1. **Resting habit**

**Calcutta**

James (1902) as quoted by Basu (1930) in his report 'Malaria in Calcutta' first recorded *Anopheles stephensi* in Calcutta. In another communication, Senior White (1940) reported that the existence of *An. stephensi* was first recognised in Calcutta by Stephens and Christophers in the same year (1902).

Annandale (1907) noticed the presence of *An. Stephensi* in the gardens of Indian Museum (cited from Basu 1930).

De (1923) collected a total of 1460 Anophelines, of which *An. Stephensi* comprised only 1%.

Senior White (1934), after his three years extensive study, collected 1256 Anophelines, of which *An. stephensi* comprised of only 1.2% (14). Specimens were mainly captured from ground levels of Bengal - Nagpur Railways Head quarter's colony. From his observation on resting habit of *An. stephensi* in Calcutta, Senior White concluded that the apparent rarity of *An. stephensi* in the check catches was not due to its absolute paucity of numbers, but in fact its day time resting places were unknown in Calcutta.
Knowles and Basu (1934) stated "inspite of the fact that larvae of *An. stephensi* are to be found in profusion throughout the city, yet adults of this species are curiously difficult to capture in Calcutta."

Ganguly (1935) pointed out that due to some unaccountable reasons the adults of *An. stephensi* were difficult to catch in Calcutta.

Strickland, Roy and Chowdhuri (1936) claimed that the prevalence of *An. stephensi* in this metropolis was becoming wane. Out of a total of 8564 adult anopheles comprising of 13 different species, 177 *An. stephensi* were caught by hand. The distribution of female *An. stephensi* from Pucca bungalow, Pucca cowsheds, Katcha cowsheds, Pucca servant quarters, Katcha servant quarters, School or Institution, bustee huts and flats were 27, 0, 1, 77, 1, 3, 14 and 24 respectively. No significant variation was found between male and female *An. stephensi* caught both in the morning and evening hours.

Sen (1937) searched several villages lying on either bank of the river Hooghly from Calcutta to Falta and Uluberia for a year, but not a single *An. stephensi* was obtained from both the biotopes, i.e. human habitations and cattlesheds searched.
Roy et al (1938) collected a total of 221 day time resting An. stephensi from a house in Central Calcutta. Resting sites were dark blue dressing gown and its folds, leather-bands inside hats, underneath a small parapet, projecting from the top of the almirah, etc. The room where the mosquito captured was situated on the first floor of pucca building. A cattleshed was situated within 30 yards (27 m) of that pucca building and when the cattleshed was demolished, catches were found to be lower. Finally they concluded "While it (An. stephensi) is comparatively easy to collect a large number of adults in other cities (Bombay, Delhi), it is by no means so in Calcutta."

In 28 month-efforts, Senior White (1940) collected 297 (1.8%) An. stephensi i.e. 111 from houses, 13 from cowsheds, 170 from cowtraps and only 3 from human trap. After the long term investigation, the author remarked: "Day time resting places of this species are obscure in Calcutta."

Siddons (1943) stated that Senior White in 1940 had closed the investigation of An. stephensi because of its rarity to make the cost of collection prohibitive, Siddons (1943) himself did not establish the actual resting places and concluded "until the
problem of its day time resting placed is solved, no real progress can be expected". Also in the year 1946, Siddons was not able to pinpoint the day time resting places of *An. stephensi* in Calcutta.

Mukhopadhyay (1980) obtained only 14 and 24 *An. stephensi* indoors and outdoors respectively from a *pucca* house in Calcutta.

**West Bengal**

A total of 196 (per man-hour collection 1.1) *An. stephensi* were captured from Oyaria in the district of Burdwan by Neogy and Sen (1962).

**India**

In Mysore State, Nursing et al (1934) emphasised that *An. stephensi* had a decided preference in human habitations for day time resting places. Sweet and Rao (1937) selected eight buildings in each of three different villages of the same State. Percentage catches were 1.0, 0.4 and 0.9 of the total anopheline captured.

In Kutch State, Afridi et al (1938) experienced great difficulties in collecting *An. stephensi*. This species was frequently found to hide itself
inside the concave surface of the cut bamboo pieces which support the tile roofs in most poor habitations and cattlesheds.

Barbar and Rice (1938) collected 55 An. stephensi in Poona and its vicinity, 19 from dwellings, 30 from buildings and 6 under culverts.

In a two year survey, Russel and Rao (1941) collected only 11 female An. stephensi from Puttukkottai area, Madras by searching thatched huts (human, animal and mixed).

From the villages of Vizagapatam, Senior White and Rao (1941) collected a total of 225 An. stephensi, of which, 144 and 81 specimens were captured from houses and cattlesheds respectively.

An. stephensi mosquitoes are the chief carrier of malaria in Bombay and Hyderabad cities. Abraham and Samuels (1944) caught few adults in some villages.

Subbarao and Apparao (1945) collected 388 specimens from town and 304 from rural areas of Vizagapatam and noticed that the adults were rare in pucca houses but plentiful in thatched huts and cattlesheds.
Senior White (1946) obtained a total of 189 specimens and reported that both the type and mysorensis variety of *An. stephensi* were available in Eastern Satpura ranges of Central Provinces.

