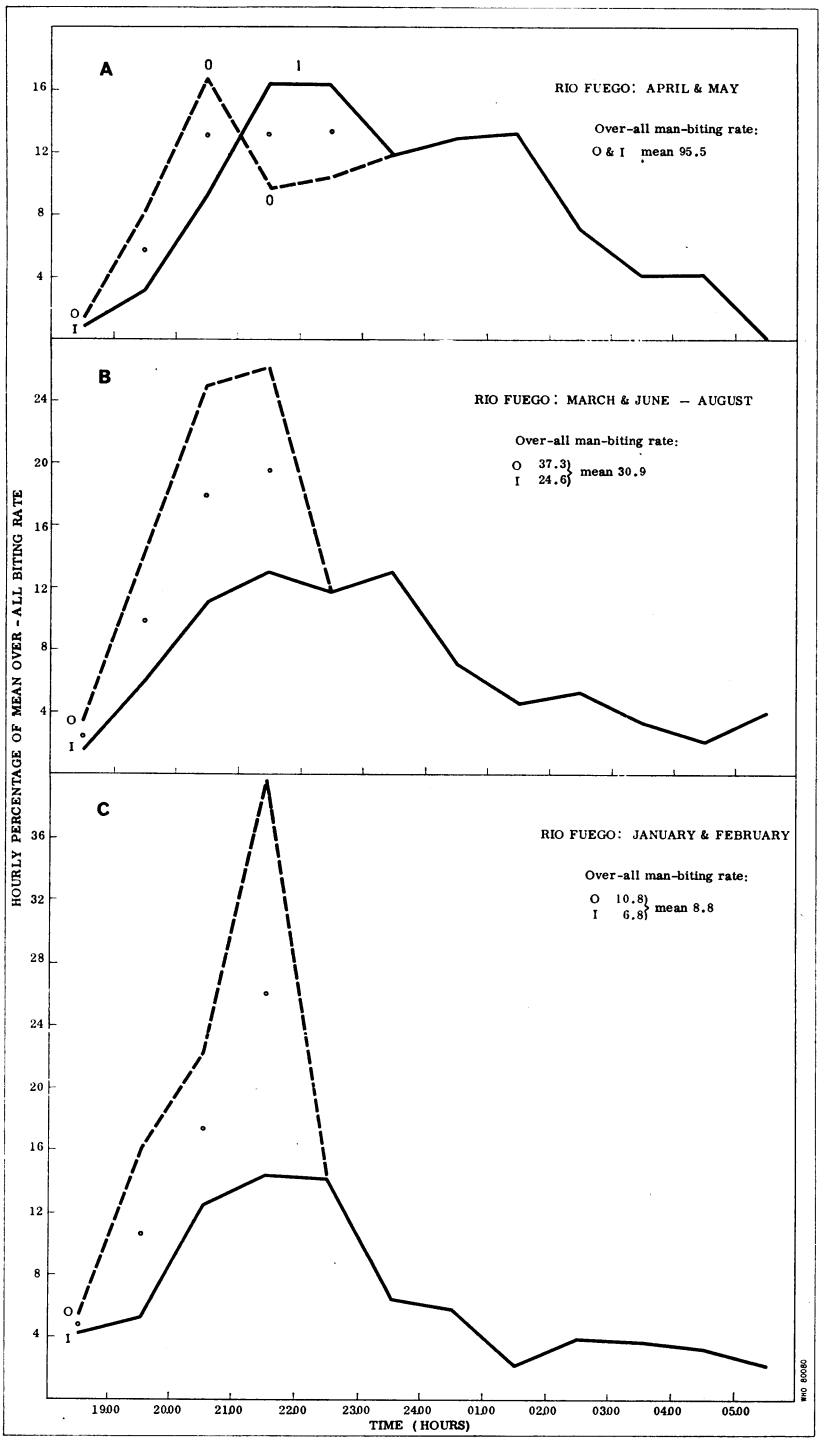
FIG. 7
MAN-VECTOR CONTACT IN *ANOPHELES DARLINGI*



by one remaining indoors (O/I) was slightly higher than in the months of high density, 1.18 : 1.

