

Natural History of *Anopheles* Mosquitoes in Sri Lanka.

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Introducing anopheles mosquitoes

The genus *Anopheles* has about 400 species and subspecies throughout the world but only 60 species have been incriminated as vectors of malaria under natural conditions (Bruce-Chwatt, 1980). Mosquitoes are divided into two main groups; the anophelines and the culicines. The malaria carrying mosquitoes can be found in the anophelines groups. The male *Anopheles* mosquito who plays a part in the transmission of malaria lives on plant juices while the female mosquito feeds on man and animals. The female mosquito who transmits malaria is much stronger and lays a hundred or more eggs every other day and requires a meal of blood before her eggs can develop (Colbourne, 1966 p 17).

The eggs are deposited on the surface of the water. After about a day eggs hatch out into larvae as small 'wrigglers' which have a head, thorax and abdomen (Bruce-chwatt, 1980 p 128). The normal incubation period of the eggs is about 2 days and the time needed for development from the larvae to the pupal stage is about 15-16 days. The pupal stage lasts about 3-5 days depending on the weather. So the whole life history from eggs to adults takes about 25 days (Hems and James, 1961; Dutta and Dutta, 1978) (see figure 2). However the growth of the mosquito is much more rapid in hot weather than in cool weather. For instance, the duration of the cycle from the egg to the adult *anopheles* varies from 7 days at 31 C and 20 days at 20 C according to Bruce-Chwatt (1980).

The length of life of adult *anopheles* depends on internal and external factors among which the temperature and humidity

are the most important. Even if the anopheles mosquitoes can survive at as low a temperature as 12 C , the best condition for survival is between 25-30 C with 60% relative humidity (Bates, 1949). However, when the mean temperature is over 35 C and the humidity is less than 50%, the longevity will be reduced drastically (Bruce - Chwatt, 1980). The longevity of anopheles under favourable climatic condition is about 3-4 weeks provided the mosquito is not attacked by his enemies. In Africa, about 25% of the anopheles mosquitoes that emerged from pupa will survive for about 13 days, This is important in the sense that 13 days are long enough to develop some malaria parasites in the mosquito. For example, Plasmodium Falciparum parasite needs only 10 days to develop in the mosquito (Colborne, 1966; Bruce - Chwatt, 1980).

The collection of water which provide basic conditions for anopheles larvae are the breeding places for anopheles mosquitoes. When selecting the site for oviposition by female anopheles, different species choose different type of habitats. This is due to a number of factors involved, among which exposure to sunshine, temperature, salinity or organic content are the most important (Bruce - Chwatt, 1980).

Russell's classification of breeding sites for anopheles mosquitoes is generally adopted as a convenient and carefully prepared list of mosquito habitats (quoted from Bruce- Chwatt's book, 'Essential Malariology" (1980) pp. 148-149).

- (1) Permanent or semi-permanent standing fresh water. Large open marshes or marshy parts of lakes, small ponds, pools, borrow pits, stagnant canals and ditches. Spring fed pools, springs and seepages from higher contours. Standing water in the fields (rice fields, plantations) open wells. Swamps and pools in the forest.

- (2) Transient or fresh water collection.
Open pools in the fields or stagnant stream beds, cattle hoof prints and pools in the cart tracks etc.
- (3) Permanent or semi-permanent running fresh water.
open streams with vegetation.
Stream beds running over gravel.
Flowing water in canals and ditches.
Streams in forest or plantations.
- (4) Container habitats.
Rock holes.
Tree holes.
Plant axils and epiphytic water bearing plants.
Discarded containers, natural and artificial (tins, tyres, coconut shells, etc.)
Crab holes and cracks in the mud (fresh or brackish water).
- (5) Brackish water.
Marshes, ponds and swamps.
Tidal swamps.
Small collection of brackish water.

Although the feeding of female anopheles normally occurs between dusk and dawn, anopheles may feed during the day time too in shaded or dark shelters and houses. Some species prefer to feed on animals while others prefer a human host (Russel et al, 1963; Bruce Chwatt, 1980; Colbourne, 1966).

Resting places are very often inside houses, clumps of vegetation, hollow trees and logs, large exposed tree roots, holes in rocks (Bruce - Chwatt, 1980). These mosquitoes also prefer to rest on walls, ceilings, cloth hanging, on the back of pieces of furniture and generally inside the houses. In particular female anopheles like dark and rather dirty houses where there are plenty of cracks to hide in (Colbourne, 1966).

The vector in Sri Lanka; *Anopheles Culicifacies*

Anopheles culicifacies is the only vector out of 20 species of anopheles mosquitoes recorded in Sri Lanka (see table 1) (James and Gunasekara, 1913; Carter and Jacocks, 1929; Clemesha, 1934; Rajendran and Jayawickrama, 1951; Tems, 1980; Brown, 1986; Herath et al, 1981). The other species found in Sri Lanka do not reach the densities required for each of them to transmit malaria because of unknown ecological conditions (Sivachanasundram, 1971).

