THE CONDITIONS OF MALARIA TRANSMISSION IN KATSINA PROVINCE, NORTHERN NIGERIA AND A DISCUSSION OF THE EFFECTS OF DICHLORVOS APPLICATION

by

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During 1963, a WHO team carried out an extended field trial with dichlorvos in Kankiya district of Katsina Province, Northern Nigeria (Poll & Pant, 1964). In the course of this work in 1963 and continuing in 1964 a study was made of the conditions of malaria transmission in the area, and the findings may be of interest as they refer to the northern part of the Guinea savannah belt of West Central Africa where such investigations are of particular epidemiological interest.

1. Description of the area

Kankiya district (12°30'N and 7°45'E) in the Province of Katsina, Northern Nigeria (Fig. 1) 114 km (71 miles) north-west of Kano and 59.5 km (37 miles) south of Katsina, chosen as the site of the trial, has been described in detail in a previous paper (Poll & Pant, 1964).

The untreated comparison area (Fig. 2), of some 70 square miles (180 km²), lies to the north of Kankiya and is rectangular in shape. The population of approximately 11,000 lives in 51 villages spread evenly throughout the area at a density of 170/square mile (66/km²) whilst in the trial area of approximately 180 square miles (466 km²) some 25,000 persons live in 62 villages at a population density of 150/square mile (58/km²).

There were 72.46 cm (28.53 in.) of rain during 1963, 33.52 cm (12.10 in.) of which fell in August. The harmattan, a strong sand-laden wind from the Sahara, started in October 1963 and resulted in a fall of humidity and temperature (this was associated with a fall in mosquito density). The mean maximum temperature for 1963 was recorded in April and the minimum in November (Table 1).
2. **Epidemiological investigations and results**

   **Malarriometric surveys** (comparison area)\(^1\) Three surveys were undertaken within this area - one at the end of the dry season of 1963, one after the rains the same year and the last after the dry season of 1964. The results of these surveys are given in Table 2. The following observations were made:

   **Crude parasite rates** Figures for infants in the second and third surveys have been calculated from the results of the special infant blood slide investigations.

   **Parasite densities** No densities were calculated for the first survey. Infant parasite densities for the second and third surveys were calculated according to Bruce-Chwatt (1958) from all positive cases in the preceding six months.

   **Spleen rates** It may be noted that the spleen rates in the third survey were appreciably less than those of the first.

   **Average enlarged spleens** In May 1964 the spleens were very slightly smaller than in May 1963.

   **Special infant investigations** As described in the report of the dichlorvos trial (Foll & Pant, 1964) all births in the area under discussion were notified, and blood slides were taken from these infants at monthly intervals. For the purposes of the trial the following definitions were used:

   A **newborn** is any infant whose blood is being taken for the first time by the blood collectors for inclusion in the series and who was born after mid-May 1963. A few cases of newborns are included who were born about one month before dichlorvos dispenser placing but who were subsequently found to have negative blood examinations.

   A **follow-up infant** is one who has been examined already as a newborn, and then is examined at monthly intervals until such time as its blood examination becomes positive (i.e. malaria parasites are found). When this happens, the child is

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\(^{1}\) Initially only the comparison area will be discussed because it was untreated in the recent dichlorvos trial.
treated with a single dose of chloroquine in accordance with its age and it is examined no more as far as this series is concerned. The diagrammatic records of this investigation are shown in Fig. 3.

Although we consider that the major transmission season is August to December, in 1963 we were working in this area only from September, and in the months September-December inclusive 199 blood slides from newborn infants were examined and 25 per cent. were found to be positive. In the same period 40 per cent. of 153 follow-up slides were also positive. During the dry season or minor transmission season, only one positive (0.5 per cent.) was found among 221 newborn slides while 3.6 per cent. of 828 follow-up blood slides were positive (Fig. 3). The results are shown in Table 3. Investigations of the children with positive blood slides found during the dry season showed that only 18 infants were almost certainly infected during the time, the other 12 could well have been infected during the main transmission season. The mothers of 17 of these infants were asked whether they had ever taken them away from the home village - only one admitted doing so and she had visited a village in the treated area. These positive cases were evenly distributed throughout the area.

The possibility of congenital malaria was considered but it would appear unlikely that all the cases could be due to this.

