Dry season survival of *Aedes aegypti* eggs in various breeding sites in the Dar es Salaam area, Tanzania *

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Abstract

In field experiments in different breeding sites in a shaded suburban area, 7–40% of A. aegypti *eggs survived a 120-day dry period. In a relatively unshaded coral area, only 3–23% of eggs survived 60 days in exposed sites, but 7–17% survived 120 days in shaded sites. Survival in some sites was higher than in the laboratory at constant conditions.*

There are three principal ways in which mosquitos survive the dry season in the tropics. Some groups, including *Mansonia, Culex,* and *Anopheles,* do so in the larval stage in permanent water such as ponds, swamps, wells, and small streams. Certain species of *Anopheles* are able to overcome severe conditions by aestivation as adults, while many species of the genus *Aedes* survive in the egg stage (Clements, 1963). This is accomplished in a state of diapause or quiescence. *A. aegypti* is one of these species ; as soon as a dry spell ends the surviving eggs begin to hatch.

The success of *A. aegypti* in multiplying as a vector of disease depends largely on the degree to which it survives, in the egg stage, the dry seasons that characterize East Africa and many other tropical areas. Considering the numerous records of the resistance of its eggs to drying, surprisingly little information has been obtained from studies in the field. The present work was undertaken to ascertain the rates of survival and mortality of *A. aegypti* eggs in various common breeding sites in the coastal zone of East Africa during the 4-month dry season. The findings should contribute to an understanding of the seasonal changes in the population levels of *A. aegypti* in certain areas, and especially the rapid eruption of adults observed at the onset of the rainy season. They should also assist in determining the proper timing of applications of insecticide in control and eradication programmes.

The study area

The study area lies within the coastal zone of East Africa. Although seasonal variation in temperature is small, there are marked variations in rainfall and winds. Relative humidity is generally high, reaching 100% almost every night throughout the year but falling to 50–60% during the day. Dar es Salaam has two dry and two rainy seasons. The main dry season lasts from June to September or October. The reduced heat from the sun, which is in the northern hemisphere at this time, combines with the south-east monsoon to make this period dry and cool. From October to December, when the Equatorial Trough is moving southwards, the convectional showers of the short rainy season occur. The hot dry season follows from late December until the beginning of March, when the north-east monsoon becomes established and the sun is nearly overhead. The main rainy season runs from March to May before the south-east monsoon again becomes established.

Two contrasting areas were chosen for the studies. One study was carried out in Buguruni, a high-density residential area in the south-west part of Dar es Salaam where *A. aegypti* breeds in containers in association with man. The other study was carried out on Msasani peninsula, where *A. aegypti* breeds in coral rock holes and in shells of the giant African snail, *Achatina fulica* (Trpiš et al., 1971).

For the Buguruni biotope, an area of about 1 ha located among native houses was selected. Several kinds of man-made container and natural breeding site occur within it and all are heavily shaded by mango and palm trees ; water-pots were the only indoor receptacles. The 7 most common breeding sites of *A. aegypti* there are tires, tins, wrecked motor cars, water-pots, snail shells, co-

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conut shells, and tree holes, of which tires are by far the most important and provide a constant source of *A. aegypti*.

The Msasani peninsula, the second biotope, is located about 6 km north of Dar es Salaam and consists of hard recrystallized limestone with plentiful coarse coral breccia. A characteristic vegetational cover of low scrub is gradually replacing a former sisal plantation. There are many exposed rock holes in which rainwater accumulates, some above ground level but most below. Since the vegetational cover is fairly open, most of the holes are exposed to direct sunshine. Shells of *A. fulica* are also common, the estimated density being about 300/ha (Trpiš, 1972a).

Methods

Eggs of *A. aegypti* were obtained from females collected in the Buguruni and Msasani biotopes. Batches of 30 or 50 in three replicates were placed in 18 × 25 mm bags of extra-fine-mill silk (5 threads per mm, thickness 0.1 mm). The bags with their eggs were then attached to the walls of various breeding sites by means of plastic glue. It was considered that this would cause minimum interference with environmental influences on the eggs. The bags were collected from the breeding sites after periods of 15, 30, 60, 90, and 120 days, brought to the laboratory, and tested for viability. One series of bags with *A. aegypti* eggs from the Buguruni and another from the Msasani populations were kept in the laboratory at 25°C and 80% relative humidity as controls.