At El Pescado, where *A. albimanus* was not very common in 1965, there was a peak of predominantly outdoor biting from 21.00 to 22.00 hours; reduced activity continued through the night, with no pre-dawn peak. It appears that in this species, although the outdoor component of biting at all seasons adds from 10% to 40% to the total incidence of man–mosquito contact, this contribution is less important at high densities, during the season of malaria transmission.

FIG. 8. MAN-VECTOR CONTACT IN *ANOPHELES NUNEZTOVARI*



Human contact in A. (Nyssorhynchus) darlingi *Root (Fig. 7)*

At El Pescado, during the 3 months June–August, *A. darlingi* showed a mean biting density of 68 bites per man-night, with the peak of biting from 22.00 to 01.00 hours, when the great majority of the human population are indoors; both in the evening and at dawn there was a slight preponderance of outdoor over indoor biting. During the moderate density period, January, March–May, and September, with a mean biting rate of 25 per night, outdoor biting showed a peak between 20.00 and 21.00 hours, indoor biting, an hour later; a minor peak followed between 02.00 and 03.00 hours. Outdoor biting was distinctly more important during the evening period of exposure. In the months of low density, February and October–December, the peak of outdoor biting was earlier, from 19.00 to 20.00 hours, and higher; the period before dawn also showed heavy outdoor attack (Fig. 7B and 7C). For the three periods, the ratios O/I were, respectively, 1.01, 1.33 and 1.69, which lie in a linear inverse relationship with log density, as can be seen in Fig. 11, although individual months show a pronounced scatter when plotted in the same way. At Las Arañas, the peak of both indoor and outdoor biting over the year was between 22.00 and 23.00 hours, with outdoor biting predominant up to 22.00 hours.

Human contact in A. (Nyssorhynchus) nuneztovari *Gabaldon (Fig. 8 and 9)*

At Rio Fuego, this species showed during the peak months of April and May a different pattern from those species already discussed; the first 4 hours of the evening were divided into two of predominantly outdoor, followed by two of predominantly indoor, biting; over the whole night the ratio O/I was 1.00. In the periods of moderate density (March and June–August), the hours of intense activity ended about midnight instead of being spread over most of the night, and the outdoor component was relatively greater, making the O/I ratio of 1.52 : 1. An exag-

