STUDIES ON MAN-VECTOR CONTACT IN SOME MALARIOSUS AREAS IN COLOMBIA

by

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1. INTRODUCTION

The man-biting rate, defined as the index of actual incidence of contact between man and mosquito, can be estimated by catches of biting mosquitoes on human bait, but Garrett-Jones (1964) 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 estimation of 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, in that outdoor baits remaining outside the houses after the normal hour of retirement of the people may attract larger or smaller numbers of mosquitoes than the indoor baits. In dealing with observations made in this way in Mexico and 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:

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

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(b) the number of bites per person indoors sunset to bedtime;
(c) the number of bites per person indoors bedtime to dawn.

The man-biting rate was then calculated by adding (c) to the mean of (a) and (b). The mosquitos found biting human baits outdoors between normal bedtime and dawn were disregarded, as they would ordinarily be obliged to seek a meal indoors 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 (ibid.).

2. SITES OF OBSERVATIONS

The observations on human and anopheline habits 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 above sea level, with rainfall between 200 and 400 centimetres annually, and which are more fully described in Elliott (1967). 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 hrs; at Turbo the main occupation is work in commercial banana plantations, and the daily round starts and finishes an hour later. Housing types include wood and adobe, with mainly thatch but some corrugated iron roofs, except again at Turbo, where regular employees occupy concrete or brick cottages, though transients live in very roughly constructed shelters. In general, from the viewpoint of spraying operations, the majority of houses are poorly constructed, with incomplete walls presenting many openings, and are frequently altered or rebuilt, with destruction of sprayed surfaces.

During the year of observations the thirteenth and fourteenth semi-annual cycles of house-spraying with DDT were in progress, using 2 g/m² of technical material applied as 75% water-dispersible powder. The percentage coverages obtained were, respectively, 73 and 84 at El Pescado, 59 on both at Rio Fuego, 100 on both at Puerto Reyes and Turbo, and 94 on the fourteenth at Las Arañas. The biting incidence fluctuated in the villages in a manner that could not be correlated with the passage of the spray-teams through them. However, there was no evidence of physiological resistance to the insecticide in 1965 or thereafter, and considerable evidence of continued susceptibility.
3. METHODS

3.1 Human habits. During the period between 18.00 and 06.00 hrs, in the course of
the mosquito captures, the movements of the inhabitants of the houses selected for study
were observed. Each half-hour the whereabouts of each member of the household was noted,
the population being divided into five groups: men and women (over 15 years), boys and
girls (five to 15 years) and children under five years. A five-fold classification
of their activity was made: away from the house, near but outside the house, inside
the house, with the last two subdivided according to whether the person was sleeping
or resting, or active.

3.2 Habits of mosquitos. The observations on the biting of mosquitos were made by
three-man teams led by entomological technicians, but about ten per cent. of the work
was professionally supervised. Baits were stationed inside the houses from 18.00 to
06.00 hrs, and in the peridomestic area occupied by the people during the hours from
18.00 to 21.00 hrs (at Turbo 22.00 hrs), and again in the morning from 05.00 to 06.00
hrs (except at Turbo, where very few people were abroad before 06.00 hrs). The
collectors sat with their legs exposed from the knee to the ankle, and caught mosquitos
biting themselves and, occasionally, local volunteers. The individuals were rotated
between the various positions on a shift system. The number of catches was eight to
10 per month, with occasional gaps due to public holidays or transport problems.

It will be noted that the number of baits used at any time never reached half the
minimum of eight persons recommended by Garrett-Jones (1964). The rest of his criteria
are reasonably well satisfied.

4. OBSERVATIONS OF HUMAN HABITS (Figure 1)

This sample shows rather too few children to be typical, and also has the
disadvantage that the number of individuals was less than the figures suggest, as 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.

4.1 Habits of men (over 15 years). The greatest part of the night is spent in sleep
inside the house (61% of the time between sunset and dawn). About 20% retire early,
before 21.00 hrs, then there is a steady rise to 65% by 23.00 hrs. At all times there
are some men awake and moving about indoors. The percentage indoors and awake drops
from 23% at sunset to 7% by 22.00 hrs; over the whole night it accounts for 10% of the
time of the men observed. The habit of sleeping in the peridomiciliary area, in
hammocks slung under the eves, etc., accounts for only 4% of the time. Up to 20.30 hrs
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 hrs and 53% were up by 06.00 hrs, although only 10% had left for
work by then. Between 04.00 and 06.00 hrs the number of men in the peridomiciliary area
increased from three to 30%.