The bags were opened and the eggs placed at 25° C in individual shell vials filled with 20 ml of hatching medium. This consisted of powdered nutrient broth dissolved in water and diluted 1:1000 (Horsfall & Trpiš, 1967). After 24- and 48-hour intervals the hatched larvae were removed and counted. Unhatched eggs were treated by bleaching (Trpiš, 1970) and examined for the presence of embryos.

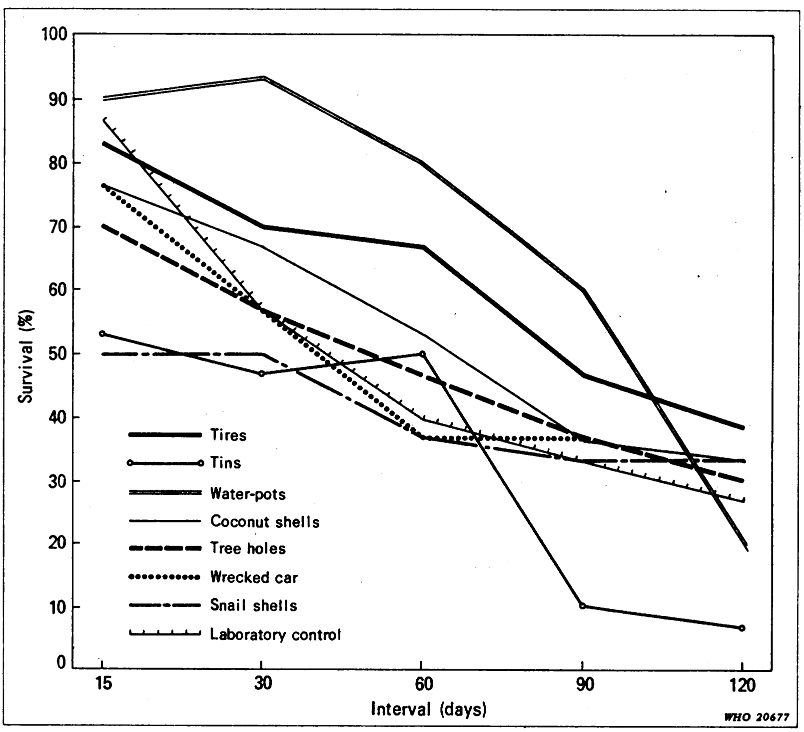

Fig. 1. Dry season survival of *Aedes aegypti* eggs in some common breeding sites in the Buguruni biotope.

