THE DURATION OF THE GONOTROPHIC CYCLE
IN ANOPELES GAMBLÉ AND ANOPELES FUNESTUS, WITH A NOTE ON THE EFFICIENCY
OF HAND CATCHING

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SOME uncertainty still exists on the rate at which development of the ovaries
takes place in the two most important vectors of malaria in Africa. Thus it
was recorded by Muirhead Thomson (1948) on the West African coast that
oviposition of gambiae occurred on the second night after feeding, that is to
say after an interval of approximately forty-eight hours. At Taveta in Kenya,
Hocking and MacInnes (1948) found that maturation of the ovaries in
gambiae was slightly more rapid than in funestus, but that oviposition followed
at the same average interval (4.75 days at 25.5° C.-77.9° F.) under the
conditions of their experiments. On the other hand Lumsden (1951),
working in Bwamba County, Uganda, estimated that oviposition followed
twenty-four hours after feeding in both species, but that a delay of twenty-
four hours occurred before the next blood meal was taken.

In order to investigate the problem further, observations were made
over a period of seven to eight months in the small village of Tengeni, twenty-
seven miles inland from the coast at Tanga, at an altitude of just over 600 feet.
An experimental hut was built with mud walls and palm-thatch roof. The
space between the top of the walls and the eaves was carefully blocked in
with mud. Five windows were incorporated with close fitting shutters,
and entry for mosquitoes was provided for by a line of slit shutters, 2.5
inches high, on all sides of the hut just below the eaves. These could be
operated from inside the hut and, when closed, the hut was effectively sealed.
In order to facilitate the capture of mosquitoes a low ceiling of white cotton
sheeting was installed, fitting flush with the walls just above the slit shutters.
The insides of the walls were given a smooth finish and no cracks or corners
remained. Two beds and a small table comprised the only furniture.

Two men slept in the hut from 20.30 hours until 05.00-05.30, that
is until fifteen to thirty minutes before dawn. At this hour, which was
varied slightly with the season, they were roused by an alarm clock and closed the shutters. Frequent surprise visits were made to check the carrying out of this routine. In this way females that might have entered the hut at dawn or afterwards for shelter only were excluded, and all mosquitoes caught inside next day could be regarded as having entered to bite. Failure of the sleepers to close the shutters before dawn was evidenced on a very few occasions by the presence of males in the morning catch; but from this rarity of males, in conjunction with the surprise checks already mentioned, it was felt that the morning catch accurately represented the biting population of the previous night.

Small numbers of gravid females were caught on most days and discarded. These were assumed to be mosquitoes that had been missed in the previous morning’s catch. No evidence from the use of window traps was found to support the suggestion (Ribbands, 1946) that appreciable numbers of females enter huts during the night for shelter alone and may leave again without feeding. Very few unfed females were found inside the hut in the morning, and fewer still in the window trap.

All mosquitoes were caught in test tubes and examined in a good light to ensure that they had fed the previous night. During the early months of the investigation this was always done by the author, and in the later months the catches were checked on at least two days a week. They were then released into a small cage. This cage was left in the hut till the following morning when its contents were lightly chloroformed, examined with a hand lens, separated according to species, and returned to separate cages. Females in which ovarian development had not followed the ingestion of blood were removed and dissected separately.

The cages used were made on cylindrical wire frames, seven inches tall by five inches across. A small gas jar of similar diameter and full of water was fitted into the lower half of the cages, so that the mosquitoes were confined in a space four to five inches across and three to four inches high immediately above the water surface. In this way the maximum opportunities for oviposition were provided. These oviposition cages, one for each of the two species, were left in the hut until the third morning, when forty-eight hours had elapsed since their capture, and the numbers that had laid eggs during the night ascertained. Females that had died before laying were excluded from the totals, but those that died after laying were counted in with the total numbers alive. Checks on the viability of the eggs were also made, and from time to time small numbers were set up for egg laying without resort to chloroform in the preliminary sorting. No change in the proportion laying was found in these specimens. A thermograph was kept on the table beside the cages so that the temperature conditions to which the mosquitoes were subjected, from the moment they entered the hut, were accurately known.