FIG. 9

MAN-VECTOR CONTACT IN *ANOPHELES NUNEZTOVARI*

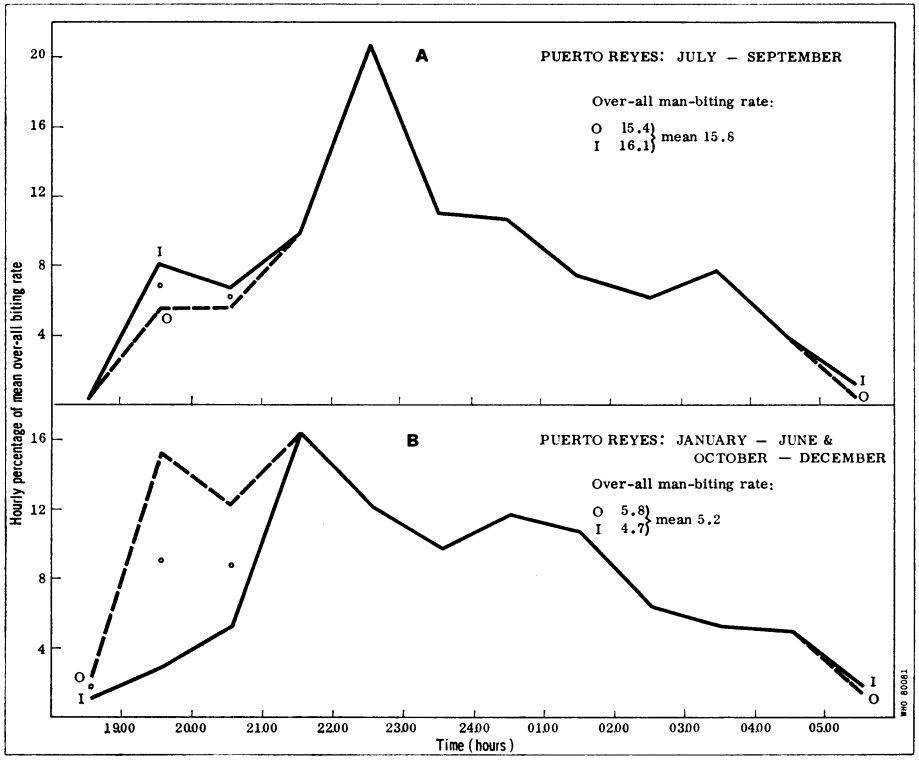
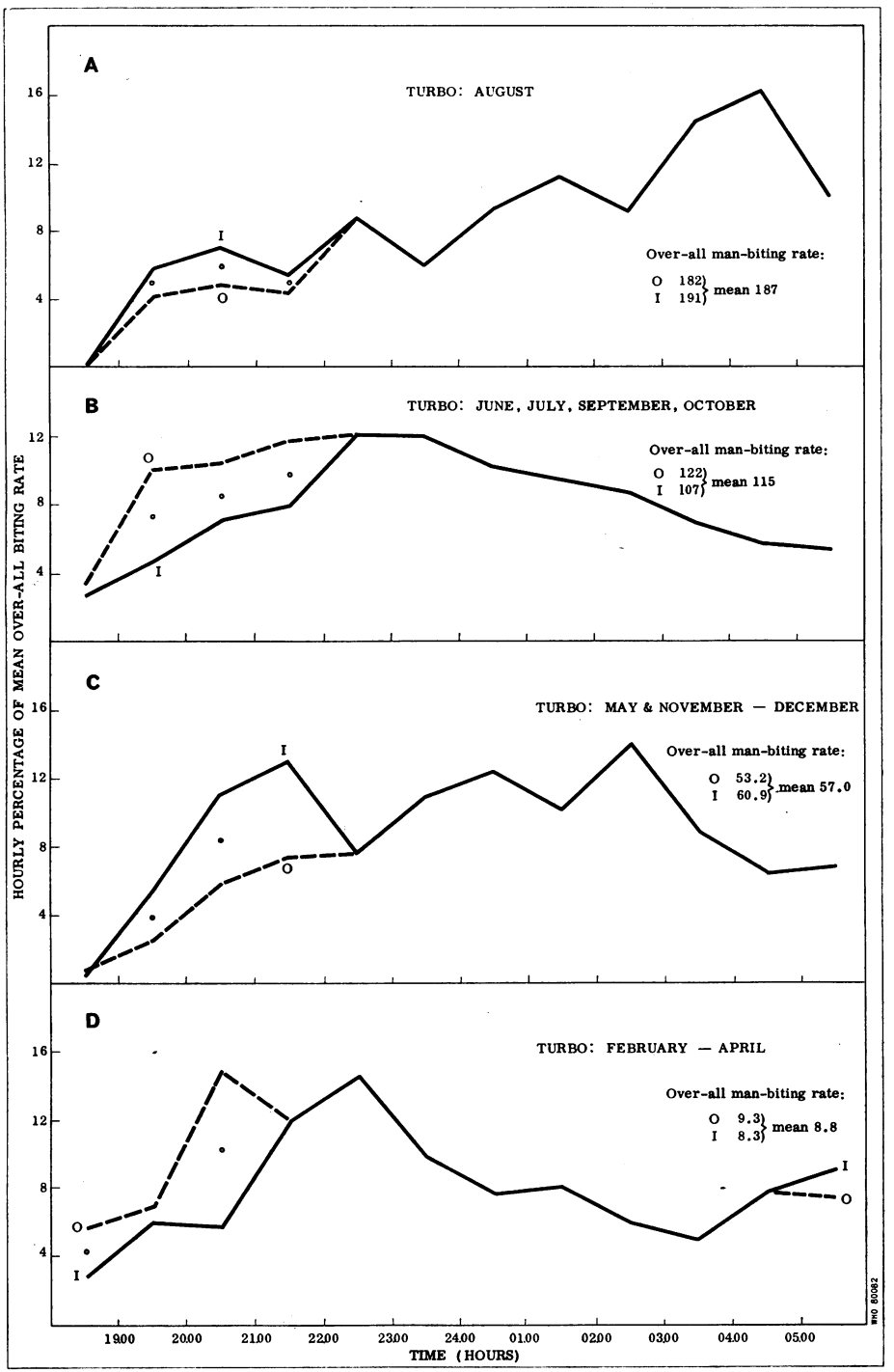