In a 27 month duration, Bhaskar Rao *et al* (1946) got 3646 *An. stephensi* from Madras. Maximum preference of resting *An. stephensi* was found in mixed dwellings (1842) followed by cattlesheds (1154) and human dwellings (650) respectively.

Adhikari and Ganguly (1949) measured the density of *Anopheles* adults in human dwellings in North Madras coast and coastal areas around Vizagapatam. Per 5 man-hour density of *An. stephensi* was found to be 0 in 1944, 1946 and 1948.

Pal and Sharma (1952) stated that the houses treated with DDT invariably showed a striking reduction both in the day time and night catches of *An. stephensi*.

Viswanathan *et al* (1952) collected a total of 86 *An. stephensi*, of which, 35 were collected by hand before pyrethrum spraying and 51 after pyrethrum spraying in Poona district. The collection was done from March to July 1951.
In Salem, Tamilnadu, Batra et al (1979) reported that majority of *An. stephensi* were obtained from *pucca* houses. Resting specimens were also found in huts, godowns, firewood depots, cattlesheds and walls of the wells and so on.

Rahman et al (1979) collected a total of 761 *An. stephensi* from two villages of rural Rajasthan. Per man-hour density in the post monsoon season (Aug/Sept) was 0.15 (10) indoors and 0.4 (4) outdoors. In the premonsoon season (Mar/Apr) the corresponding data were 18.24 (727) and 2.0 (20) respectively.

Subbarao et al (1984) found that per man-hour collection of *An. stephensi* was 20.8 with a peak in February in Mandora, Haryana.

Singh et al (1985) after surveying nine talukas of Kutch State in morning and evening hours, found a high density (6729) of *An. stephensi*.

Sharma et al (1985) stated that the per man-hour density of *An. stephensi* in Delhi, starting from May 1982 to December 1983 were 4.00, 2.00, 10.50, 24.50, 33.50, 40.50, 19.50, 9.50, 0, 0, 0, 1.00, 0, 0, 5.00, 13.75, 17.50, 8.25, 0 and 0 respectively.
In Mesopotamia, Christophers and Shortt (1921) found that this species *(An. stephensi)* was of retiring habit and its presence was therefore oversighted.

According to Mulligan and Baily (1936) *(An. stephensi)* (total catch 1200) of Huda village, Quetta, Beluchistan, showed a marked preference for resting places which are in close proximity to human and animal dwelling shelters hastily erected by refugees. Very few catches were made from out of door.

Afridi and Majid (1938) captured 1142 *(An. stephensi)* from huts, barrack-rooms and family quarters in Bahrein island.

In Punjab (Pakistan), Rafi (1955) obtained resting *(An. stephensi)* throughout the height of the wall inside rooms.

Quraishi (1965) collected a total of 2083 adults from a pit shelter (out door) but all of them were *mysorensis* variety.

In Iran, Manouchchri et al (1976) found *(An. stephensi)* in thatched human habitations and animal sheds (Kapar or Kumesh) and it preferred to rest on lower part of the walls or on the ground of unoccupied shelters.
In Bandar Abbas of Iran, *An. stephensi* was found to rest in underground shelters such as 'Quanats' (walls built on sloping land to bring underground water to the surface).

In another report of Iran presented by Zahar (1974) *An. stephensi* was found to be largely endophilic and in Kazeroun area of Iran the average density of *An. stephensi* per room was 200.

In Pakistan, Reisen and Mahmood (1981) stated that during the premonsoon season, mosquitoes typically seek suitable microhabitats within indoor resting sites, lowering sampling proportion at this time.

### 2. Seasonal Prevalence

#### Calcutta

From the data presented by Senior White (1940), it was found that out of 169 *An. stephensi*, 53, 82 and 34 were collected in monsoon, summer and winter respectively. From man landing collection experiment total 27 *An. stephensi* were captured. The seasonal distribution was as follows: rainy (20), winter (5) and summer (2) (Mukhopadhyay 1980).
Sinton (1917) in Kohat district observed that *An. stephensi* began to appear early in May in scanty numbers and increases in abundance until July and August. In October it is still present but later in the year it is rarely or never found.

Ramsay and Macdonald (1936) reported that in the coastal towns such as Bombay and Calcutta it appeared to have a marked seasonal increase during the monsoon, though it is to be found at all times.

Bhaskar Rao *et al* (1946) found 976 (48.4%) 678 (33.6%) and 363 (18%) *An. stephensi* in winter, monsoon and summer respectively in Madras.

Bhatia *et al* (1958) collected a total of 1924 *An. stephensi* mosquitoes from near Delhi. 26, 221, 419, 649, 258, 109, 97, 19, 39, 38, 22 and 27 *An. stephensi* were collected in the months of January, February, March, April, May, June, July, August, September, October, November, December respectively.