From a study of Fig. 3 the average age at which an infant living in the comparison area first had a positive blood slide during the January-June 1964 period can be determined as 19.4 weeks, and for the trial area over a similar period as 25.8 weeks. Thus, infants in the trial area were on average 6.4 weeks older when positive blood slides were first obtained. On studying similar data for the period of major transmission in the trial areas a figure of 14.5 weeks was obtained, and in the comparison area 10.9 weeks (i.e. a difference of 3.6 weeks). This would appear to indicate that dichlorvos during its period of application (May-December 1963) by reducing the mosquito population reduced the inoculation rate and had an effect on the age at which infants were first infected. It would thus appear possible that study of the age of infant first positivity might be used as an indication of insecticide effectiveness.
Entomological investigations  Anopheline densities were obtained by space spraying of the huts by a 0.1-0.2 per cent. pyrethrum solution. The huts were very suitable for this method of sampling because there were no windows. While spraying was done inside the hut, the eaves were also sprayed with pyrethrum solution from outside to prevent the mosquitos from flying out.

The collected sample was identified for species and classified according to ovarian development and blood digestion. Salivary glands were dissected for sporozoite infection.

The comparison, or untreated, village was visited once every week and six to eight huts were used for space spray collection. The dichlorvos treated villages were visited twice a week and each time 12 to 16 huts were sampled.

In order to find out the average number of inhabitants sleeping per hut in the area, a sample of 1483 huts was taken and inquiries about the number of persons sleeping in them were made. It was revealed that 3910 people slept in those huts. On this basis the average number of inhabitants per hut was found to be 2.6, although if the total population is divided by the total number of huts a figure of 1.7 is obtained, which means that many huts are unoccupied at night.

Dissections for physiological age were confined to A. gambiae with the ovarian development of Christophers' Stage III.

The following anopheline species were identified from the area. Some specimens collected from pyrethrum space spray were so damaged that identification was not possible. A. gambiae, A. funestus, A. rufipes, A. welcombei, A. nili, A. pharoensis, A. flavidostia, A. leesoni (?), A. coustani. On the basis of positive gland findings and abundance, however, the only two species which seem to be important from the malaria transmission point of view are A. gambiae and A. funestus.

Seasonal history of A. gambiae and A. funestus  Table 4 shows the period of abundance and hut densities of A. gambiae and A. funestus. It will be seen that the major influence of the two species is exerted during different parts of the year. A. gambiae is the predominant species from May to August, and A. funestus from September to March. This is probably dependent on the presence of a suitable
habitat for the breeding of the two species. It is known that *A. gambiae* breeds in sunlit pools and borrow pits. During the dry weather the vegetation disappears and from April to August such conditions occur. Rains commence in May (the first rain in 1964 was on 26 April), and by the end of August vegetation is abundant on the water pools and production of *A. funestus* increases.

During the months of November to March inclusive the temperatures and humidities fall (Table 1). Consequently the combined densities of *A. gambiae* and *A. funestus* also start falling. Due to lack of rain the breeding places also start drying and the anophelines are found only in villages which are in the vicinity of some permanent water pools.

Both *A. gambiae* and *A. funestus* transmit malaria in this area and it will be seen that one of these or both occur throughout the year. During December, January, February and March, the combined densities are very low.

Table 5 gives the results of dissections for sporozoites; it will be seen that sporozoite positive mosquitos were collected throughout the year except February, March and April. However, the sample dissected during these three months was very small due to a considerable drop in densities. Infected *A. gambiae* were collected from May to November and infected *A. funestus* from August to January. *A. gambiae* is the main vector species exercising its influence till the beginning of the dry weather whilst *A. funestus* continues throughout this time. Thus transmission in the area continues throughout the year, though the quantum of transmission is very low during the extreme dry weather. A confirmation of this will be found in the infant parasite rates series.

**Longevity and survival rate of *A. gambiae*** Advanced age-grouping using Polovodova/Detinova technique of extracting and counting follicular dilatations was used on a sample of *A. gambiae* during April to September in the comparison area. Only ovaries of Stage III (Christophers) were used in this dissection. Table 6 gives the results of these dissections.
During the period June to September, when transmission was taking place at a high rate by *A. gambiae*, the total proportion parous in the sample dissected was 0.78. Assuming a gonotrophic cycle of two days during this period for *A. gambiae* it has been shown that the probability of survival through one day "p" is given by the following formula.

\[ p = \sqrt{\text{proportion parous}} \]

Thus from our sample of dissections the value of "p" for *A. gambiae* is 0.88 giving a survival rate of 88 per cent. per day.

