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Life table attributes study of vector of Dengue (*Aedes aegypti*) from Gwalior, Madhya Pradesh, India

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Abstract
Mosquitoes (Order Diptera) have been known to be vectors of various diseases. They are carriers of many pathogens (viruses, bacteria, protozoa etc) transmitting diseases in human beings like malaria, chikungunya, dengue, dengue haemorrhagic fever, lymphatic filariasis, Japanese encephalitis etc. *Aedes aegypti* is a world vector for dengue. It is a container breeding mosquito found in tropical countries and whose occurrence has grown dramatically throughout the world in recent decades. It is highly infectious mosquito borne disease. Gwalior has recorded high number of deaths due to dengue for last few years. We have studied the life table developmental attributes of field collected *Aedes aegypti* which were brought in laboratories, cultured and reared and study was carried on successive generations, so that mosquitoes ecology, growth and survival parameters, developmental attributes, fecundity and reproductive potential may be calculated for Gwalior region. The parameters like Net Reproductive Rate (R_o), Mean Generation Time (T), Intrinsic rate of increase (r_m), Finite rate of increase (λ), Doubling Time (T) were calculated for Gwalior strain of *Aedes aegypti* adult mosquitoes. The various egg developmental parameters like egg hatching rate, larval duration, pupal duration, sex ratio etc, were also observed. This is the first study report on life table attributes study of *Aedes aegypti* mosqitoes from Gwalior district of Madhya Pradesh, India This study provides baseline knowledge about population dynamics studies and also in understanding dengue transmission and implementing effective control strategies under regional conditions.

Keywords: Gwalior, life table attributes, *Aedes aegypti*

Introduction
Mosquitoes are known to cause nuisance since time immemorial. They are carriers of various deadly diseases. Mosquitoes are vectors of broad range of parasitic and viral harmful diseases which affects both animals as well as human beings (Guruprasad *et al*., 2014) [10]. Occurrence of vector borne diseases is seen throughout the world except Antarctica. Diseases like malaria, dengue, chikungunya, dengue hemorrhagic fever (DHF), Japanese encephalitis, west nile virus fever, yellow fever, lymphatic filariasis etc. India is facing many deaths due to these vector borne diseases, of which, Dengue is emerging very fast. It is a disease of public health concern which is spreading throughout tropical and subtropical countries of the world (Gubler, 1978) [8]. *Aedes aegypti* is a vector for arboviruses, responsible for causing dengue and dengue haemorrhagic fever. *Aedes aegypti* is a container breeding cosmopolitan mosquito found in both rural and urban areas of Gwalior district. It is a carrier of arboviruses causing dengue and dengue haemorrhagic fever (DHF). It is a container breeding cosmopolitan mosquito found in both rural and urban areas of Gwalior district. India reports 129166 cases due to dengue of which number of cases alone due to dengue in Madhya Pradesh estimates to 3150 in year 2016 (NVBDCP report, 2016) [13]. Quick urbanization, industrialization and colonization without proper management strategy and drainage methods facilitates the growth of mosquitoes in various sites and thus causing havoc for mankind by transferring vector borne diseases. Today, control of mosquitoes is of utmost importance to control vector borne diseases and ultimately human lives. Various strategies have been adopted to control mosquitoes.

Numerous studies have been carried out on *Aedes aegypti* mosquitoes but only little work has been done regarding its life table characteristics. This is the first study on *Aedes aegypti* mosquitoes life table and biological attributes from urban areas of Gwalior district of Madhya Pradesh, India.

Life table studies helps to have better understanding and good knowledge about various attributes of population dynamics of vector species. Even feasible mosquito intervention strategies requires sound and deep understanding of mosquitoes various biological parameters i.e., developmental time, survival rate, fecundity, mortality and other growth rate parameters. Life table studies throws light on inherent differences in survival and fecundity strategies of populations present in various ecological regimes (Maharaj, 2003) [15]. Life table study has been conducted to estimate survivorship and reproductive strategies of culicine mosquitoes by Christophers (1960) [3], Southwood *et al*., (1972), Lansdowne and Hacker (1975) [12] etc. Life table study includes stage-specific survivorship, birth rate, death rate, fecundity, developmental parameters, longevity, emergence ratio, egg hatching period, female gonotrophic cycle and egg laying pattern (Grieco *et al*., 2003) [7].