FIG. 10

MAN-VECTOR CONTACT IN *ANOPHELES PUNCTIMACULA*



geration of this tendency was seen in the low-density months of January and February, with a ratio of 1.59 : 1; these ratios are shown in Fig. 11 against mean density.

A. nuneztovari at Puerto Reyes, in its period of highest density between July and September, showed a slight over-all preponderance of indoor biting, the ratio O/I being 0.96. The peak of biting fell between 22.00 and 23.00 hours. In the remaining months of the year, outdoor biting during the evening was higher than indoor biting with an early peak between 19.00 and 20.00 hours; the main peak was an hour earlier than in the high-density months, between 21.00 and 22.00 hours. The ratio O/I was 1.23 : 1.

At El Pescado the same species showed a similar contrast between a late peak before midnight in the months of high density (May–July), with a slight preponderance of outdoor biting in the evening and early morning, and an early peak of mainly outdoor biting between 20.00 and 21.00 hours, in the remaining months. A lower indoor peak followed between 22.00 and 23.00 hours. The ratios for O/I were 1.03 : 1 and 1.19 : 1, respectively.

At Turbo, where the biting density of *A. nuneztovari* was low except in June, there was less difference between the incidence of indoor and outdoor contact. Indoor contact predominated both in the high-density month of June and over the rest of the year. The O/I ratios were 0.91 : 1 and 0.98 : 1, respectively, again showing relatively less outdoor biting in the high-density period.

Human contact in A. (Arribalzagaia) punctimacula *Dyar & Knab (Fig. 10)*

A. punctimacula was prevalent at Turbo through most months. The seasonal patterns of its biting behaviour were complex, and may be considered in four series. In August, with a mean density of 187 bites per night, indoor biting was heavier in the evening period, and a series of low peaks through the night culminated in a period of maximum biting between 03.00 and 05.00 hours. In the 2 months before and the 2 months after August, the biting was steady through the night, the maximum activity being between 21.00 hours and midnight. Outdoor biting was heavier than indoor in the evening. In May, November and December, when the density was about half that of the 5 months of high density, internal biting was again heavier than external in the evening, and a series of peaks developed, the last and highest between 02.00 and 03.00 hours. Finally, in the 3 low-density months of February–April there was a peak of outdoor biting between 20.00 and 21.00 hours, an indoor peak between 22.00 and 23.00 hours, and a small peak of mainly indoor biting before dawn; in general, the biting took place earlier than during the months of higher densities. The evening period also showed more outdoor than indoor activity. The O/I ratios for the four periods of descending density were, respectively, 0.95, 1.14, 0.87 and 1.12 : 1.