A total of nine sporozoite positive females were dissected for physiological age. Of these, seven had three ovariole dilations and two had four dilations. Thus the epidemiologically important age is the fourth gonotrophic cycle and beyond. The proportion of such females from our sample was 0.20. Detinova & Gillies (1964), in East Africa, reached the same conclusions.

**Biting habits** *A. gambiae* and *A. funestus* were found to be late biters.

Both species were found to be biting outdoors when baits were present outdoors. To assess the importance of outdoor biting, human habits should be also kept in mind. During the summer months (dry period), a part of the population sleeps outside. However, anopheline densities during this period are low. During the rains people do not sleep outdoors. In some parts even if people sleep outdoors early in the evening, they move inside after midnight. In view of the fact that the bulk of biting occurs after midnight, outdoor transmission may not be very significant in the area. Considering all factors, the biting habits of the vectors, the sleeping habits of the population, and the vector densities during different times of the year, we believe that outdoor transmission occurs only to a very minor degree in the area.

**Resting habits** Both *A. gambiae* and *A. funestus* were found to be resting predominantly indoors. Besides the huts used by the population for sleeping, anophelines were collected from kitchen shelters and animal shelters. A classification of the abdominal stages of *A. gambiae* collected indoors during the morning spray catch showed that during the dry months of 1963 the distribution of fed to
gravids was near 50:50 (1197 *A. gambiae* examined). During the rainy months the above ratio was nearer 65:35 (2239 *A. gambiae* examined). This shows that there is exodus to a certain degree above the normal exit for egg laying during the rainy months. These mosquitoes leaving the huts may be resting outdoors where during rainy months there is high humidity and vegetation.

3. **Transmission during the dry season**

At the end of the malarometric and entomological surveys in April-May 1963 we postulated that transmission in this district would be seasonal (i.e. during and immediately after the rains), and that during the dry season transmission would only occur in those few localities in which ponds remained with water in them throughout the dry season. We based this view on the belief that the extreme dryness of the weather, which led to a desert-like appearance of the countryside, provided an atmosphere whose level of humidity was too low for mosquitoes to survive long enough to play their part in the transmission cycle. In this belief we were wrong.

No measurable amount of rain fell in the area from 17 October 1963 until 26 April 1964. An examination of the infant blood slides obtained from comparison and trial areas showed little difference and for the purpose of this discussion both will be considered (Table 8). In the trial areas, of the 54 cases (48 follow-ups and six newborns) found to be positive during the January-June period, only 32 (30 follow-ups and two newborns) could be confirmed as having almost certainly been infected after 1 January (Fig. 3). From Fig. 4, although blood slides were taken with an even distribution throughout the area, 28 of these infants lived in villages situated in the eastern half of the trial area and two others lived in villages just inside the western half. In the comparison area 18 out of 31 cases were confirmed as almost certainly occurring after 1 January and these were spread evenly throughout the area. Thus two factors clearly emerge. Firstly, transmission takes place at a reduced rate throughout the dry season (Table 8), and secondly, transmission appears to be concentrated within the eastern half of the trial area (Fig. 4).

The last dichlorvos dispensers (solid) were placed in the western half of the trial
area in the second week of November and the last liquid ones in the eastern half in the third week of October. Our investigations during the dichlorvos trial led us to believe that these dispensers could have exerted little influence on mosquito population after the end of February.

Our previous surveys had indicated that the area was homogeneous from an epidemiological viewpoint. Meteorologically, and as far as the distribution of houses is concerned, it was also homogeneous but it was noted that in certain places there was permanent water - in the large borrow pits in Kankiya town, in Machinjin and Bela, and in Karaski where a spring supplies a small pool. The positive cases in the trial area occur within a circle of about seven miles (11.2 km) diameter centred on Karaski (Fig. 4).

In Karaski, a village of some 800 people, from January-June 1964 some 94 blood slides from newborns and follow-ups were examined but no positives were found, but on 11 July 1964 six positive slides were found amongst 16 follow-ups examined. Pyrethrum spray catches in 16 huts were done at weekly intervals, and between 3 December 1963 and 3 March 1964 only two *A. gambiae* and three *A. funestus* were found in a total of 224 huts giving an average hut density for those three months of 0.02. On 23 June 1964 a hut density of 31.0 was found in the same village, as compared to an average density of 0.22/hut for the months of November to April inclusive. On the same day, 23 June 1964, three positive sporozoite glands were found among the 67 dissected. Malariometric surveys taken in December 1963 and May 1964 showed a reduced spleen rate at the latter date.