In all experiments on oviposition in the laboratory great difficulties are encountered over the possibly inhibitory effect of unnatural surroundings.
on the normal urge to oviposit. It is likely that this may account for the very long interval between blood meal and egg laying recorded by Hocking and MacInnes (1948). The results obtained by the method described above suggest that here this inhibitory effect was reduced to a minimum. The method introduces however another potential error, in that the necessity for flight in search of a breeding site is removed. It is known that certain conditions inhibit the flighting of mosquitoes, for example wind or rain and possibly lack of moonlight. So it can be argued that females whose ovaries mature too late in the night to be able to oviposit under natural conditions may yet do so in a small cage. The error involved may not be great but it should be borne in mind.

In this way the proportion of females entering and biting under natural conditions, and laying eggs within forty-eight hours, was ascertained for the two species under the temperature conditions prevailing at different times of the year. The results are set out in Table I and graphically in Figure 1.

**TABLE I**

<table>
<thead>
<tr>
<th>Date</th>
<th>A. gambiae</th>
<th>A. funestus</th>
<th>Mean Temperature</th>
<th>Daily Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nos. laying</td>
<td>Total</td>
<td>% laying</td>
<td>Nos. laying</td>
</tr>
<tr>
<td>Apr.</td>
<td>7-15</td>
<td>69</td>
<td>71</td>
<td>97.2</td>
</tr>
<tr>
<td></td>
<td>16-30</td>
<td>125</td>
<td>150</td>
<td>83.3</td>
</tr>
<tr>
<td>May</td>
<td>1-15</td>
<td>81</td>
<td>112</td>
<td>70.4</td>
</tr>
<tr>
<td></td>
<td>16-31</td>
<td>41</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Jun.</td>
<td>1-11</td>
<td>32</td>
<td>48</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>12-3 Jul.</td>
<td>32</td>
<td>35</td>
<td>94</td>
</tr>
<tr>
<td>Jul</td>
<td>4-31</td>
<td>38</td>
<td>44</td>
<td>86.4</td>
</tr>
<tr>
<td>Aug.</td>
<td>1-15</td>
<td>17</td>
<td>22</td>
<td>77.3</td>
</tr>
<tr>
<td></td>
<td>16-31</td>
<td>20</td>
<td>22</td>
<td>98.9</td>
</tr>
<tr>
<td>Sept.</td>
<td>1-15</td>
<td>12</td>
<td>13</td>
<td>92.3</td>
</tr>
<tr>
<td></td>
<td>16-30</td>
<td>21</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>Oct.</td>
<td>1-15</td>
<td>39</td>
<td>40</td>
<td>97.5</td>
</tr>
<tr>
<td></td>
<td>16-31</td>
<td>29</td>
<td>30</td>
<td>96.7</td>
</tr>
<tr>
<td>Nov.</td>
<td>1-15</td>
<td>265</td>
<td>278</td>
<td>95.3</td>
</tr>
<tr>
<td></td>
<td>16-30</td>
<td>165</td>
<td>192</td>
<td>96.4</td>
</tr>
</tbody>
</table>

**Figure 1.**

From this it is seen that throughout the year the mean temperature (daily max. + min. over fortnightly periods) in the experimental hut never dropped below 74°F, and that the great majority of gambiae laid eggs within forty-eight hours of the blood meal. The temporary falling off in the proportion laying during May and early June was associated with the substitution during that time, in the gambiae cage only, of an alternative egg
Figure 1. Percentage of A. funestus laying within 48 hours of feeding, in relation to mean temperature.
laying surface using wet filter paper in place of water. The figures for *funestus* show that when the temperature exceeded 78°F, about ninety percent of females laid eggs within forty-eight hours of the blood meal, and below 76.5°F, only a negligible number. There is a very small percentage of females apparently continuing to oviposit, as if on a two-day cycle all through the cool season. This may in fact be due to errors in the collecting technique, and may consist of females that had been missed in the previous day's catch and not recognised and discarded at the time of collecting.