Subbarao *et al* (1984) captured the highest number of *An. stephensi* in the month of February in Mandora, Haryana.
An. stephensi is an important vector of malaria in the coastal areas of the Persian Gulf and Oman sea from Abadan to Bandar Abbas and Chahbahar. In such areas, this species was active throughout the year with two peaks, one in April-May and other, which is higher, in August-September. In hilly areas of the southern slopes and valleys of the Zargros chain or in Beluchistan, its activity started in May and reached its peak in August and then gradually declined. In cold weather, no An. stephensi was obtained (Manouchchri et al 1976).

Reisen, Mahmood and Parveen (1982) reported that maximum resting An. stephensi were captured during November and December in rural Punjab province, Pakistan.

3. Larval survey

Calcutta

Iyenger (1920) found the presence of breeding places (Garden tubs, old unused cisterns, shallow pits) of An. stephensi throughout the entire city of Calcutta.
According to Basu (1930) out of a total of 4119 spots examined, 27.45% (1131) spots were found to be positive with *An. stephensi* larvae in an area, one square mile in extent in central Calcutta bounded by Machu bazar and Cotton Street on the North, Bowbazar, Lalbazar, Dalhousie Square North on the South, Amherst Street on the East and Charnock Place and Clive Street on the West. Larvae of *An. stephensi* were observed both in filtered and unfiltered water. An exact correlation was noted between breeding habits and rainfall.

In Calcutta, Roy (1931) observed the presence of *An. stephensi* larvae in open earthen drains and ponds, full of aquatic weeds and lillies.

Roy (1931) made a critical laboratory studies on breeding habits of *An. stephensi*. The maximum and minimum time taken by larvae to pupate under laboratory condition were found to be 58 and 9 days. The effect of low temperature on the development of larvae was studied. When subjected to a constant temperature of 24°C, they usually took about 16 to 20 days to pupate, while in a temperature of 12°C the large ones did not survive for more than 3 to 4 days and the small ones for more than 24 hours.
By conducting four year larval survey (July 1928 to June 1932), Knowles and Basu (1934) detected *An. stephensi* larvae in 33.05% (3942), of 11927 spots searched. The prevalence of positive containers was reported to be higher in the month of July and lower in April. Distribution of positive container were: Earthen handis 29.3%, Earthen tubs 26.4%, Jars 30.0%, Kerosine tins 29.2% and Iron tubs 28.3%.

According to both Senior White (1934) and Ganguly (1935) *An. stephensi* larvae were very common in the sewered area of Calcutta.

After a long gap, Mukhopadhyay (1980) conducted a natural survey in and around 100 brick houses in Central Calcutta and detected the existence of *An. stephensi* larvae in 202 water holding containers, of which, 158, 18, 11 and 15 were found on ground, first, second and third floors respectively. By conducting ovitrap experiment in Calcutta Mukhopadhyay (1980) showed that *An. stephensi* could lay eggs throughout the year but the breeding propensity expressed in term of 'ovitrap index' was higher in the month of July.
West Bengal

Neogy and Sen (1962) found 3.1% larvae from empty containers, ditches or neglected pits in Oyaria, Burdwan.

India

Hodgson (1914) described that the larvae of *An. stephensi* were never found in large numbers in any part of the district of Delhi, but their universal distribution in wells, not only in the city but throughout the countryside seemed to be extraordinary. *An. stephensi* larvae were also found in fair numbers in the pools of Bela. One very unusual breeding place for this mosquito was found in April 1913, a slowly moving shallow stream called the Khudsia creek. In this position the larvae were numerous.

Sinton (1917) in Kohat district found that *An. stephensi* mosquitoes were found to breed in almost any collection of water. In 1914 the larvae of *An. stephensi* were first recognised at the end of May and were very common in July and August.
Table 7. Description of breeding sites of *An. stephensi* throughout the globe