It was noticed during field trips in January-June that the western half of the trial area appeared much drier, more desert-like and wells in many villages dried up. It was decided to investigate the village of Busta (which seemed one of the driest) to see if the dry weather had in fact stopped transmission. No positive cases were found among the infants and only four *A. funestus* were found in 80 huts sprayed monthly between 23 November 1963 and 28 February 1964, giving a hut density of 0.05, but malariometric surveys showed that transmission continued as in Karaski.
In Machinjin, which lies midway between Busta and Karaski, there had been positive infant blood slides in February and May. Pyrethrum spray catches were carried out in 16 huts at regular intervals and between 11 December 1963 and 5 May 1964 only five *A. gambiae* and four *A. funestus* were found in 240 huts giving a hut density of 0.04.

Kafin Dangi village had positive infant cases in February and March 1964, but between the beginning of January and the end of April 1964 monthly pyrethrum catches yielded only four *A. gambiae* and two *A. funestus* giving a hut density of 0.1. Sporozoite positive gland dissections from mosquitoes captured in the area were found up to January 1964 and then again in May - a very small sample was available between these two times. Malarioriometric results from the villages of Karaski, Machinjin and Tsa (combined), Busta and Gedar Buba showed that there is a reduction in parasite and spleen rates as one goes from east to west during the dry weather survey of 1964, but only in the spleen rates in the post-rains survey of 1963.

Had transmission been interrupted during the dry six months, we would have expected a reduction in the crude parasite rate to a figure not more than 40 per cent. of the original (WHO, 1964). Studies of children aged five to nine years in Kafin Dangi, Busta and Karaski villages showed reductions of crude parasite rates to 84.8 per cent., 93.8 per cent. and 94.5 per cent. of the originals respectively between the post-rains survey of 1963 and the dry weather survey of 1964. In the dry weather survey the percentage of heavy infections (more than 1000 parasites/mm³) in Kafin Dangi for children aged two to nine years was 41.4 per cent. and among children aged two to 1½ years was 40.0 per cent. Comparative figures for Busta were 39.2 per cent. and 35.7 per cent. Had interruption of transmission occurred the figure for the whole community should have been less than 7.5 per cent. (WHO, 1964). By calculation on the basis of total population in this district, this (7.5 per cent.) represents a maximum value for the two to 14 years age-group of 12 per cent., (cf. Kafin Dangi 40.0 per cent. and Busta 35.7 per cent.). In December 1963, heavy infections in the two to 14 years age-group represented 46.9 per cent. and 35.8 per cent. of the total infections in Kafin Dangi and Busta.
Thus it is clear that transmission at a very low level continued throughout the dry weather in spite of unfavourable meteorological conditions and a much reduced mosquito density.

4. Effects of dichlorvos on malaria transmission

In our previous report of the dichlorvos trial we stated that dichlorvos had not interrupted the transmission of malaria although it had certainly reduced hut mosquito densities, and it was decided to study the result of the May 1964 survey to see whether any late effects of the trial could be noted. The full details are given in Table 8.

The striking difference in the spleen rates of children two to four years of age was immediately demonstrated. This was associated with a small reduction in the average enlarged spleen (AES) for the same age-group. Further investigation of spleen sizes showed that the percentage of spleens size 2 or more compared to the total spleens examined was 16.3 per cent. in the trial area and 33.6 per cent. in the comparison area. This ratio of two to one in the difference was much greater than in either of the other two surveys and since dichlorvos was shown to reduce hut mosquito densities (cf. Foll & Pant, 1964) it is postulated that infants in the trial area had less infective bites - presumably as a result of reduced mosquito density caused by dichlorvos (cf. results of longitudinal infant study). It was also noted that crude parasite rates, spleen rates and AES for the May survey of 1964 were all lower than those found in the dry weather survey of the preceding year. However, the results of the 1964 malarious survey in Karaski were very similar to those of the comparison area. Two possibilities may be considered, firstly, that the permanent water in Karaski allowed transmission to continue at a higher level than the rest of the trial area and the difference in percentages of spleen size 2 or more is due to lack of transmission in the dry season and not due to dichlorvos (not reflected in comparison area). Secondly, that without dichlorvos dispensers all the results of the malarious survey in Karaski would have been higher than in the comparison area (e.g. hut density for Karaski in May 1963 was 52.1 and for comparison area 27.3). All spleens were examined by the same person (CVF) using the same technique.
7. **Conclusion**