Life table study helps to determine mosquito population biology and dynamics, vectorial capacity of species, spread of diseases, effectiveness of control strategies adopted to control vector species and to know the effect of habitat changes and modifications (Costero *et al*., 1988; Tejerina *et al*., 2009) [4, 18]

Gwalior faces continuous increase in number of deaths due to dengue. Data on *Aedes aegypti* in Gwalior district is lacking regarding its life table, population dynamics, control methods effectiveness, etc. Thus, this is the first and foremost study conducted on urban strains of *Aedes aegypti* from Gwalior district to know vector species life table attributes, which is ultimately helpful in knowing population dynamics of *Aedes aegypti* in Gwalior.

Materials and Methods

Study Site

Gwalior: Gwalior is located in northern Madhya Pradesh with latitude as 26.2334°N and longitude as 78.2191°E. It is a historical ancient city with center for tourist attraction, having good connectivity by rail and road with other metropolitan cities of India. It is 121 kms from Agra, 398 kms from Bhopal and 321 kms from Delhi. It is a beautiful city having vast flora and fauna. The city falls in mid-rain shadow zone with generally mild warm and temperate conditions. The climate of Gwalior is extreme with scorching summer temperature and chilly winters. Average temperature in winters (November-February) found to be 10°C to 15°C and in summers (May-June) is 34°C to 41°C. Gwalior records annual precipitation of 75-125cms. It covers 5214 sq. km. area, covering 1193 sq.km area as forest cover. Urban areas were selected for *Aedes aegypti* larval collections.

Collection, rearing and culture of mosquitoes

The larval *Aedes aegypti* mosquitoes were collected from small aquatic bodies in urban areas of Gwalior. They were bought to the laboratories and transferred into white enamel bowls containing 2 liters dechlorinated water. The larvae were fed with yeast powder sprinkled on the water surface. The water was aerated with the help of bubbler and water which was evaporated was added into the bowl. If needed, the water from culture bowl was changed till pupation stage. Pupae were collected with the help of dipper carefully and transferred to small white plastic container (10x10x7cm.) and these containers were then placed in adult holding wooden cages (60x60x60cm.) for adult emergence. Cotton soaked in 10% glucose solution was placed in petridish and was kept in adult cages for feeding. Every alternate days, they were given blood meal (for oviposition by female). A plastic bowl of capacity of 400 ml. containing 150ml. dechlorinated water (containing a lining of Whatman's filter paper no.1 slightly dipped in water.) was kept inside the cage for ovipositon. Eggs laid by female mosquitoes were collected daily, taken out and counted daily under microscope and were transferred into white enamel culture tray for further hatching of eggs. Ovipoisition was recorded daily until all the female mosquitoes dies. The eggs hatched were analyzed daily and 24 hrs. after hatching, 100 larvae in 2 litre dechlorinated water were maintained and there after culture was also maintained. The colony was allowed to reach successive generations to observe life table. Than, 50 males and 50 females were separated from these wooden cages and transferred to another experimental wooden cage to record and analyze various parameters. The lab was maintained at standard temperature (25±2°C), relative humidity (75±5%) and photoperiod of 14L:10D.

Data Analysis

The various life table attributes data was analyzed with the help of formulae based on different observations given by Reisen *et al*., (1979) [17].

1. Age-specific survivorship, lx

$$\mathbf{l_x = y_x / y_o}$$

where, y_x= number of mosquitoes which were alive on day x, y_o= starting number of mosquitoes in a given population