<table>
<thead>
<tr>
<th>Authors</th>
<th>Place</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iyenger (1920)</td>
<td>Calcutta</td>
<td>Garden tubs, old unused cisterns, shallow pits</td>
</tr>
<tr>
<td>Basu (1930)</td>
<td>Calcutta</td>
<td>Filtered and unfiltered water</td>
</tr>
<tr>
<td>Roy (1931)</td>
<td>Calcutta</td>
<td>Open earthen drains and ponds</td>
</tr>
<tr>
<td>Knowles and Basu (1934)</td>
<td>Calcutta</td>
<td>Earthen handis, Earthen tubs, Jars, Kerosine tins, Iron tubs</td>
</tr>
<tr>
<td>Senior White (1934)</td>
<td>Calcutta</td>
<td>Sewered areas</td>
</tr>
<tr>
<td>Mukhopadhyay (1980)</td>
<td>Calcutta</td>
<td>Cemented floors, masonry tanks, cistern, corporation key hole, fountain, large collection of water in burrow pits, earthen ware pot, iron pan, marble pot, flower tubs (made up of both marble and clay), water tub, broken procelain pot, water logged of houses undergoing construction wells.</td>
</tr>
<tr>
<td>Neogy and Sen (1962)</td>
<td>West Bengal</td>
<td>Empty containers, ditches and neglected pits</td>
</tr>
<tr>
<td>Hodgson (1914)</td>
<td>Delhi</td>
<td>Wells, pools, slowly moving shallow stream</td>
</tr>
<tr>
<td>Sinton (1917)</td>
<td>Kohat district</td>
<td>Old tins and broken pots in the square brick tanks, rain water puddles, pools, grass-grwn ditches, burrow pits.</td>
</tr>
<tr>
<td>Covell (1928)</td>
<td>Bombay</td>
<td>Dark places, any depth of water, roofs (height 24.4 m to 30.5 m), cisterns, roof gutters, terraces</td>
</tr>
<tr>
<td>Abraham and Samuel (1944)</td>
<td>Bombay</td>
<td>Rivers and wells</td>
</tr>
<tr>
<td>Authors</td>
<td>Place</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Banerjea (1930)</td>
<td>Lucknow</td>
<td>Wells</td>
</tr>
<tr>
<td>Afridi (1938)</td>
<td>Kutch State</td>
<td>Troughs, siphons, reservoirs, wells</td>
</tr>
<tr>
<td>Russel and Rao (1941)</td>
<td>Madras</td>
<td>Wells</td>
</tr>
<tr>
<td>Bana (1943)</td>
<td>Bombay</td>
<td>Salt pans, tanks and drums</td>
</tr>
<tr>
<td>Senior White and Rao (1944)</td>
<td>Vizagapatnam</td>
<td>Wells</td>
</tr>
<tr>
<td>Covell (1944)</td>
<td>Bombay</td>
<td>Wells, cisterns, fountains, garden tanks and tubs, cement floors where water accumulates, reservoirs, roof gutters, tins, pools, stream, irrigation channels, reservoirs.</td>
</tr>
<tr>
<td>Batra and Reuben (1979)</td>
<td>Suramangalam and Shevapet</td>
<td>Wells</td>
</tr>
<tr>
<td>Kaur and Reuben (1981)</td>
<td>South India</td>
<td>Wells</td>
</tr>
<tr>
<td>Gad (1967)</td>
<td>Suez</td>
<td>Gulf of Suez</td>
</tr>
<tr>
<td>Zaluesta (1968)</td>
<td>Iraq</td>
<td>Saline water</td>
</tr>
<tr>
<td>Monouchchari (1976)</td>
<td>Iran</td>
<td>Wells, garden ponds, hoof prints of animals, seepages, rice fields, goat skin bag.</td>
</tr>
</tbody>
</table>
The following are some of the breeding places in which it was found: (i) Old tins and broken pots, (ii) In tins and vessels used to store water. In porous earthenware pots buried beside little trees and filled with water to water the roofs in the hot weather, (iii) In the square brick tanks used to store water for gardens, (iv) In rain water puddles and in little pools of water left after irrigation, (v) In grass-grown ditches and irrigation channels, (vi) In borrow pits.

Covell (1928) in his monograph 'Malaria in Bombay' reported that An. stephensi will breed with equal facility in dark places and in those exposed to the direct sunlight and larvae flourished in any depth. The breeding place may be situated below the level of the ground or on the roof of a building 80 to 100 ft (24.4 - 30.5 m) in height. The roof cisterns is the permanent breeding sites in Bombay along with the improperly graded roof gutters and terraces. Generally large roof cisterns connected with mills and railways (touching a great height) were invariably found breeding places of An. stephensi.

Banerjea (1930) experienced great difficulties in finding An. stephensi larvae in wells of Lucknow. But in the month of August 1929 however, after a break in the rains, the wells became active source of larvae of An. stephensi.
In Kutch State, Afridi (1938) recorded that *An. stephensi* used to breed in troughs, siphons, reservoirs and wells in Vijaya villa place while in Bhuj it was almost exclusively well breeders.

In Puttukkottai, Madras, the larvae *An. stephensi* were found to be restricted in wells (Russel and Rao 1941).

Bana in 1943 reported that *An. stephensi*, the malaria vector in Bombay, bred in the salt pans in September and October, when these were used for rearing fish. In addition to the salt pans, *An. stephensi* was also found breeding in A.R.P. tanks and drums filled with sea water which had become diluted with rain water, and even occasionally when the sp. gravity was as high as 1030 (i.e. equal to that of sea water). The author compared the adaptability of *An. stephensi* to water of different composition with the constant preference of *Aedes aegypti* for highly specialized breeding places.

Senior White and Rao (1944) found that *An. stephensi* bred in *pucca* (14.9%) and *kaccha* (7.0%) wells as well as nalas (78.1%) in Vizagapatnam.

In towns larvae of *An. stephensi* were found in wells, cisterns, fountains, garden tanks and tubs, water used for soaking bricks and keeping the surface
of cement concrete wet during building construction, cellars in to which subsoil water percolates, leakages from reservoirs, improperly graded roof-gutters, discarded tins and receptacles of all kinds, hollows in machinery and scrap iron etc. (Covell, 1944). In rural areas they were found in pools, in stream beds and at the margins of stream itself, in seepages and marshy areas with gentle flow of water, irrigation channels, reservoirs and springs, showing a preference for sunlit breeding places.