4.2 *Habits of women (over 15 years).* 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, few women remaining outside after 20.30 hrs,
and none after 23.00 hrs. Over the whole night, the women spent 77% of their time
inside the house, against 71% for the men, and 4% away from the house, against 7% for the
men. The time spent in the peridomiciliary area was almost the same, 19% against 21%.
The women in this sample rose a little later than the men in the morning. Fewer of them
left the house, which is to be expected. On the whole, these observations do not
indicate any great excess of exposure to outdoor biting in men compared with women.

4.3 *Habits of boys (over five and under 15 years).* The 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 hrs; 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.

4.4 *Habits of girls (over five and under 15 years).* The girls spent more time away
from the house in the early evening than their elders, but rather less than the boys;
like the boys, they went to bed earlier than the men; a few slept in the peridomiciliary
area; they rose earlier than the boys in the morning. 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.
4.5 Habits of children (under five years). This is the only group with really divergent habits: they leave the house completely even less than women, and are all indoors and in bed by 22.00 hrs; 89% of their time is spent indoors, 5% of it in sleeping. They also rise later than the other groups.

This study has not demonstrated differences in the habits of the sexes and the ago-groups as great as might have been anticipated. In Figure 1 are shown the percentages of the members of each group found in each of the five situations between the hours of 18.00 and 06.00 hrs and between 18.00 and 21.00 hrs.

5. OBSERVATIONS ON HABITS OF MOSQUITOS

5.1 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 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 Figures 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 Figure 2; at El Pescado the species showed a low level throughout the year. At Turbo, however, for the three months June to August, it showed over 10 bites per man per night.

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

The seasonal densities of A. muzestovari (see Figures 4 and 5) show at Rio Fuego a peak in May; at Puerto Reyes and El Pescado a peak 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, below 10 bites per night; four months of medium density in March and June to August, with between 10 and 40 bites per night; and a high-density period in April and May. The last four months of 1965 could not be studied in this area. At Puerto Reyes, there may be considered two periods, that of
high density from July to September with a mean biting rate of over 10, and a low density period over the rest of the year. At El Pescado similarly a high density period of May to July may be compared with a low density period for 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; four months of low density, below 20 bites per night, in February to April; three of moderate density, between 20 and 100, May, November and December, and five of high density, over 100, from June to October. The peak density fell in August, in the centre of this period, as can be seen in Figure 5.

5.2 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 (0) and indoors (1) for those hours when contact occurs in both situations. In Figures 6-10 the two indices are calculated to the base of the mean expressed as 100%.

5.3 Human contact in *A. (Nyssorhynchus) albimaculatus* Weidemann (Fig. 6). At Turbo, during the June to 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 four 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 (Figure 6-b). After this peak at 20.00 to 22.00 hrs 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 by one remaining indoors (0/1) was slightly higher than in the months of high density, 1.18: 1.

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1 The biting cycles of the same vector populations have been discussed by the author in an earlier paper: WHO/Mal/67.600 [Ed.].
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 hrs; 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.

5.4 Human contact in A. (Nyssorhynchus) darlingi Root (Fig. 7). At El Pescado, during the three months June to August, A. darlingi showed a mean man-biting density of 68 bites per man-night, with the peak of biting from 22.00 to 01.00 hrs, 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 to May, and September, with a mean biting rate of 25 per night, outdoor biting showed a peak between 20.00 and 21.00 hrs, indoor biting, an hour later; a minor peak followed between 02.00 and 03.00 hrs. Outdoor biting was distinctly more important during the evening period of exposure. In the months of low density, February and October to December, the peak of outdoor biting was earlier, from 19.00 to 20.00 hrs, and higher; the period before dawn also showed heavy outdoor attack. Figures 7b and 7c refer. For the three periods, the ratios 0/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 Figure 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 10 and 11 p.m., with outdoor biting predominant up to 10 p.m.