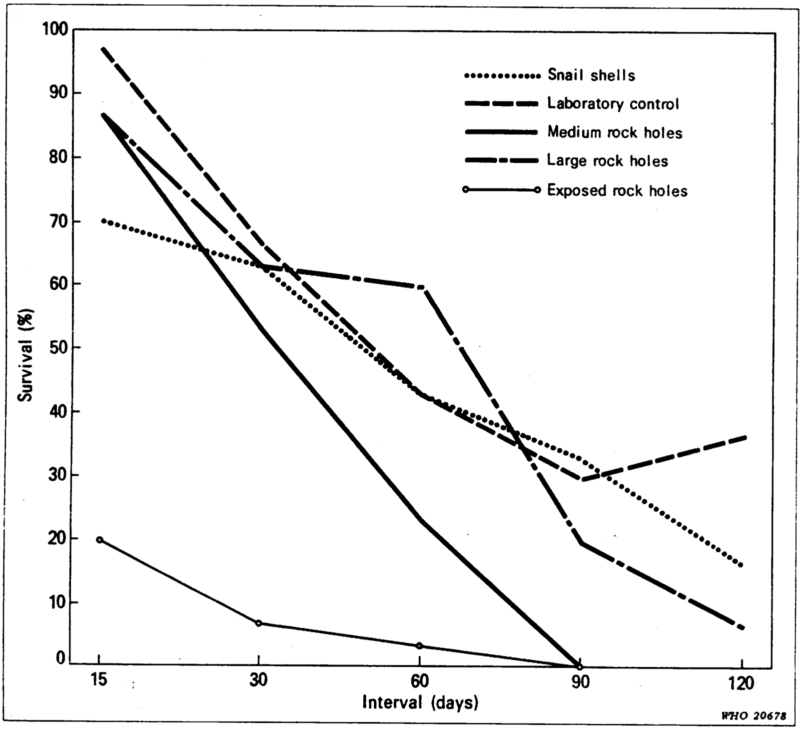

Fig. 2. Dry season survival of *Aedes aegypti* eggs in rock holes and *Achatina fulica* snail shells in the Msasani biotope.

Results

Data on the survival of eggs exposed during the 1969 dry season to periods of 15, 30, 60, 90, and 120 days in 11 different breeding sites are shown in Fig. 1 and 2.

Breeding sites in the Buguruni biotope. The 15-day survival of eggs in man-made containers such as tires, tins, water-pots, and wrecked cars, and in some natural breeding sites such as coconut shells, snail shells, and tree holes, was between 50 % and 93 %. After 30 days of exposure fewer eggs hatched; although the proportion ranged from 93 % to 47 %, in the majority of sites it was between 70 % and 50 %. An increase in the duration of exposure to 60 days further decreased survival to between 80 % and 37 %. The 90-day exposure resulted in a marked decrease of viability (60–10 %). Even after 120-day exposure some eggs hatched, the highest survival (43 %) occurring in discarded tires. Survival in coconut shells and snail shells was 33 %, in tree holes 30 %, in a wrecked car 27 %, in water-pots inside houses 20 %, and in tins less than 7 %.

Breeding sites in the Msasani biotope. Here the survival period of eggs placed in coral rock holes was shorter and the number that survived smaller than in breeding sites at Buguruni.

On the wall of a rock hole located above ground, 20 % of eggs survived after 15 days of exposure. Survival in holes below ground level and in snail shells over the same period was 70–87 %. After 30 days only 7 % of the eggs placed on the wall of an exposed rock hole survived; in holes below ground level and in snail shells, 30-day survival was 53–63 % and 60-day survival 23–43 %. After 90 days, all eggs placed on the walls of exposed rock holes and of a medium-size rock hole below ground level were found dead; the survival in a large rock hole located below ground was 20 % and in snail shells 33 %. After 120 days, about 7 % of eggs survived in the large rock holes and 17 % in snail shells. Among the controls kept

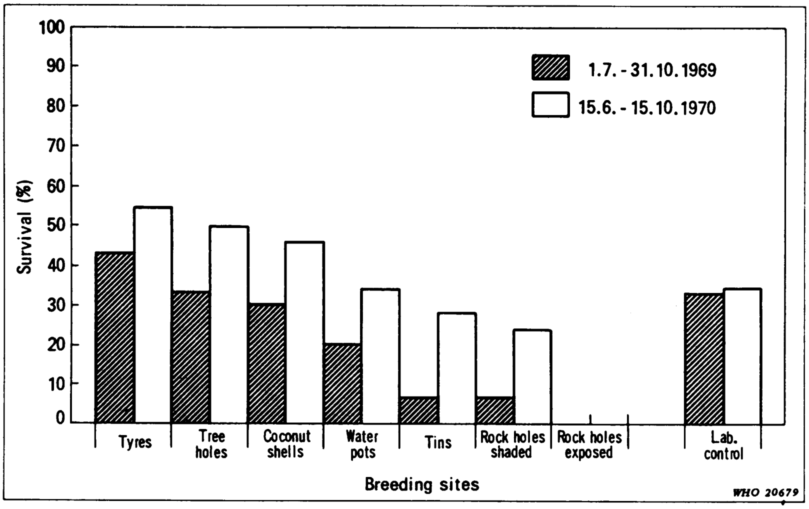

Fig. 3. Survival of *Aedes aegypti* eggs in seven common breeding sites in the Dar es Salaam area during the 1969 and 1970 dry seasons.

in the laboratory, more than 33 % of the eggs of the Buguruni population and more than 36 % of those of the Msasani population survived after 120 days.