Krishnan (1961), Dhir (1970) observed larvae of *An. stephensi* at the floor of newly constructed rooms where the water being kept to moisten the cement layer.

Batra and Reuben (1979) collected *An. stephensi* larvae from wells and cisterns in Salem. The collection was done from December to November in Old Suramingalam and Shevapet. In Old Suramangalam, out of 451 wells positive, 421 were identified as containing the larvae of *An. stephensi*. The corresponding figure of Shevapet were 163 and 121 respectively.

Kaur and Reuben (1981) did not find direct effect of rain fall on survival or density of *An. stephensi* larvae after 14 months survey in 20 wells in a malarious town in South India.
World

Gad (1967) found *An. stephensi* larvae near Gulf of Suez.

Zuluesta (1968) also reported the presence of larvae in saline water at Fao, Iraq (quoted from Monouchchri 1976).

In Burma, Khin-Maung-Kyi (1971) as quoted by Rao (1984) reported "In the foot hill areas from which the species have mainly recorded the larvae been found in pools in river beds, in seepages and along edges or reeky hill streams.

Manouchchari (1976) pointed out that *An. stephensi* bred in all sorts of water, mainly in wells and garden ponds in Southern Iran. The larvae of *An. stephensi* were even detected in hoof prints of animals around the seepages of marshy areas. *An. stephensi* also bred readily in rice fields, especially in nurseries and newly planted rice fields. In rural area of Southern Iran, this species was also found in small amount of water which leak from the 'mashk' - the goat skin bag used to hold drinking water or hoof prints of animals.
4. Blood meal analysis

Calcutta

Roy et al (1938) carried out blood meal analysis of 172 female An. stephensi by micro precipitin test, of which, 33.1% (57) specimens were found to be disintegrated. The result showed that only 3.4% (4) had taken human blood and 95.5% (111) taken bovine blood.

Hati et al (1979) got 50% human blood and 50% bovine blood among the specimens (20) collected from Calcutta.

Mukhopadhyay (1980) conducted blood meal analysis of only 10 mosquitoes. The result showed that all mosquitoes had taken human blood.

India

Barber and Rice (1938) found that maximum An. stephensi were positive for bovine blood in Poona. Out of a total of 43 blood smear examined, human positive (AI) was found to be nil.

Afridi et al in the year 1939 found 1.19 (4) human blood index of An. stephensi in Delhi urban area. The corresponding figure in the year 1938 was 4.16 (1).
Table 8. Anthropophilic index (A.I.) of *An. stephensi* throughout the globe

<table>
<thead>
<tr>
<th>Species</th>
<th>AI (%)</th>
<th>Locality</th>
<th>Authors (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>An. stephensi</td>
<td>3.4</td>
<td>Calcutta</td>
<td>Roy <em>et al</em> (1938)</td>
</tr>
<tr>
<td></td>
<td>50.0</td>
<td>Calcutta</td>
<td>Hati <em>et al</em> (1979)</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>Calcutta</td>
<td>Mukhopadhyay (1980)</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>Poona</td>
<td>Barber and Rice (1938)</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Delhi urban area</td>
<td>Afridi <em>et al</em> (1939)</td>
</tr>
<tr>
<td></td>
<td>4.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>Madras</td>
<td>Bhaskar Rao <em>et al</em> (1946)</td>
</tr>
<tr>
<td></td>
<td>11.0</td>
<td>Bellary, Karnataka</td>
<td>Reported by Malaria Institute of India (Rao 1984)</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>Vizagapatnam</td>
<td>Senior White (1947)</td>
</tr>
<tr>
<td></td>
<td>41-47.0</td>
<td>Hyderabad State</td>
<td>Krishnan (1961) as quoted by Bruce-chwatt (1966)</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
<td>Gujrat</td>
<td>Nair and Samnotra (1964)</td>
</tr>
<tr>
<td></td>
<td>0.3 - 5.3</td>
<td>Iran, Iraq, Saudi Arabia &amp; Pakistan</td>
<td>Bruce-chwatt (1966)</td>
</tr>
<tr>
<td></td>
<td>24.0</td>
<td>Iran</td>
<td>Zahar (1974)</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>Pakistan</td>
<td>Reisen and Boreham (1982)</td>
</tr>
</tbody>
</table>
Bhaskar Rao et al (1946) treated 97 blood smear of *An. stephensi* by preceipitin test in Madras, of which, 67 and 8 were found to be positive for bovine and human blood respectively.

In Vizagapatnam, 80 blood smear of *An. stephensi* were analysed of which, 12 (15.07%) were found to be positive with human blood (Senior White 1947).

Macdonald (1957) described that *An. stephensi* was highly zoophilic and in the country side of Bombay State conveyed highly unstable malaria.

Nair and Samnotra (1964) found 37.5% human blood index of *An. stephensi* in Broach town, Gujrat.

**World**

Krishnan (1961) got 41.0 - 47.0% human blood index of *An. stephensi* in Hyderabad State.