DISCUSSION

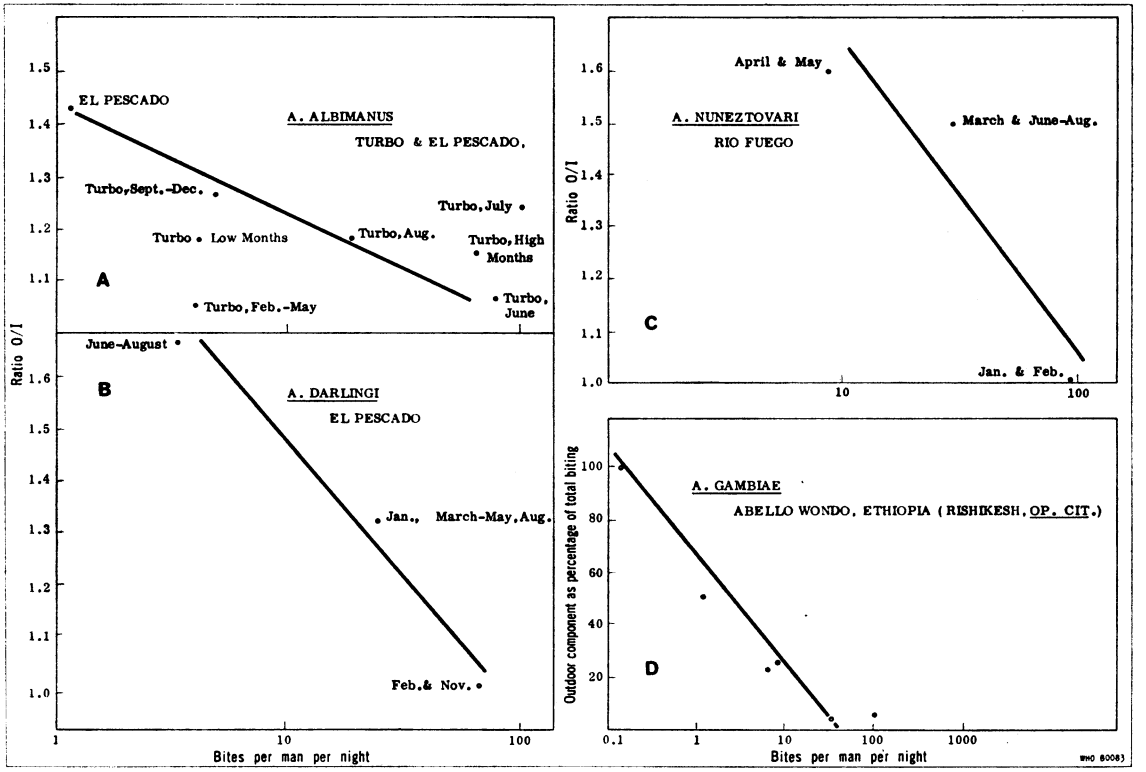
In considering the persistence of malaria transmission in the face of well-executed eradication campaigns, the role of outdoor biting in the early evening hours has been emphasized by several authors. Dodge [1] studied a situation in Northern Nigeria, where by 21.00 hours only 7% of men, 23% of women and 50% of children had retired indoors; by 23.00 hours only 78% of men, 95% of women and 98% of children had retired. He concluded that there was ample opportunity for the transmission of malaria to occur by outdoor biting alone. However, the outdoor bait-net catches of the local vector, *A. gambiae* s.l., quoted by the same author show that only 2.6% of the biting activity took place before 21.00 hours, and even by midnight only 27% of the total activity for the night was completed. Since 97% of men and over 99% of women and children were indoors by midnight, the major amount of man–mosquito contact would take place indoors, during the period from midnight to 03.00 hours, when 42% of the nightly mosquito activity was observed. That population also contained early-rising members, 61% of the men, 35% of the women and 9% of the children rising before 06.00 hours. These people would receive outdoors some of the biting taking place between 03.00 and 06.00 hours, which on the evidence of the trap-nets, was 31.5% of the total nightly activity. Since the habits of the people in Nigeria are correlated with a much later-biting vector than any present in Colombia, the outdoor component of the man-biting rate is probably not much different proportionally in the two populations, apart from the much greater exposure of the Nigerian men to outdoor biting.

In all the Colombian vectors except *A. punctimacula* there are indications of a negative correlation

[1] Dodge, J. S. (1965) *Outdoor malaria transmission in a DDT-sprayed area of Western Sokoto, Northern Nigeria* (unpublished working document WHO/Mal/520.65). A limited number of copies of this document are available to persons officially or professionally interested on request to Distribution and Sales, World Health Organization, 1211 Geneva, Switzerland.

FIG. 11

INVERSE RELATIONSHIP OF BITING-RATE TO RATIO OF INCIDENCE OF BITING BY FOUR SPECIES OF *ANOPHELES* ON TWO PERSONS HAVING DIFFERENT HABITS



between the seasonal density and the proportion of outdoor biting in the evening and morning hours (see Fig. 11). Thus, in the main transmission season a person remaining indoors may receive as many or more bites than one spending the evenings and early morning hours outside the house. Similar findings have been reported from Peru (Acosta, personal communication) with *A. pseudopunctipennis*. Some observations by Rishikesh [1] on *A. gambiae* in Ethiopia seem to point in the same direction. Fig. 11 shows his outdoor component as a proportion of the total man-biting rate, plotted against that rate. An inverse linear relationship is suggested.