As a result of this study we believe that:

(a) malaria in this semi-desert savannah region is holoendemic and that transmission continues throughout the year even when demonstrable vector densities fall to a level of 0.02 per hut;

(b) longitudinal infant studies may give a misleading picture if studied on a village rather than an area basis during minor transmission periods;

(c) longitudinal infant studies are of great value during months when transmission is occurring at a higher level;

(d) six monthly malarialometric surveys show without doubt the persistence of transmission.

**ACKNOWLEDGEMENTS**

We are grateful to the Ministry of Health, Government of Northern Nigeria, who were associated with WHO in this project and to Professor G. Macdonald who read this manuscript. We acknowledge gratefully the technical assistance of Messrs Ashkar, Lietaert, Rickman and Rivola.
RESUME

En 1963, une équipe de l'OMS a fait, à grande échelle sur le terrain, un essai du dichlorvos dans le district de Kankiya, Province de Katsina, en Nigéria du nord. Au cours des travaux, les conditions de transmission du paludisme dans la région ont été étudiées.

Dans la zone témoin non traitée, trois enquêtes ont été entreprises, deux en 1963, l'une à la fin de la saison sèche et l'autre après les pluies, la troisième en 1964 après la saison sèche. Les résultats de ces enquêtes ont permis de calculer les indices parasitaires bruts, les densités de parasites, les indices spléniques et le degré moyen d'hypertrophie splénique.

Toutes les naissances qui ont eu lieu dans la zone ont été déclarées, et des étalements sanguins ont été prélevés sur les nouveau-nés de mois en mois.

Des études entomologiques ont été effectuées. L'espèce prédominante est *Anopheles gambiae* de mai à août et *A. funestus* d'août à janvier. En décembre, janvier, février et mars, les densités mixtes en étaient très faibles, mais on trouvait des spécimens de l'une ou de l'autre, ou des deux espèces, pendant toute l'année. La longévité, les taux de survie, les habitudes d'alimentation et de repos des deux espèces ont été étudiés. Sept autres espèces anophéliennes ont été découvertes dans la région.

Les recherches épidémiologiques ont permis de conclure que le paludisme est holoendémique dans cette région semi-désertique de savanes et que la transmission a lieu à un très faible degré pendant toute la saison sèche, malgré des conditions météorologiques défavorables aux moustiques et une densité anophélienne fortement réduite.

On a constaté que les études longitudinales sur les nourrissons fournissaient des renseignements extrêmement précieux pendant les mois de forte transmission, mais qu'elles risquaient de donner un tableau trompeur de la situation lorsqu'elles portaient sur un seul village, plutôt que sur toute une zone, pendant les périodes de faible transmission.
FIG. 2

KANKIYA DISTRICT TRIAL AREAS
FIG. 3
LONGITUDINAL STUDY OF ALL POSITIVE INFANTS (JAN. - JUNE INCLUSIVE)
FIG. 4
CASES PROBABLY INFECTED AFTER JANUARY 1ST 1964 (UP TO JUNE 30TH 1964)
REFERENCES


Foll, C. V. & Pant, C. P. (1964) A large scale trial with dichlorvos as a residual fumigant insecticide in Kankiya district, Northern Nigeria (Mimeographed document WHO/Mal/451)

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TABLE 2. MALARIOMETRIC SURVEYS - COMPARISON AREA

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<td>84.6 (122)</td>
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<tr>
<td>5-9</td>
<td>40.7 (145)</td>
<td>78.5 (140)</td>
<td>73.0 (141)</td>
</tr>
<tr>
<td>Adults</td>
<td>-</td>
<td>23.3 (146)</td>
<td>14.0 (57)</td>
</tr>
<tr>
<td></td>
<td>Parachute densities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No densities taken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td>5.3</td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>2-4</td>
<td>4.7</td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>5-9</td>
<td>3.7</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>Adults</td>
<td>2.3</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Spleen rates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>77.4%</td>
<td>69.0%</td>
<td>51.6%</td>
</tr>
<tr>
<td>5-9</td>
<td>57.5%</td>
<td>31.5%</td>
<td>34.3%</td>
</tr>
<tr>
<td>2-9</td>
<td>67.9%</td>
<td>50.2%</td>
<td>42.4%</td>
</tr>
<tr>
<td></td>
<td>Average enlarged spleen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - 4</td>
<td>2.11</td>
<td>2.14</td>
<td>1.92</td>
</tr>
<tr>
<td>5 - 9</td>
<td>2.04</td>
<td>1.67</td>
<td>1.82</td>
</tr>
<tr>
<td>2 - 9</td>
<td>2.08</td>
<td>1.99</td>
<td>1.86</td>
</tr>
</tbody>
</table>