According to Bruce-chwatt et al (1966), Lister Institute of Preventive Medicine, England, performed blood meal analysis of *An. stephensi*, collected from Iran, Iraq, Saudi Arabia and Pakistan. Human blood index was found to be 0.3% to 5.3% in those countries.

Zahar (1974) reported 24% human blood index of *An. stephensi* in Iran.
In the year 1982, Reisen and Boreham carried out blood meal analysis of 439 *An. stephensi*. Human blood index was found to be only 0.9% (4).

5. **Manlanding collection**

**Calcutta**

Early observation of Choudhury (1936) indicated that *An. stephensi* was most active night biting mosquitoes in Calcutta.

Strickland *et al* (1936) used tea box traps with feather-dusters, dried glass, old snipe boots, worn clothes, leather shoes, straw etc. as trap, but no *An. stephensi* adults entered such traps. They also concluded that there appeared to be a very marked preference in *An. stephensi* for biting natives of India than natives of Nepal rather than Europeans.

Senior White (1940) captured 3 *An. stephensi* mosquitoes one each in the months of July, August and December by using a trap net where he acted himself as the bait. By placing a trapnet with a cow as bait in a modern house of Calcutta, 170 female and 1 male *An. stephensi* were captured. The conclusion of the painstaking experiment was that both the types and mysorensis forms are attracted to cattle rather than man.
Das et al (1971) collected several species of mosquitoes including one *An. stephensi* off human bait at Baghbazar area of Calcutta.

Between July 1977 and June 1978, a total of 27 *An. stephensi* mosquitoes were landed on human bait. Per man-hour density was found to be 0.023 (Mukhopadhyay 1980).

India

Nursing et al (1934) collected 33% *An. stephensi* with fresh blood between 21.00 and 24.00 hrs and 67% between 04.00 and 6.00 hrs from the then Mysore State.

Senior White and Rao (1944) captured 0, 3 and 1 *An. stephensi* from human trap, cattle trap and Gorilapalem respectively in Vizagapatnam.

Senior White (1946) captured the only female *An. stephensi* at 04.00 and 01.00 hours respectively in April and May engaging himself in a series of night catches at various points in the Korea coalfield, situated in the Hazaribagh ranges of Central India.

From September 1976 to October 1977 (14 months) Batra et al (1979) collected 44 and 65 *An. stephensi* off man and cow bait respectively. Collection was done in urban and rural areas. Per man per night collection of
An. stephensi in urban area (Shevapet) was 1.0 (Sept), 0.4 (Oct), 0.08 (Nov), 0.03 (Dec), 0 (Jan), 0 (Feb), 0 (Mar), 0 (Apr), 1.0 (May), 0.2 (Jun), 0.3 (Jul), 0.3 (Aug), 0 (Sep), 0.2 (Oct) respectively. The corresponding figures for rural area (Suramangalam) were found to be nil except in the month of June '77 where per man per night density of An. stephensi was 0.3.

World

In Bagdad, certain observations in 1941, showed that biting time of An. stephensi was over by mid night (cited from Krishnan, 1961).

De Burca and Jacob (1947) found that the feeding of An. stephensi occurred in the open at 09.00 hrs.

Samimi et al (1966) reported that altogether 16 and 20 An. stephensi were collected indoors and outdoors respectively off human bait during September-October in South India.

Reisen and Aslamkhan (1978) made a critical observation on seasonal man and cattle landing An. stephensi in Pakistan and concluded that An. stephensi fed mostly before midnight being markedly crepuscular during periods of low ambient temperature. They stated that during warmer months (June to November), biting rates on both man
and cattle were the highest during the second quarter of night. In January and February no biting took place after 19.00 hrs and the biting was actually crepuscular, but in November and December some biting took place also in late night. They stated that they had made similar observations in Karachi also.

6. Infection and infectivity

Calcutta

Mayne (1930) established that there were some influence of relative humidity on the life and infectibility of *An. stephensi*.

Iyenger (1933) observed that positive results were obtained in every one of the batches of *An. stephensi* fed on infective gametocyte carrier of *P. falciparum*. Out of 122 mosquitoes examined, 71 were positive for oocysts, 32 for sporozoites in the salivary glands and 76 had either sporozoites or oocysts or both. The results showed that *An. stephensi* is very susceptible to experimental infection with *P. falciparum*. *An. stephensi* is very susceptible to *P. vivax* infection when fed on infective gametocyte carriers. Out of total number of 112 mosquitoes dissected after the infective feed, 69 showed an infection
either with oocysts or sporozoites or both. Sporozoites were observed in the salivary glands in 48 out of 112 specimens examined.

Strickland et al (1933) examined the salivary glands of An. stephensi for the presence of sporozoites in Calcutta under laboratory condition. The striking period of infection (90%) was found in November to January and an striking period of non infection (0.7%) from March to July.

Roy (1943) made an experiment in laboratory for calculating the infectivity rate of An. stephensi in Calcutta. The total oocyst and sporozoite rates were found to be 50.9 and 45.3 respectively, indicating that An. stephensi was the classical vector of malaria in the city of Calcutta.