Table 1

Anopheles mosquitoes in Sri Lanka

Local vector

1. *A. culicifacies*.

Vectors outside Sri Lanka

2. *A. maculatus*.
3. *A. aconitus*.
4. *A. annularis*.
5. *A. barbirostris*.
6. *A. hyrcanus*.
7. *A. leucosphyrus*.
8. *A. tessellatus*.
9. *A. varuna*.

Probably of no practical importance

10. *A. aitkeni*.
11. *A. annandalei*.
12. *A. gigas*.
13. *A. insuloefflorum*.
14. *A. jamesi*.
15. *A. karwari*.
16. *A. pallidus*.

17. *A. pseudobarbistrotris*.
18. *A. ramsayi*.
19. *A. subpictus*.
20. *A. vagus*.

Source: T. Visvalingam (1961)

Larvae ecology of anopheles culicifacies

The larvae of anopheles culicifacies have been found in a variety of breeding places in Sri Lanka. Rajendran and Jayawickrama (1951) recognized 8 major breeding sites for anopheles culicifacies in Sri Lanka.

1. Sand and rock pools in rivers and streams; also to a lesser extent the margins of rivers and streams.
2. Wells of all types, built and unbuilt.
3. Brick, quarry and coral pits, also coconut pits.
4. Borrow pits, particularly when freshly dug.
5. Irrigation channels; also seepages from them.
6. Road side drains where water is stagnant.
7. Rice fields, particularly fallow and up to a quarter grown.
8. Rain pools (Rajendran and Jayawickrama, 1951, p. 17.)

The larva has been regarded as being a sun loving stage of mosquito breeding cycle (Carter, 1930).Rjendran and Jayawickrame (1951) found that larvae breeding occurs in shaded conditions in stream even in thick jungles. Clemesha (1934) made an extensive observation of the breeding habitat of this species in Sri Lanka and described the conditions of breeding sites most graphically.

"The optimum breeding place for this species is a stream running over flat country at the foot of the hills

which is almost empty from drought. The water must be clear; the current must be slow as one would expect in a stream nearly dry, the stream must not be entirely shaded, there must be a portion in the middle of the bed on which the sunlight plays for a good number of hours in the day time. A stream in this position usually has a sandy bed with some rocks visible in places. Very small collections of water in the sand are much favoured by this species; foot marks, both of cattle and man, are frequently full of larvae; back waters with the water only half to three quarter of an inch deep usually contain many larvae provided they are in the sun" (Clemesha, 1934, p. 158.).

These streams where mosquito breeding is made produce more *Culiseta* larvae during a drought than during the ordinary rainy weather. The water in streams is clearer, warmer and shallower during the drought than in the rainy season so that the drought, particularly a few weeks after the rainy season is the worst period for massive breeding of *Anopheles culicifacies* (Clemesha, 1934).

In a study on breeding habits of this species in Pattukkottai in India, larvae of *Anopheles culicifacies* were found in irrigation channels, wells, field channels, waste irrigation water, borrow pits, tanks, ditches, seepage and spring pools, rice fields, rain water pools, hoof marks and car tracks (Russell and Rao, 1940). In a separate study, Russell and Rao (1942) examined the breeding of *Anopheles culicifacies* in rice fields and found that the rice fields freshly watered but not ploughed are ideal breeding places for this species. They noted that fallow rice fields flooded and ploughed, growing rice fields in the first stage with plants less than 12 inches high and growing rice fields in the second stage after rice plants were 12 inches high are also suitable for *Anopheles culicifacies* breeding.

Senior White (1928) recorded 28 C as the optimum temperature for developing of larvae. Pal (1945) noted that the lowest temperature tolerated by eggs was 5 C, larvae 3 C, pupae 3 C and the highest temperature which pupae could withstand was 43 C (Pal, 1945).

Behaviour pattern of adult anopheles culicifacies

The adult female mosquito normally feed from dusk to dawn but they may feed during the day time as well (Clyde, 1931; King and Krishnan 1929; Bruce-Chwatt, 1980). Carter (1927) reported that *Anopheles culicifacies* was active both at night and from 5 to 6 in the morning in Sri Lanka. Rajendran and Jayawickrama (1951) found that adult *culicifacies* mosquitoes enter houses from dusk to till about 9.30 pm. *Anopheles culicifacies* is known to be zoophilic feeding both on man and animals. Russel and Jacob (1939) found in Madras in India, that the anthropophilic rate of *anopheles culicifacies* (feeding on man) is 80%. Barber and rice (1938) found in Poona in India that among the stomach bloods examined, the human blood positives were only 3,4 percent. Nevertheless, the man biting rate may vary according to season and the number of animals in the locality (Macdonald, 1957) Human blood index represents the proportion of human blood in freshly fed *anopheles* (W. H. O. 1963). Although the proportions given by defferent observers vary greatly, the figures vary roughly between 2% and 25% (Sivachanasundram, 1971). Covell and Singh (1943) gave values in the region of 12.8% and 25.7%. Rao and Ariyaratnam (1963) (quoted by Sivachanasundram in 1971) measured the host preference of *anopheles culicifacies* in Sri Lanka and they are:

Man	31.9%
Cattle	48.0%
Dog	17.9%
Bird	1.3%

Anopheles culicifacies is predominantly a domestic species and prefers dark houses and cattle sheds (Pal, 1945). Most observations have confirmed that man made structures are much favoured by this species to rest during the day time. Ariyaratnam (1955) found in Sri Lanka that when cattle are tethered in the homestead, the mosquito prevalence in these houses are much higher than on other days. Pal (1945) observed the preference for walls in different houses and found that the unplastered walls are more favoured by *Anopheles culicifacies* than the rooms with plastered walls. Surfaces such as walls, screens, furniture, firewood, and roofs are ideal resting places for this species (Thomson, 1951; Pal and Sharma, 1952). Ariyaratnam found in Sri Lanka that walls below 6 feet are much preferred by *Anopheles culicifacies*. The indoor resting habits of this species are well known and the cattle sheds are also famous as resting places for this species.

Anopheles culicifacies does not fly more than half a mile from its breeding places according to early observers (Stephens and Christophers, 1902; Christophers, 1904; James, 1903; Bose, 1934; Mulligan and Barily, 1936). According to Russell (1944) the greatest flight range of *Anopheles culicifacies* was between 1.5 and 1.75 miles from the breeding places. Carter (1934) found that the mosquito catch fell away in dwelling situated beyond 500 yards from the Daduru river in Sri Lanka. (as shown by Carter's paper, the catching rate is ambiguous)

Distance of huts from river	Catching rate per hour
50 - 200 yards	16.3
500 yards	9.9
1000 - 1300 yards	.7
2000 - 2200 yards	.5
2500 - 3000 yards	.06

Bruce Chwatt (1980) indicates that *Anopheles* mosquitoes are not usually found more than two or three kilometres from their

breeding places. Recent studies confirm the previous findings made on *Anopheles culicifacies* in Sri Lanka that flights of 2 km are possible (Rawlings et al, 1981; Curtis and Rawlings, 1980; Rawlings and Davidson, 1982). The effective flight range and dispersal seem to depend on some major factors such as the intensity of breeding, the pattern of distribution of breeding places, the availability of suitable host for feeding, velocity of the wind, physical barriers like rocks and trees.

The longevity of *Anopheles culicifacies* is partly determined by temperature and the relative humidity. Pal (1943) observed the time of survival of *Anopheles culicifacies* in a laboratory study in Lahore in Pakistan and found that *Anopheles culicifacies* survive about 4 to 8 weeks at low temperatures between 12°C to 18°C. But they did not survive for more than 24 hours at 40°C. It is considered that 41°C is the thermal death point for this species. At 30°C they survived from 6 to 18 days, at 35°C they lived about 10 days. Afridi and Puri (1940) found in India that longevity is chiefly associated with the season. Russell and Rao (1942) made an extensive study on longevity of this species in the Thangavur district in Tamil Nadu in India and they also found that the longevity is mainly associated with the season, temperature and relative humidity. It was revealed in this study that *Anopheles culicifacies* lived only 11 days (maximum) in April and 24 days in July and 32 days in October. Rajendran and Jayawickrame (1951) noted that nowhere in Sri Lanka is temperature and humidity adverse enough at any time for a cessation of the development of *Anopheles culicifacies*.

A recent study by Curtis and Rawlings (1980) in Sri Lanka on dispersal of *Anopheles culicifacies* concluded that the average longevity of the adult of this species was 17 or 18 days. Since this study was carried out in an area where the temperature is about 30°C, this seems to be the average time of survival of *Anopheles culicifacies* in Sri Lanka. The average expectation of infected life of this species with *Plasmodium vivax* infection is about 4 days (Sivachanasundram, 1971 p. 135).

Summary

The anopheles and the culicins are the two main groups of mosquitoes. Although there are about 400 species and subspecies of anophelines, only 60 species have been incriminated as vectors of malaria. The slow-moving streams and temporary water bodies such as drains and cart tracks exposed to sunshine are the main breeding places for anopheles mosquitoes. The resting places are very often inside houses, clumps of vegetation, hollow trees, large exposed tree roots, and holes in rocks.

The anopheles culicifacies is the only vector out of 20 species of anopheles mosquitoes recorded in Sri Lanka. The larvae of anopheles culicifacies can be found in shaded places in streams, wells, brick coral and coconut pits, borrow pits, irrigation channels, road side drains, rice fields and rain pools in Sri Lanka. The anopheles culicifacies is a domestic species who prefers dark houses and cattle sheds, surfaces such as walls, screens, furniture, firewood and roof are ideal resting places for this species. This species does not fly more than two kilometers from their breeding places. The average longevity of the adult of Anopheles culicifacies is 17 or 18 days.

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