5.5 Human contact in A. (Nyssorhynchus) nuñezovari Gabaldon (Figs. 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 four hours of the evening were divided into two of predominantly outdoor, followed by two of predominantly indoor biting; over the whole night the ratio 0/I was 1.00. In the periods of moderate density (March and June to 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, giving an 0/I ratio of 1.52: 1. An exaggeration 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 Figure 11 against mean density.
A. *nuñeztovari* at Puerto Reyes, in its period of highest density between July and September showed a slight over-all preponderance of indoor biting, O/I being 0.96. The peak of biting fell between 22.00 and 23.00 hrs. In the remaining months of the year outdoor biting was higher than indoor through the evening with an early peak between 19.00 and 20.00 hrs; the main peak was an hour earlier than in the high density months, between 21.00 and 22.00 hrs. 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 hrs, in the remaining months. A lower indoor peak followed between 22.00 and 23.00 hrs. The ratios O/I were 1.03: 1 and 1.19: 1, respectively.

At Turbo where the biting density of *A. nuñeztovari* 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.

5.6 Human contact in *A. (Arribalzagaia) punctimaculata* Dyar and Knab (Fig. 10). *A. punctimaculata* 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 hrs. In the two months before and the two months after August the biting was steady through the night, the maximum activity being between 21.00 hrs 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 five 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 hrs. Finally, in the three low-density months of February to April there was a peak of outdoor biting between 20.00 and 21.00 hrs, an indoor peak between 22.00 and 23.00 hrs, and a small peak of mainly indoor biting before dawn; in general the biting was 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, 0.55, 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 (1965) studied a situation in Northern Nigeria, where by 21.00 hrs only 7% of men, 23 of women and 50 of children had retired; by 23.00 hrs only 73% 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 hrs, 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 0300 hrs, 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 hrs. These people would receive outdoors some of the biting taking place between 03.00 and 06.00 hrs, which on the evidence of the trap-nets was 31.5% of the total nightly activity. Since the habit 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 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 (1966) on *A. gambiae* in Ethiopia seem to point in the same direction. Figure 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.

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 population 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-five age-group, who are exposed to very little outdoor biting, show quite high parasite rates in Colombia. Dodge’s (1965) figures show a rise in parasitaemia from 2 to 10% between 1961 and 1964 in infants, and from 12 to 31% in the three to four 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.
However, the most probable conclusion, 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 that of de Zulueta and Garrett-Jones (1965) after investigations on the stabilized low-level transmission of malaria carried by *A. pseudopunctipennis* and *A. albimanus* in DDT-sprayed areas of Oaxaca, Mexico.
RESUME

Une étude a été faite, en 1965, dans cinq localités de Colombie choisies pour leur indice élevé de transmission du paludisme, sur les mouvements nocturnes de la population humaine ainsi que sur les variations suivant la saison, le temps et le lieu, du taux des piqûres faites à l'homme par les insectes vecteurs. Toutes ces localités, situées à moins de 200 m au-dessus du niveau de la mer, reçoivent annuellement en moyenne entre 200 et 400 cm de pluie et le type dominant de végétation est la forêt claire tropicale humide. Les treizième et quatorzième cycles de traitement des habitations par des pulvérisations de DDT (poudre dispersable dans l'eau) à 75 %, à la dose de 2 g/m² ont eu lieu au cours de cette même année.

Pendant la période comprise entre 18 h. et 6 h., le pourcentage de temps passé à l'intérieur des habitations était de 71 % pour les hommes (au-dessus de 15 ans) et les garçons (de 5 à 15 ans), de 77 % pour les femmes (au-dessus de 15 ans), de 74 % pour les filles (de 5 à 15 ans) et de 89 % pour les très jeunes enfants (au-dessous de 5 ans). Les groupes d'âge supérieur à 5 ans passaient 18 à 21 % de ce temps dans le voisinage des habitations et 4 à 10 % loin des maisons; les chiffres correspondant pour les enfants étaient de 9 et 2 % respectivement.

Entre 18 h. et 21 h., les hommes et les femmes passaient 40 % du temps à l'intérieur des maisons, les garçons 31 %, les filles 36 % et les très jeunes enfants 66 %. Seulement 4 % des hommes dormaient toute la nuit dehors. Quelques femmes dormaient dehors au début de la nuit, mais aucune ne restait après 23 h. Les garçons passaient plus de temps que les autres groupes loin de la maison, mais tous y retournaient vers 23 h. Les filles s'absentaient plus longtemps que les adultes et se retiraient plus tôt que les garçons; tous les jeunes enfants étaient à la maison et dormaient vers 22 h.