\[a\] Does not include Kankiya (as in previous report).

\[b\] 5-10 year age-group.

\[c\] 2-10 year age-group.

\[d\] Calculated from infant data and represents incidence of +ve cases during months of major and minor transmissions.

\[e\] Numbers too small to be of significance.
### TABLE 3. INFANT BLOOD SLIDE INVESTIGATIONS (COMPARISON AREA) 1963-1964

<table>
<thead>
<tr>
<th></th>
<th>Newborns</th>
<th></th>
<th>Follow-up newborns</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. +ve</td>
<td>No. exam</td>
<td>No. +ve</td>
<td>No. exam</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>10</td>
<td>41</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>25</td>
<td>87</td>
<td>10</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>8</td>
<td>31</td>
<td>14</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>7</td>
<td>40</td>
<td>16</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51 (25.6%)</td>
<td>199</td>
<td>40 (25.3%)</td>
<td>158</td>
<td>91 (25.5%) 357</td>
</tr>
<tr>
<td>1964</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1</td>
<td>33</td>
<td>4</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>0</td>
<td>31</td>
<td>6</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>0</td>
<td>34</td>
<td>8</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>0</td>
<td>35</td>
<td>3</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>0</td>
<td>44</td>
<td>3</td>
<td>172</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>0</td>
<td>45</td>
<td>6</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (0.5%)</td>
<td>222</td>
<td>30^a (3.6%)</td>
<td>828</td>
<td>31 (3.0%) 1050</td>
</tr>
</tbody>
</table>

^a Of these 30, we believe 18 to have been infected after January (this gives a figure of 2.2% +ve for follow-ups).
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of huts examined</th>
<th>A. gambiae/hut</th>
<th>A. funestus/hut</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>April</td>
<td>12</td>
<td>7.1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>13</td>
<td>26.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>22</td>
<td>27.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>26</td>
<td>22.8</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>6</td>
<td>19.8</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>16</td>
<td>11.6</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>24</td>
<td>3.4</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>8</td>
<td>0.5</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>32</td>
<td>0.7</td>
<td>2.7</td>
</tr>
<tr>
<td>1964</td>
<td>January</td>
<td>32</td>
<td>0.2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>32</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>8</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>April^b</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>32</td>
<td>5.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>38</td>
<td>13.6</td>
<td>0</td>
</tr>
</tbody>
</table>

^a This village has a permanent water source.

^b No examination carried out in April 1964.
<table>
<thead>
<tr>
<th></th>
<th>A. gambiae</th>
<th></th>
<th>A. funestus</th>
<th></th>
<th>Combined sporozoite rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>+ve Sporozoite rate</td>
<td>Total</td>
<td>+ve Sporozoite rate</td>
<td></td>
</tr>
<tr>
<td>1963 April</td>
<td>368</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>1245</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>576</td>
<td>4</td>
<td>0.69</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>623</td>
<td>1.4</td>
<td>2.25</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>232</td>
<td>8</td>
<td>3.45</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>September</td>
<td>458</td>
<td>17</td>
<td>3.71</td>
<td>354</td>
<td>1</td>
</tr>
<tr>
<td>October</td>
<td>85</td>
<td>3</td>
<td>3.53</td>
<td>253</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>32</td>
<td>1</td>
<td>3.10</td>
<td>157</td>
<td>3</td>
</tr>
<tr>
<td>December</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>1</td>
</tr>
<tr>
<td>1964 January</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>63</td>
<td>1</td>
</tr>
<tr>
<td>February</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>43</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>386</td>
<td>1</td>
<td>0.25</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>993</td>
<td>8</td>
<td>0.81</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
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<sup>a</sup> This may be due to an unusual sample of A. funestus.
### TABLE 6. RESULTS OF ADVANCED AGE-GROUPING DISSECTION - UNTREATED AREA (A. Gambiae)