Knowles and Basu (1944) also carried out laboratory experiment for studying the infectivity rate of An. stephensi in both controlled and uncontrolled situation of temperature and humidity. The results were depicted in tabular form:
Table 9. Experimental infections of *An. stephensi* with temperature and humidity uncontrolled.

<table>
<thead>
<tr>
<th>Period</th>
<th>Temp. range (°F)</th>
<th>Humidity range (%)</th>
<th>No. of Expt.</th>
<th>Survived %</th>
<th>Gut +</th>
<th>Gland +</th>
</tr>
</thead>
<tbody>
<tr>
<td>April to Dec 1933</td>
<td>64.4 - 85.8</td>
<td>71 - 86</td>
<td>19</td>
<td>45</td>
<td>42</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 10. Experimental infections of *An. stephensi* under controlled conditions representing the different seasonal period in Calcutta.

<table>
<thead>
<tr>
<th>Period</th>
<th>Temp. range (°F)</th>
<th>Humidity range (%)</th>
<th>No. of Expt.</th>
<th>Survived %</th>
<th>Gut +</th>
<th>Gland +</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monsoon (Mid June to Mid Sept)</td>
<td>83</td>
<td>85</td>
<td>6</td>
<td>64</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Post-monsoon (Mid Sept to end of Nov)</td>
<td>78</td>
<td>80</td>
<td>20</td>
<td>53</td>
<td>50</td>
<td>0.4</td>
</tr>
</tbody>
</table>
The available literatures—regarding natural infection of An. stephensi in Calcutta consulted Siddons (1946) first incriminated An. stephensi as the vector of malaria in Calcutta. Out of 1052 An. stephensi dissected, 6 salivary gland and 3 gut infections were found. Total infection rate was found to be 0.85%, of which, oocyst and sporozoites rates were 0.58 and 0.56 respectively.

Mukhopadhyay in 1980 again incriminated An. stephensi as the vector of malaria in Calcutta. The infectivity rate was found to be 1.56 in that year. Only one infection was found out of 64 An. stephensi dissected.

West Bengal

Neogi and Sen (1962) dissected 193 An. stephensi from Oyaria, Dist. Burdwan and found one gland infection (infection rate 0.51).

India

In Bombay city, Bentley (1911) dissected 1228 An. stephensi of which, 30 and 91 was found with gut and gland infections respectively.

Hodgson (1914) recorded 2 gut infections out of 110 specimens of An. stephensi dissected in Delhi.
In Kohat District in India, Sinton (1917) examined 45 specimens of An. stephensi and found sporozoites in the salivary glands of one specimen.

Chalam (1927) found 5 gland and 2 gut infections out of 151 mosquitoes dissected in Bombay (quoted from Covell, 1928).

Covell (1928) got 12 gland infections out of 671 An. stephensi dissected in Bombay.

In Andhra Pradesh King and Iyer (1929) got one gland and nine gut infections out of 166 An. stephensi dissected.

Banerjea (1930) dissected 75 females An. stephensi caught from the city of Lucknow and found 7 of them infected (5 salivary gland and 2 gut infections).

Sweet and Rao (1931) dissected 2,708 An. stephensi from Mysore State and found two gut infections but no gland infection.

Sur, Sarkar and Banerjee (1932) found 23.1% oocyst in the stomach of An. stephensi.

Ramsay and Macdonald (1936) stated that sporozoites of An. stephensi had been recorded in the salivary glands in Bombay, the North-West Frontier Province, the
United Provinces and Madras. Specimens with oocysts only were found in Mysore, Sind and Delhi. It is probably an important vector under rural condition in the West of India and under urban conditions throughout most peninsular and Northern India.

Afridi, Majid and Singh (1938) dissected 238 *An. stephensi* collected from Vijaya Vilas Palace, Kothda, Baharampur, Durgapur and from Bhuj city in Kutch State and found 5 infected mosquitoes.

Roy Chandra and Siddons (1939) suggested that the two varieties of *An. stephensi* differed in their potentiality to act as vectors of malaria in nature.

According to Singh and Jacob (1943) the infectivity rate of *An. stephensi* in Ahmedabad was 1.4%.

Basu (1946) carried out a series of experiments containing 'black spore' or abnormal oocyst of *An. stephensi* in laboratory. In the first series of experiments, 173 of the mosquitoes, fed on gametocytes carriers of *P. vivax*, survived and were serially sectioned, stained and examined. Two showed 'black spore'. In the second series, 61 mosquitoes fed on gametocytes carrier of *P. malariae* survived, and were sectioned, stained and examined. Four of them showed degenerated and pigmented oocysts or 'black spore', associated with normal oocysts. In the
third series, survivals of mosquitoes fed on gametocyte-carriers of \textit{P. falciparum}, 354 in number; were sectioned, stained and examined. Thirteen of them showed the 'black spore' which were associated with normal oocysts in some case. In the fourth series, included as a comparison, batches of normal unfed \textit{An. stephensi} were sectioned, stained and examined, but none of them contained 'black spore'.