Les hommes commençaient à se lever à 4 h. et à 6 h., 53 % étaient levés et se tenaient surtout autour des maisons. Les femmes se levait un peu plus tard. Les filles, puis les garçons, puis les très jeunes enfants se levait dans l'ordre, après
leurs parents. En ce qui concerne le mode de vie et l'exposition aux piqûres à l'extérieur des habitations, les plus grandes différences ont été observées entre les très jeunes enfants et le reste de la population; les différences étaient peu marquées entre les sexes.

Des équipes formées de trois hommes ont étudié les moeurs des moustiques en découvrant leurs jambes au-dessous du genou et en capturant tous les anophèles qui les piquaient. Pour cela, ces hommes s'exposaient aux piqûres à l'intérieur des maisons de 18 h. à 6 h. et dans le secteur avoisinant aux heures où il était fréquenté par une partie de la population. Les opérations de capture ont été répétées 8 à 10 fois par mois avec permutation des personnes servant d'appât chaque fois. On a calculé les taux moyens mensuels de piqûres sur la base d'une personne "moyenne", c'est-à-dire d'une personne ayant reçu la moitié des piqûres dénombrées à l'intérieur des habitations et la moitié des piqûres dénombrées à l'extérieur chaque soir et/ou chaque matin, plus toutes les piqûres dénombrées à l'intérieur des habitations entre-temps.

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

Pour A. muñeztovari à Rio Fuego, les densités ont été élevées en avril-mai, moyennes en mars et en juin-août et faibles en janvier-février; on a enregistré de fortes densités en juillet-septembre à Puerto Reyes, en mai-juillet à El Pescado et en juin à Turbo. Les densités, pour ce qui est de A. punctimacula à Turbo, peuvent se répartir en 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 et février-avril avec moins de 20.

Les densités moyennes peuvent être classées en densités 0 (nombre de piqûre/nuit/personne dans les conditions d'exposition maximale à l'extérieur) et densités I (nombre de piqûre/personne exposée entièrement à l'intérieur des habitations); le rapport 0/I exprime l'importance relative des piqûres à l'extérieur des habitations.
Pour *A. albimanus*, avec des densités moyennes de 64, 4 et 1,1 piqûres/nuit, le rapport O/I prend respectivement les valeurs 1,16, 1,18 et 1,44. Pour *A. darlingi* à El Pescado, les densités 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 la densité annuelle de 0,6 donne un rapport O/I égal seulement à 1,21.

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

Le rapport O/I augmente lorsque la densité diminue, mais *A. punctimacula* à Turbo fait exception à cette règle : à des densités de 187, 115, 57 et 9 piqûres correspondent des rapports O/I respectivement égaux à 0,95, 1,14, 0,87 et 1,12.

Le rôle des piqûres reçues à l'extérieur, souligné par certains auteurs qui y ont vu une explication de la transmission continue du paludisme dans des secteurs où les habitations étaient traitées par des pulvérisations de DDT pendant de longues périodes, est en général minimal à la saison des plus fortes densités d'anophèles, lorsque la personne soumise à l'exposition externe maximale peut effectivement recevoir moins de piqûres que les personnes demeurées à l'intérieur pendant toute la nuit. Cette corrélation négative n'est pas suffisamment exacte pour qu'on puisse la considérer comme une régression et il est par conséquent probable qu'elle n'est pas fonction de la densité. Elle est peut-être due à la prévalence des cycles gonotrophiques de 48 h. aux saisons de forte densité, où beaucoup de femelles pondent au début de la soirée et viennent piquer plus tard lorsque les gens sont chez eux; elle peut aussi être imputable à un taux d'humidité relative à l'intérieur des habitations qui incite les anophèles à entrer plus tôt dans la soirée en ces mêmes saisons; peut-être encore ces deux facteurs sont-ils à incriminer.
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FIGURE 1

NOCTURNAL DISTRIBUTION AND ACTIVITY, BY AGE-GROUP AND SEX,
OF INHABITANTS OF THE FIVE LOCALITIES STUDIED

PERCENTAGES OF HUMAN POPULATION

1800 hours to 0600 hours

Men Women Boys Girls Children

1800 hours to 2100 hours

Men Women Boys Girls Children

a = indoors awake
b = indoors asleep
c = outdoors awake
d = outdoors asleep
e = away from house
FIGURE 2