The correlation is not sufficiently close to study as a regression on a monthly basis, which in turn suggests that the decline in the relative importance of outdoor biting with increasing density is not caused by a density-dependent factor. Two possible explanations may be considered. First, in the season of highest density it may be that there is a large part of the anopheline population operating on a 48-hour gonotrophic cycle. This would lead to many females laying eggs early in the night and biting later the same night. It would account for the later peaks of nightly activity observed with several species, shifting the bulk of activity to a period when more people are indoors. Secondly, it may be that in the season of highest density, corresponding in general with that of highest rainfall, relative humidities are generally higher. The relative humidity inside houses, which may well inhibit entry when it is low in the first hours after sunset, would rise sooner in the wet season as the house cools. It will be noted that the two hypotheses offered are not mutually exclusive.

[1] Rishikesh, N. (1966) *Observations on anopheline vectors of malaria in an upland valley in Ethiopia* (unpublished working document WHO/Mal/66.554). A limited number of copies of this document are available to persons officially or professionally interested on request to Distribution and Sales, World Health Organization, 1211 Geneva, Switzerland.

Outdoor exposure to anopheline biting is not necessarily incompatible with the termination of malaria transmission by intradomiciliary insecticidal treatments; the habit of remaining outdoors in the evening and emerging in the morning during the period of mosquito activity can be observed equally in the human populations of areas that have successfully passed to the consolidation phase of malaria eradication. However, it is clearly one of a number of factors that have to be considered in accounting for the lack of progress in certain areas of the eradication campaign. The main conclusion from this study is that, while at some seasons outdoor exposure may increase the bites received by as much as 70%, as in *A. darlingi* at El Pescado, those are not the seasons of highest vector density and maximum transmission of malaria. At these seasons the person exposed to maximum outdoor biting may actually receive fewer bites than one spending the whole night indoors. The under-5-year age-group, which is exposed to very little outdoor biting, shows quite high parasite rates in Colombia. Dodge's (*op. cit.*) results show a rise in parasitaemia from 2% to 10% between 1961 and 1964 in infants, and from 12% to 31% in the 3–4-year age-group in an area sprayed since 1957. But even in the seasons of high biting-rates, the fringe percentage of outdoor biting may reduce the incidence of the insecticide on the mosquito population enough to allow transmission to continue. The most probable conclusion, however, for the Colombian localities at least, is that malaria is being transmitted mainly inside sprayed houses, by vectors that, although susceptible to the insecticide in use, are not reduced sufficiently in numbers nor in expectation of life to ensure the interruption of transmission. This conclusion agrees with the findings of de Zulueta & Garrett-Jones (1965) following investigations on the stabilized low-level transmission of malaria carried by *A. pseudopunctipennis* and *A. albimanus* in DDT-sprayed areas of Oaxaca, Mexico.

ACKNOWLEDGEMENTS

I have to thank the Minister of Public Health and the Director of the Malaria Eradication Service, Republic of Colombia, for permission to publish these results, and also to acknowledge the willing co-operation and hard work of Sr G. Garcés and the other *entomólogos* of the Service, often performed under difficult conditions.

RÉSUMÉ

Une enquête a été faite, en 1965, dans cinq localités de Colombie choisies pour leur indice élevé de transmission du paludisme, sur les habitudes nocturnes de la population humaine ainsi que sur les variations suivant la saison, le temps et le lieu, du taux d'agressivité des vecteurs. Les 13e et 14e cycles de traitement des habitations par le DDT ont eu lieu au cours de cette même année.

