Survival and Development of a Tropical Mosquito, *Aedes aegypti*, in Southern England*

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With rapid international air transport between the tropical and temperate regions, and the difficulty of always ensuring that aircraft have been properly disinsected at the departure point, the risk of mosquitos being carried from one country to another is constant. The yellow fever mosquito, *Aedes aegypti*, had spread widely over continents even before the advent of air travel, and the studies reported here demonstrate that this species could not only survive and bite repeatedly but could also develop to a limited extent in southern England.

Field observations

In June 1967, cages measuring 15 cm by 15 cm by 22 cm and covered with mosquito gauze, containing 3-day-old adults of the Lagos strain of *Aedes aegypti* reared at 25°C and a relative humidity of 70%, were exposed to ambient conditions. Three colonies were used: (1) a control colony maintained in an incubator at 25°C and 70% relative humidity, (2) a colony kept in an unheated single-storey prefabricated building, and (3) a colony kept outside the building against a south-facing wall. Climatic records for the immediate area showed that during the period of study the maximum and minimum temperatures varied between 26.3°C and 12.6°C and that the relative humidity varied between 98% and 45%. Sliced banana was placed in each cage as a source of sugar for the male mosquitos and mice anaesthetized with pentobarbital sodium were introduced twice a week. The number of female mosquitos engorging and the number of dead mosquitos of each sex were recorded daily, and an estimate was also made of the amount of egg-laying in each colony.

The highest proportion (70%) of mosquitos feeding was in the colony inside the unheated building, when a mouse was made available after 1 week of exposure (Table 1), while the lowest proportion (53%) was in the colony maintained outside. Feeding continued at about 50% in the control colony and at about half this level in the outside colony, while it varied from 20% to 94% in the indoor colony.

The survival of females was highest (78%) in the control colony and lowest (19%) in colony (2). Taking the two experimental colonies together, 27% of the females were still alive after 5 weeks' exposure. An estimate of egg-laying in the two experimental colonies indicated that it was almost as high as in the control colony. In all colonies, male survival was lower than female.

Laboratory studies

Biting. More detailed studies were carried out in the laboratory using simulated climatic conditions based on 30-year records for Oxford for May–August. Insects bred at 25°C were exposed in samples of 10 to mean monthly temperature conditions at a relative humidity of 72%, a mouse being offered on the second, third, and fourth days of exposure. The number of mosquitos taking a blood meal was recorded and the results (Table 2) show that although no feeding was recorded in May conditions, blood meals were taken in June, July, and August conditions, the highest level of feeding (59%) being recorded in July conditions.

Development. As eggs were observed in the initial field studies the effect of temperature on larval development was examined. Individual larvae were reared in 3 in by 1 in (7.5 cm by 2.5 cm) glass tubes in 15 ml of water plus 1 mg of mouse food.[1] The results (Table 3) indicate that at an average temperature of 18°C, approximating to July conditions, development from egg to adult could take place in approximately 16 days. In the field studies, adults exposed to ambient conditions laid eggs after 14 days of exposure; thus, a complete generation could occur in 1 month.

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[1] Main constituents: wholemeal flour and ground oats.

Table 1. Survival and feeding of *Aedes aegyptis* (Lagos strain) in southern England

Colony	Maximum and minimum temperatures	Survival, feeding and egg-laying	Sex	Exposure for following no. of days: 0[a]	7	14	21	28	35	Survival (%)
1 (control)	25.8°C; 23.8°C	No. surviving	M	28	25	23	22	17	15	(54)
			F	40	39	36	35	34	31	(78)
		No. (and percentage) feeding on blood		0	26 (67)	7 (19)	20 (57)	18 (53)	14 (45)	
		Assessment of eggs		none	many	many	many	many		
2 (inside)	24.1°C 16.5°C	No. surviving	M	30	20	11	6	4	2	(7)
			F	59	27	25	20	16	11	(19)
		No. (and percentage) feeding on blood		0	19 (70)	10 (40)	4 (20)	15 (94)	3 (27)	
		Assessment of eggs		none	none	many	many	few	many	
3 (outside)	26.3°C 12.6°C	No. surviving	M	29	21	5	11	6	2	(7)
			F	49	33	30	27	23	18	(37)
		No. (and percentage) feeding on blood		0	18 (55)	6 (20)	7 (26)	3 (13)	3 (17)	
		Assessment of eggs		none	none	many	many	few	very few	

[a] i.e. number at start of experiment.