**World**

\textit{Afridi and Majid (1938) caught and dissected 1,142 wild \textit{An. stephensi} and found 8 gut and 1 gland infections. The percentage of infection was 0.7\% in Baherin islands in the Persian Gulf.}

In 1941, when troops were concerned in and around Bagdad and there was an epidemic of malaria, only one \textit{An. stephensi} was found infected (Krishnan, 1961).

\textit{Rahaman and Muttali (1967) found one female \textit{An. stephensi} with sporozoites in the salivary glands among 204 examined. Muttali and Akiyama (unpublished WHO document 1967, 1968) dissected 505 \textit{An. stephensi} collected from Karachi city and found 6 gland infections (1.18\%).}
Manouchehri et al (1976) stated that a number of investigators obtained naturally infected An. stephensi mysorensis in Abadan, Bandar Abbas, Kazerum and Dezful in Southern Iran. The sporozoite rate was 0.2 to 0.7%. They further stated that in 1962, 298 An. stephensi mysorensis were collected and kept in an insectary of Kazerum Medical Research Station for 12 days 283 of those were dissected and 14 specimens were found positive for sporozoites in their salivary glands and two contained oocyst in their guts (delayed sporozoites rate about 5%). According to Hati et al (1980) 28% in An. stephensi was achieved with P. vivax infection.

7. Age determination

Longevity

Calcutta

The maximum time taken by larvae to pupate under ordinary surroundings in laboratory were 58 and 9 days (Ray 1931).

Knowles and Basu (1944) conducted three series of experiments in laboratory with the object of inducing An. stephensi to breed continuously but they failed to
rear them beyond the third generation. The length of survival of 474 laboratory bred females was studied under 36 different combinations of temperature and humidity. But only in the cool incubator at 22°C that insects survived long enough for transmission to be possible i.e. 7 to 10.6 days. Those investigators noticed that carbon dioxide or sulphuric acid vapour in the closed desicators was responsible for heavy mortality. They formed a new device to eliminate these problems by a special mosquito chamber with thermometer, dew point hygrometer and a filter pump. This chamber was attached to a wolf bottle. In such chamber at 27°C they survived as long as 26 days.

According to Hati et al (1980) the mean survival period of adult *An. stephensi* was 33 days (range 2-91 days).

India

According to Mayne Bruce (1930) survival time of *An. stephensi* under different temperature and relative humidity were as follows: (i) At 26.7° - 30.5°C and 80.0 - 87% rh, survival period was one (1) day. (ii) 29.4° - 34.4°C and 85.0 - 94% rh survival period was 55-58 days. (iii) At 29.4° - 30°C and 85.0 - 86% rh survival period was 80-88 days.
Observations of caged mosquitoes was shown that relative humidities of above 55%, individual specimens lived up to 32 days (quoted from Rao 1984).

Sweet and Rao (1937) stated that *An. stephensi* type form was harder and lived longer than *Ver mysorensis* and fed readily on man.

According to Roy and Brown (1946) the maximum longivity noticed in *An. stephensi* was about 5 weeks.

Clements (1963) described that eggs, larvae and pupae of *An. stephensi* were killed by prolonged exposure to 8°C. Longevity of *An. stephensi* at 25°-35°C increased with rising relative humidity up to 70% but at 90% rh longivity was reduced.

World

Studies of adult longivity and survival have been made under insectary condition by Meller (1962), Stahler and Black (1970) and Reddy (1976) and under field conditions by Quraishi et al (1966) and Reisen and Aslamkhan (1979).

Schlein and Gratz (1973) determined age of *An. stephensi* by noting daily growth layers of skeletal apodems in the laboratory bred specimen of the mosquito.
According to them it was possible to count up to 10 daily growth layers of phragmata of 85% of the field collected mosquitoes and 25% of those bred in laboratory. During longevity study, Zahar (1974) found 4.4% of *An. stephensi* dissected to have at least 3 dilatations and considered these mosquitoes to be at a potentially dangerous age.

**Proportion parous and daily survival rate**

**India**

In Broach town, Gujrat, Nair and Samnotra (1964) found that proportion parous of *An. stephensi* was 0.85.

Batra *et al* (1979) found 0.53 proportion parous in Salem, Tamilnadu. The constant daily survival rate was found to be 0.85 assuming gonotrophic cycle as 3 days. The vectorial capacity of two areas of Salem were 0.04 to 0.45 and 0.07 to 0.50 respectively. Out of a total of 63 *An. stephensi* collected from different areas of Salem, 16 parous females were found. Out of 102 *An. stephensi*, collected off cow and man baits, 47 and 55 were found to be nulliparous and parous.
World

In Iran proportion parous of *An. stephensi* was calculated to be 0.20 (Quraishi, 1966).

Zahar (1974) recorded 0.53 and 0.60 proportion parous of *An. stephensi* in sprayed and unsprayed areas respectively in Iran. The corresponding daily survival rates were 0.726 and 0.775 respectively, assuming gonotrophic cycle as on 2 days (on an average).

The constant daily survival rate in Pakistan was $0.81 ± 0.03$ (Reisen and Mahmood 1980).