SEASONAL VARIATION OF MAN-BITING DENSITY IN A. ALBimanus,
TURBO AND EL PESCADO, 1963

NUMBER OF BITES PER MAN PER NIGHT

M O N T H S

(El Pescado)

(Turbo)

DDT

DDT

DDT
FIGURE 3

SEASONAL VARIATION OF MAN-BITING DENSITY IN A. DARLINGI, EL PESCA D AND LAS ARAÑAS, 1965

NUMBER OF BITES PER MAN PER NIGHT

MONTHS
SEASONAL VARIATION OF MAN-BITING DENSITY IN A. NUÑEZTOVARI, RIO FUEGO AND PUERTO REYES, 1965
SEASONAL VARIATION OF MAN-BITING DENSITIES IN A. NUÑEZTOVARI AND A. PUNCTIMACULA, TURBO AND EL PESCADO, 1965
FIGURE 7c

EL PESCADO – FEBRUARY & OCTOBER TO DECEMBER

Over-all man-biting rate:

0 4.3)
I 2.1) mean 3.5
FIGURE 8

MAN-VECTOR CONTACT IN A. NUÑEZTOVARI

![Graph showing man-vector contact in A. NuñezTovari.

**Time:**
- 1900
- 2000
- 2100
- 2200
- 2300
- 2400
- 0100
- 0200
- 0300
- 0400
- 0500

**Hourly Percentage of Mean Over-All Biting Rate:**
- 0
- 4
- 8
- 12
- 16

**Figure 8a:**
RIO FUEGO - APRIL & MAY

Over-all man-biting rate:
0 & I 95.5
FIGURE 8b
RIO FUEGO - MARCH & JUNE TO AUGUST

Over-all man-biting rate:

0 37.3
I 24.6
Mean 30.9
FIGURE 8c

RIO FUEGO - JANUARY & FEBRUARY

Over-all man-biting rate:
0 10.8
1 6.8 mean 8.8

HOURLY PERCENTAGE OF MEAN OVER-ALL BITING RATE

TIME
1900 2000 2100 2200 2300 2400 0100 0200 0300 0400 0500
FIGURE 10
MAN-VECTOR CONTACT IN A. PUNCTIMACULA

FIGURE 10a
TURBO - AUGUST

Over-all man-biting rate:
0 182) mean 187
1 181

FIGURE 10b
TURBO - JUNE, JULY, SEPTEMBER, OCTOBER

Over-all man-biting rate:
0 112) mean 115
1 107
FIGURE 10c  TURBO - MAY & NOVEMBER TO DECEMBER

Over-all man-biting rate:
0 53.2) mean 57.0
I 60.9)

FIGURE 10d  TURBO - FEBRUARY TO APRIL

Over-all man-biting rate:
0 5.3) mean 8.8
I 8.3)
FIGURE 11

INVERSE RELATIONSHIP OF MAN-BITING RATE TO RATIO OF INCIDENCE OF BITING ON TWO PERSONS HAVING DIFFERENT HABITS

**FIGURE 11a**

A. ALBIMANUS
TUNO (T) & EL PESCADO, COLOMBIA

- T, IX-XII
- T, Low Months
- T, VIII
- T, High Months
- T, VI

**FIGURE 11b**

A. DARLINGI
EL PESCADO, COLOMBIA

- VI-VIII

**FIGURE 11c**

A. NUÑEZTOVARI
RIO FUEGO, COLOMBIA

- IV & V
- III & VI-VIII

**FIGURE 11d**

A. GAMBIACE
ABELLO WONDO, ETHIOPIA (RISHIKESH, 1866)

- I, III-V, IX

**FIGURE 11e**

OUTDOOR COMPONENT AS PERCENTAGE OF TOTAL BITING

- II & X

**Figures 11f**

BITE PER MAN PER NIGHT

- 10
- 100

**Figures 11g**

BITES PER MAN PER NIGHT

- 0.1
- 100
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(a) to acquaint WHO staff, national institutes and individual research or public health workers with the changing trends of malaria research and the progress of malaria eradication by means of summaries of some relevant problems;

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