Entre 18 heures et 6 heures, le pourcentage de temps passé à l'intérieur des habitations variait de 71% à 89% suivant l'âge et le sexe des habitants. Les groupes d'âge supérieur à 5 ans passaient 18 à 21% de cette période nocturne dans le voisinage des habitations et 4 à 10% loin des maisons; les chiffres correspondants pour les enfants étaient de 9 et 2% respectivement. Entre 18 heures et 21 heures, le pourcentage de séjour à l'intérieur variait de 31 à 66%. En ce qui concerne le mode de vie et l'exposition aux piqûres à l'extérieur des habitations, les plus grandes variations étaient observées entre les très jeunes enfants et le reste de la population; les différences étaient peu marquées entre les sexes.

Des équipes de capture ont été exposées aux piqûres d'anophèles à l'intérieur des maisons de 18 heures à 6 heures, et dans le secteur avoisinant aux heures de fréquentation par certains habitants. On a calculé les taux moyens mensuels de piqûres sur la base d'une personne « moyenne » hypothétique recevant la moitié des piqûres enregistrées dans les habitations, la moitié des piqûres dénombrées à l'extérieur le soir et le matin et le total des piqûres constatées à l'intérieur des habitations entre-temps.

Pour *Anopheles albimanus*, le taux de piqûres a été faible pendant toute l'année à El Pescado; à Turbo, on a compté plus de 10 piqûres par nuit de juin à août. Pour *A. darlingi*, on a enregistré plus de 40 piqûres par nuit de juin à août, moins de 10 en février et d'octobre à décembre à El Pescado; les taux étaient intermédiaires pendant les autres mois. A Las Aranas, les taux ont toujours été faibles.

Pour *A. nuneztovari* à Rio Fuego, les taux ont été élevés en avril-mai, moyens en mars et en juin-août et faibles en janvier-février; ils ont été importants en juillet-septembre à Puerto Reyes, en mai-juillet à El Pescado et en juin à Turbo. Pour *A. punctimacula*, à Turbo, on peut considérer quatre périodes: août avec près de 200 piqûres par nuit; juin, juillet et septembre

avec plus de 100 piqûres; mai, novembre et décembre avec 20 à 100 piqûres; février-avril avec moins de 20 piqûres.

Les taux moyens d'agressivité ont été classés en taux O (nombre de piqûres par nuit et par personne en cas d'exposition maximale à l'extérieur) et taux I (nombre de piqûres par personne exposée uniquement à l'intérieur); le rapport O/I exprime l'importance relative des piqûres à l'extérieur des habitations.

Pour *A. albimanus*, avec des taux moyens de 64; 4 et 1,1 piqûres/nuit, les valeurs du rapport O/I sont respectivement de 1,16; 1,18 et 1,44. Pour *A. darlingi* à El Pescado, les taux de 68; 25 et 3,5 donnent un rapport O/I égal à 1,01; 1,33 et 1,69 respectivement, mais à Las Aranas le taux annuel de 0,6 donne un rapport O/I égal à 1,21 seulement.

Pour *A. nuneztovari* à Rio Fuego, aux taux de 96; 31 et 9 piqûres/nuit correspondent des rapports O/I de 1,00; 1,52 et 1,59; à Puerto Reyes, des taux de 16 et 5 piqûres donnent pour O/I les valeurs 0,96 et 1,23. De même, à El Pescado, pour un taux égal à 25, le rapport O/I est égal à 1,03 et pour un taux de 2,3, O/I est égal à 1,09; à Turbo, enfin, des taux de 8,5 et 0,8 donnent des rapports O/I de 0,91 et 0,98.

Le rapport O/I augmente lorsque le taux d'agressivité diminue; seul *A. punctimacula* à Turbo fait exception à cette règle.

L'influence de l'agressivité des vecteurs à l'extérieur, soulignée par certains auteurs, ne doit pas être surestimée. Une personne soumise à une exposition extérieure maximale peut effectivement recevoir moins de piqûres qu'une personne demeurée à l'intérieur pendant toute la nuit. Dans les localités colombiennes étudiées, il semble que la persistance de la transmission soit due essentiellement au fait que les traitements insecticides ne réussissent pas à réduire suffisamment le nombre et la durée de vie des vecteurs.

REFERENCE

Zulueta, J. de & Garrett-Jones, G. (1965) *Amer. J. trop. Med. Hyg.*, **14**, 63