2. Age-specific life expectancy, e_x

$$\mathbf{e_x = \sum T_x / l_x,}$$

where, $T_x = \sum L_x$ and $L_x = (I_x + I_{x+1})/2$

3. Net Reproductive Rate, R_o

$$\mathbf{R_o = \sum L_x m_x}$$

Where, m_x= number of off springs produced per female per age interval

4. Infinite rate of Increase, r_m

$$\mathbf{r_m = \log_e R_o / T_o}$$

where $T_o = \sum x L_x m_x / R_o$

5. Finite rate of increase, λ,

$$\mathbf{\lambda = anti\ log\ e\ r_m}$$

6. Mean Generation Time, T

$$\mathbf{T = \log_e R_o / r_m}$$

7. Doubling Time, DT

$$\mathbf{DT = ln\ 2 / r_m}$$

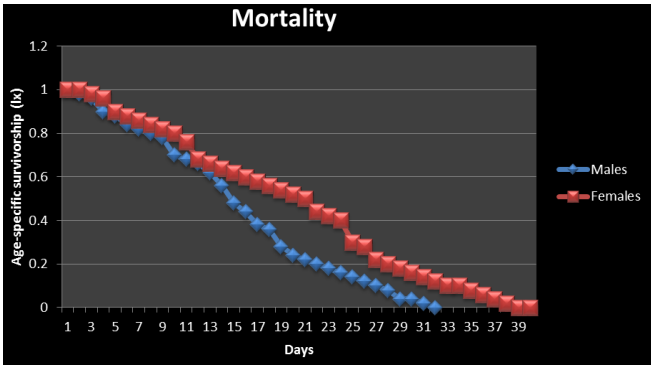

Fig 1: Age-specific survivorship graph showing mortality pattern of *Aedes aegypti* adult mosquitoes.

Results

The life table attributes study for Gwalior strain of *Aedes aegypti* has successfully been completed. Fig. 1 shows the age

specific survivorship (l_x) graph for males and females both. Longevity found for males *Aedes aegypti* comes as 12.45 days(6.32 to 26.34 days) and for females it is 17.63 days(9.43 to 34.41 days). Fig.2 shows the egg laying pattern of female *Aedes aegypti* mosquitoes which indicates that the peak was observed during mid of females life cycle and decline thereafter.

Table.1. clearly illustrates the life table attributes of adults measured for Gwalior strain of *Aedes aegypti* adult mosquitoes. The net reproductive rate (R_o) was found to be 51.32 which represents the average number of female offspring produced from the single female. The mean generation time (T) recorded was 31.31 days and intrinsic rate of increase (r_m) estimated to be 0.12 per female per day of life. The finite rate of increase (λ) calculated was 1.13 and 5.51 days was the time required by *Aedes aegypti* population to double its strength (doubling time).

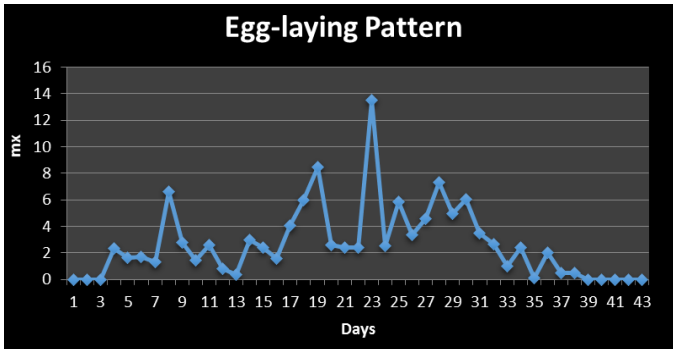

Fig 2: Egg-laying Pattern of female *Aedes aegypti* mosquitoes.

The time for eggs to hatch into first instar stage was recorded to be 3.94 days. The egg hatching rate was found to be 81.34% (i.e. percentage of hatched eggs from total number of oviposited eggs by female cohort of adult *Aedes aegypti* mosquitoes). The larval period (first instar to fourth instar time duration) was calculated to be 10.23 days and pupal period(pupae duration) was found to be 1.98 days. The sex ratio was found as 0.44. One average gonotrophic cycle length for adult females *Aedes aegypti* mosquitoes was observed to be 8.67 days while female fecundity was 224 eggs/female/lifespan. The above all results indicates very low reproductive capacity and growth potential is comparatively low.

Table 1: Various life table parameters of adult *Aedes aegypti* of Gwalior strain.

Life table parameters	*Aedes aegypti*
Mean life expectancy for females	12.45
Mean life expectancy for males	17.63
Net reproductive rate, R_O	51.32
Mean generation time, T	31.31
Intrinsic rate of increase, r_m	0.12575
Finite rate of increase, λ	1.13399
Doubling time, DT	5.51

Table 2: Egg development parameters of *Aedes aegypti* of Gwalior strain.