It is of interest that the 4-month survival of eggs was higher in tires than in the laboratory at constant conditions of 25°C and 80 % relative humidity. The survival after 4 months in tree holes, coconut shells, and snail shells in an urban area was the same (33 %) as for the laboratory control. These results indicate that 7–40 % of eggs laid at the end of the dry season are able to survive the 4-month period in man-made containers and some natural breeding sites in the Buguruni biotope in Dar es Salaam and about 7–20 % in large rock holes and snail shells in the Msasani biotope.

A similar experiment was repeated in the 1970 dry season. Five of the most common breeding sites (tires, tins, water-pots, coconut shells, and treeholes) were chosen in the Buguruni biotope and two types of rock hole (large holes below ground level and medium holes above ground) in the Msasani biotope. Three replicates of 50 eggs each (total 1 200 eggs including the laboratory control) were placed in each breeding site. The eggs were placed in the sites on 15 June and collected on 15 October.

The results showed that the survival rate of *A. aegypti* eggs in the chosen breeding sites was higher in 1970 than in 1969, but that the trend was similar in both years (Fig. 3). Although there was a considerably greater survival rate in 1970, the reason for this difference is obscure.

There is no significant difference in the ability of the Buguruni and Msasani egg populations to resist drought, but the total survival of eggs placed in the Buguruni biotope after 15, 30, 60, 90, and 120 days was 12–28 % higher than in the Msasani biotope (Fig. 4). The heat collected by the coral rocks and the very low relative humidity resulting from the more exposed nature of the Msasani biotope are probably responsible for the reduced survival of eggs in this biotope.

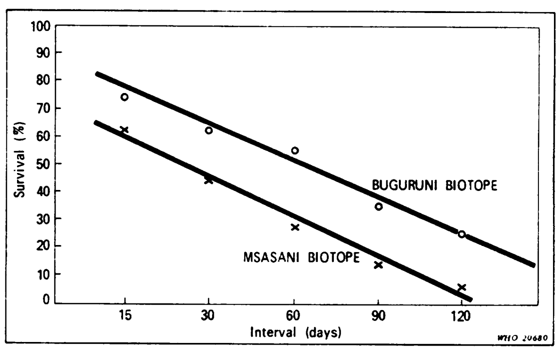

Fig. 4. Comparison of dry season survival of *Aedes aegypti* eggs in breeding sites in the Buguruni and Msasani biotopes.

Discussion

In most places in Tanzania where they occur, the dark *formosus* form of *A. aegypti*, as well as the type form, breed in both "artificial" and "natural" sites. They are more commonly found in artificial (man-made) containers located out of doors, though the absence of indoor breeding is attributed to the water storage habits of different ethnic groups rather than to peculiarities of the two forms of *A. aegypti* in this region. A survey in Dodoma, in one of the driest areas of Tanzania, showed that during the rainy season *A. aegypti* breeds in natural and man-made containers located out of doors, all outdoor containers being empty of water during the 6-month dry season. Similar conditions can be found in many other parts of Tanzania.

It has been shown that a part of the *A. aegypti* population in East Africa is maintained in some biotopes such as automobile dumps and coral rock holes by continuous breeding (Trpiš, 1972b). This breeding has a focal character. In coastal areas of East Africa there are always some short scattered showers during the dry season that prevent these foci from completely drying out. In some, such a tires and rock holes below ground level, even 3–5 mm of rain is sufficient for some eggs at the bottom of the container to hatch and the resulting larvae to complete their development. The eggs laid by the females that emerge are capable of surviving until the next heavy rains because they are fresh and more viable than those laid 2–3 months earlier. Nevertheless, the population eruption that occurs at the onset of the first heavy rains is mainly due to eggs that have survived the entire period of the dry season.

The resistance of *A. aegypti* eggs to drying has been investigated by many workers, mostly under laboratory conditions. Horsfall (1955) and Christophers (1960) discuss the literature on this problem. The different results obtained from apparently similar experiments are perhaps due to varying combinations of temperature and moisture content of the substrate, which are very difficult not only to maintain but also to measure. It seems that from a practical point of view data on dry-season survival of *A. aegypti* are required from many more climatic zones and areas, in order to provide a more precise guide in local control operations.

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