Conclusions

These studies show that *Aedes aegypti* could survive, bite, and, to a limited extent, develop in southern England between the months of June and August. The rate of development would probably be slower than the limited studies suggest since low night temperatures would retard growth.

Although the global distribution of *Aedes aegypti* is delimited by the 20°C isotherm, the species has been recorded from north-eastern Portugal, northern Greece, and Italy (Stone et al., 1959). In 1865 there was an outbreak of yellow fever in Swansea, Wales, presumably transmitted by mosquitos flying ashore from a ship (Manson-Bahr, 1968). There is also an isolated record of larvae of *Aedes aegypti* from a beech-tree rot-hole in Epping Forest, southern England, in 1919 and a record of the species in Brittany, northern France (MacGregor, 1919; Seguy, 1924). In a recent study made at Nairobi airport, 13 species of mosquito were taken from aircraft and 1, *Aedes sollicitans*, an American species, was found on an aircraft that

Table 2. Biting activity of *Aedes aegypti* (Lagos strain) in simulated temperature conditions for southern England [a]

	May	June	July	August
Day temperature (°C)	16.7	20.0	21.5	21.7
Duration (hours)	15.50	16.75	15.5	14.75
Night temperature (°C)	7.2	10.0	12.5	11.7
Duration (hours)	8.50	7.25	8.50	9.25
Total tested	20	50	70	50
Total feeding	0	12	41	24
Percentage feeding		(24)	(59)	(48)

[a] Relative humidity: 72%.

Table 3. Mean developmental period (egg-adult) of *Aedes aegypti* (Lagos strain) [a]

Temperature (°C)	Development period (days)
20	11.8
25	9.7
30	6.0
37.5	No development beyond 3rd instar

[a] A total of 30 larvae was tested at each temperature.

departed from Rome (Highton & van Someren, 1970). Health authorities are also concerned with the possibility that yellow fever could be introduced into the USA from areas where sylvan yellow fever is prevalent, tropical regions being only a few hours flying-time away (Hayes & Tinker, 1958).

If infected tropical mosquitos were able to reach southern England by either air or sea, there is the possibility that a virus could be transferred via a vertebrate host to indigenous species of mosquito such as *Culex modestus* or *Aedes vexans*, which have transmitted arboviruses to man in southern France and Central Europe, respectively (Hannoun et al., 1969; Bardos & Danielova, 1959). These observations serve to emphasize the warning given by Highton & van Someren (1970) that disinsection of aircraft using "blocks away" methods, as approved by the World Health Organization, should be reimposed.

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Disability Index for Leprosy Patients

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When disabilities are recorded in any leprosy project it is easy to determine their frequency, i.e., the proportion of patients that is found to suffer from some kind of disability. Comparison of these findings with those from other areas or countries can also be made easily, as shown in Table 1. However, it is difficult to appraise simply and quickly the severity of disabilities in several hundred or thousand patients in a certain area, country or continent, and on a world-wide basis, and to compare the findings. The presentation of data concerning the severity of these disabilities and comparisons between areas or countries demand more elaborate tables, such as Table 2, in which the first WHO classification of disabilities in leprosy (WHO Expert Committee on Leprosy, 1960) was used.

It is realized that there are difficulties in analysing the data concerning disability grades 1–5 in different areas, even for those familiar with the subject. The difficulties would obviously be greater if we wished to compare the severity of disabilities in a large number of countries.

It should also be noted that the items in the classification of disabilities are not mutually exclusive; for example, a person having a disability in the hand might not have a disability in the feet or face, and

Table 1. Frequency of disabilities in leprosy (sampling) in northern Nigeria (Katsina), Cameroon and Thailand (Khon Kaen) [a]

Country	Population examined	No. of cases	Disabled	
			No.	%
Nigeria	24 538	705	165	23.4
Cameroon	14 473	374	133	35.6
Thailand	16 568	205	85	41.5

[a] Reproduced by permission from Martinez Dominguez, Bechelli & Patwary (1966).

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