<table>
<thead>
<tr>
<th>Months (1963)</th>
<th>Total dissected</th>
<th>Nulliparous</th>
<th>Number of dilatations</th>
<th>Proportion parous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>April</td>
<td>35</td>
<td>8</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>May</td>
<td>72</td>
<td>22</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>June</td>
<td>13</td>
<td>2</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>July</td>
<td>69</td>
<td>16</td>
<td>22</td>
<td>15</td>
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<tr>
<td>August</td>
<td>23</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>September</td>
<td>22</td>
<td>5</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>234</td>
<td>58</td>
<td>91</td>
<td>48</td>
</tr>
<tr>
<td>%</td>
<td>24.8</td>
<td>38.9</td>
<td>20.5</td>
<td>11.1</td>
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</table>
### TABLE 7. INFANT BLOOD SLIDE INVESTIGATIONS
(TRIAL AND COMPARISON AREAS)

<table>
<thead>
<tr>
<th></th>
<th>Newborns</th>
<th>Follow-ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial</td>
<td>Comparison</td>
</tr>
<tr>
<td></td>
<td>% +ve</td>
<td>No. exam</td>
</tr>
<tr>
<td>Major transmission season 1963 (August-December)</td>
<td>18.5</td>
<td>816</td>
</tr>
<tr>
<td>Minor transmission season 1964 (January-June)</td>
<td>2.0</td>
<td>393</td>
</tr>
<tr>
<td>Major transmission season 1963 (August-December)</td>
<td>19.0</td>
<td>962</td>
</tr>
<tr>
<td>Minor transmission season 1964 (January-June)</td>
<td>2.1</td>
<td>2417</td>
</tr>
<tr>
<td>Age-groups</td>
<td>Dry weather 1963</td>
<td>Post-rains 1963</td>
</tr>
<tr>
<td>------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>Comparison area</td>
<td>Trial areas</td>
</tr>
<tr>
<td></td>
<td>Adults (N)</td>
<td>Adults (N)</td>
</tr>
<tr>
<td></td>
<td>0-1</td>
<td>2-4</td>
</tr>
<tr>
<td>Comparison</td>
<td>34.5</td>
<td>67.8</td>
</tr>
<tr>
<td>area</td>
<td>(119)</td>
<td>(263)</td>
</tr>
<tr>
<td>Trial</td>
<td>34.4</td>
<td>78.9</td>
</tr>
<tr>
<td>areas</td>
<td>(395)</td>
<td>(705)</td>
</tr>
</tbody>
</table>

Parasite densities

<table>
<thead>
<tr>
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<th>Parasite densities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>Comparison</td>
<td>5.3</td>
</tr>
<tr>
<td>area</td>
<td>(146)</td>
</tr>
<tr>
<td>Trial</td>
<td>5.3</td>
</tr>
<tr>
<td>areas</td>
<td>(257)</td>
</tr>
</tbody>
</table>

Spleen rates

<table>
<thead>
<tr>
<th></th>
<th>Spleen rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>Comparison</td>
<td>2.3</td>
</tr>
<tr>
<td>area</td>
<td>(122)</td>
</tr>
<tr>
<td>Trial</td>
<td>2.4</td>
</tr>
<tr>
<td>areas</td>
<td>(140)</td>
</tr>
</tbody>
</table>

Average enlarged spleens

<table>
<thead>
<tr>
<th></th>
<th>Average enlarged spleens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>Comparison</td>
<td>1.9</td>
</tr>
<tr>
<td>area</td>
<td>(120)</td>
</tr>
<tr>
<td>Trial</td>
<td>1.9</td>
</tr>
<tr>
<td>areas</td>
<td>(120)</td>
</tr>
</tbody>
</table>

% spleens

<table>
<thead>
<tr>
<th></th>
<th>% spleens 2+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>Comparison</td>
<td>54.9</td>
</tr>
<tr>
<td>area</td>
<td>(120)</td>
</tr>
<tr>
<td>Trial</td>
<td>44.4</td>
</tr>
<tr>
<td>areas</td>
<td>(120)</td>
</tr>
</tbody>
</table>

\(a\) % we (total examined shown in brackets)
\(b\) 2-10.
\(c\) 5-10.
\(\) To be calculated.
\(d\) Numbers too small to be significant.
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