Taking into account the defects of observations based on caged mosquitoes, the results may be condensed as follows:

**TABLE II**

<table>
<thead>
<tr>
<th>Species</th>
<th>Temperature</th>
<th>Length of cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. gambia</em></td>
<td>above 74°F</td>
<td>2 days</td>
</tr>
<tr>
<td><em>A. funestus</em></td>
<td>below 76.5°F</td>
<td>3 days</td>
</tr>
<tr>
<td><em>A. funestus</em></td>
<td>76.5–78°F</td>
<td>2–3 days</td>
</tr>
<tr>
<td><em>A. funestus</em></td>
<td>above 78°F</td>
<td>2 days</td>
</tr>
</tbody>
</table>

Comparison of temperatures in the experimental hut and in a representative ordinary African house, over a period of two months, showed that the mean temperature in the latter was half a degree lower than in the former, and subject to greater extremes, and that the mean screen temperature was again half to one degree lower than this. If mosquitoes are mainly domestic, then the normal hut temperature is of most relevance; but it should not be forgotten that night temperatures outside are appreciably lower, and that females spending part of the gonotrophic cycle outside, whether they re-enter houses at dawn or not, may be living under cooler conditions.

Mean monthly screen temperatures at Muheza, two and a half miles from Tengeri, during July and August are between 73°F and 74°F, and a proportion of the *gambiae* population may then be on a three-day cycle. Insufficient evidence was obtained to establish this. For the rest of the year the mean temperature is above 74°F, and *gambiae* is therefore predominantly on a two-day cycle. From November to mid-May the mean temperature exceeds 78°F, and for these six to seven months the cycle in *funestus* also lasts two days.

This work gives no information on the interval elapsing between oviposition and the next blood meal. But observations on the ovarian stages of unfed females in catches made in houses and outside resting sites indicate that the great majority of females feed again the same night. These results will be presented elsewhere. It may be concluded however that, in the coastal region, *gambiae* bites every second night throughout most of the year,
while with *funestus* the frequency of biting is reduced to ever third night during the five to six cooler months.

In the higher and cooler inland regions of East Africa a three-day cycle may be more generally encountered. For instance, at Kisumu on Lake Victoria, the mean monthly temperature is never above 76°F., and remains below 74° for five months from May to September.* It should be possible to predict that *funestus* in this locality has a three-day cycle throughout the year, but that in *gambiae*, for at least six to seven months, the cycle lasts two days.

It should be noted that, in these experiments, females were not given the opportunity to oviposit during the first night after they fed. At no time of the year were the ovaries of females of either species dissected after this interval, found to have advanced beyond Christopher's stage III or IV, and they could not therefore be ready to oviposit for a further twenty-four hours.

*A note on the efficiency of hand catching.*

Hand catching in houses is known to be a relatively inefficient method of catching mosquitoes. In the observations made in the experimental hut a direct opportunity presented itself of verifying the efficiency of the collecting technique.

On certain days catches in the hut were delayed until the following morning in order to find out the proportion of females that might attempt to leave through window traps twenty-four hours after entering to feed. The findings will not be discussed here but, in these evening catches small numbers of fully gravid females with stage V ovaries were caught in addition to the half gravid females which were the main object of the study. As the shutters in the house were closed before dawn every day (with only very occasional lapses), these females cannot have entered for shelter early that same morning. They must then have been females that were missed when freshly fed from the catch made on the morning of the previous day. But it was found that very few *funestus* females leave before becoming fully gravid, and these females may be taken to represent the proportion of the previous day's catch that was missed by routine hand catching.

In eight delayed catches seventy-four fully gravid *funestus* were caught in these evening window catches, on the day following morning catches that totalled 143 freshly fed (and subsequently gravid) females.

This shows that in a small hut with a low cotton ceiling and a minimum of furniture, which was searched for two hours daily by the author and a keen African Malaria Assistant, fourteen per cent. of the mosquitoes were missed.

*Fourteen per average at Kisumu, probably an overestimate. Data kindly supplied by the East African Meteorological Department in the regime of Mr. J. C. Mackay.*
SUMMARY

1. Observations were made on the proportion of *A. gambiae* and *A. funestus* laying eggs within forty-eight hours of feeding in an experimental hut. It was shown that when the temperature exceeds 78°F, the gonotrophic cycle lasts for forty-eight hours in both species. Below 76.5°F, *funestus* has a three-day cycle, but in the majority of *gambiae* the cycle still lasted only two days at 74°F.

2. Careful hand catching in the same hut missed fourteen per cent. of the *funestus* females resting in it.

Acknowledgements

This paper is published with the approval of the Director of the East African Malaria Unit. Mr. C. D. Ramsdale, Malaria Field Officer, gave much valuable help in the running of these experiments.

References