Development Parameters	*Aedes aegypti*
Egg Hatching Period	3.94 days
Egg hatching Percentage	81.34 %
Larval Duration	10.23 days
Pupal Duration	1.98 days
% Males Emerged	48.23 %
% Females Emerged	51.77%
Female One gonotrophic cycle	8.67 days
Male : Female Ratio (Sex ratio)	0.44

Discussion

The life table attribute study applied to study survivorship and reproductive strategies of Culicine mosquitoes has been carried out by various researchers previously. This is the first time that this type of study to be conducted for *Aedes aegypti* mosquitoes from Gwalior district of Madhya Pradesh, India. The mean longevity for females was found higher than males. Tejerina *et al*., (2009) [18] also showed that male *Aedes aegypti* of Argentina lived 7.3-8.8 days shorter than females(11.5-58 days). Christophers (1960) [3] also reported longest longevity for females (58-116 days) for Saudi strain of *Aedes aegypti* this may be due to blood feeding nature of females which in turns affects age-specific survival. Also, predatory activities, ecological conditions, habitat selection, insecticidal applications etc affects longevity and population dynamics of mosquitoes. According to Estrada- Franco and Craig (1995) [6], longevity studies for different populations of vector mosquitoes generally provides important epidemiological information because higher the longevity, higher is the probability of transmitting diseases.

The net reproductive rate (R_o) reported in present study falls within range i.e., 51.32 days from the study carried out by Khater *et al*., (2013) [11] who reported R_o values as 37.5-152.5 days for Saudi strain of *Aedes aegypti*, while Baserra and Castro (2008) [2] reported R_o value as 84.8-113.4 days for *Aedes aegypti* from Brazil.

R_o and r_m values are indicators of growth and reproductive capacities. The intrinsic rate of increase (r_m) values calculated from our study is 0.125 per female per day of life which is lower than r_m values 0.24-0.92 for Argentina strain of *Aedes aegypti* mosquitoes (Baserra and Castro, 2008) [2], while Nur Aida *et al*., (2008) [14] recorded r_m values as 0.21 days for *Aedes albopictus* from Malaysia. Our values of r_m goes slightly less than findings of r_m values of Khater *et al*., (2013) [11] who found r_m value as 0.15 females per day for *Aedes aegypti* from Saudi Arabia. Reisen and Mahmood (1980) [16] found rm value for *Anopheles culicifacies* as 0.53 and for *Anopheles stephensi* as 0.19. According to Reisen *et al*., (1979) [17] low r_m values indicates that mosquitoes have low evolutionary adapting power to existing or colonizing variable environments.

Fecundity is the average number of eggs laid by a female. It represents the reproductive capacity of female species. The mean number of eggs produced by *Aedes aegypti* is in range

of 225 eggs/female/lifespan and is 64 eggs/female/day. Khater *et al*., (2013) [11] reported average number of eggs laid per female as 62 for *Aedes aegypti* Saudi strain, while Tejerina *et al*., (2009) [18] found mean number of eggs per female falls in the range of 47-301 eggs. Gubler and Bhhatacharya (1971) [9] found average number of eggs laid by female as 283 eggs (range as 10-784 eggs) while Del Rosario (1963) [5] recorded 46 eggs (range 6-124 eggs) laid by per female fed only with human blood. In our results we found low fecundity which may be due to overcrowding of female population which ultimately effects survival, population growth and rate of development (Andrewartha and Birch, 1954) [1].

Egg hatching time in our study is about 3.94 days which is within range (4.5 days) as reported by Khater *et al*., (2013) [11] for *Aedes aegypti* strain from Saudi Arabia. Temperature and humidity plays an important factor in egg development and hatching. According to Christophers (1960) [3], eggs develops faster in warm climates as in tropics.Our study results for larval duration (time period from 1st instar to pupae) and pupal duration (time period from pupae to adult) is 10.23 and 1.98 days which falls within range from previous studies done (Christophers, 1960; Tejerina *et al*., 2009; Beserra and Castro, 2008) [3, 18, 2]. Sex ratio 0.44 of Gwalior strain of *Aedes aegypti* is very close to sex ratio reported by Khater *et al*., (2013) [11] as 0.48.

Our present study results for life table attributes provide preliminary knowledge about dengue vector (*Aedes aegypti*) on its developmental aspects under specific conditions. The results would be very helpful for knowing *Aedes aegypti* life span, developmental rate, mortality pattern, age-specific survivorship, reproductive potential and stage-specific survivorships.

These studies are very important for designing, manipulating and executing various appropriate strategies for reducing and controlling vector populations to below the threshold needed for dengue virus transmission and ultimately helping to achieve the goal of reducing the outbreaks disease transmission. The reduction of *Aedes aegypti* by knowing its various aspects of life would really be helpful not only for local populations but for other places as well.

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