Laboratory studies on the development, survival and life tables of *Culex fatigans* and *Anopheles stephensi*

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ABSTRACT

Observations on the duration of pre/post embryonic stages, survival and longevity of laboratory populations of *Culex fatigans* and *Anopheles stephensi* were made in order to understand the factors controlling outbursts of these mosquito populations in original habitats. Regardless of the nature of culture medium and food, *C. fatigans* took a longer period (19 days) to complete the development of pre-embryonic stages than *A. stephensi* (17 days). The highest survival rate of *C. fatigans* was noticed in pupal stage (96%), while it was advanced to IV instar stage (95%) in *A. stephensi*. The survivorship curves of *C. fatigans* and *A. stephensi* exhibited negatively skewed rectangles, indicating that the mortality is confined exclusively to aged individuals.

1. INTRODUCTION

A laboratory analysis of life table of mosquitoes illustrates the relationship of development and survival of the species under ideal conditions. So far, life tables have been constructed for a few natural populations of mosquitoes, viz., *Aedes aegypti*,[1-2] *Anopheles stephensi*[3] and *Culex pipiens fatigans*.[4] The present paper describes the development, survival and life span of *Culex fatigans* and *Anopheles stephensi* under laboratory conditions. A comparison between life tables of laboratory and natural mosquito populations project the modifying effects of various biotic and abiotic factors operating on and limiting the natural populations. This knowledge is very essential in planning mosquito control programmes.

2. MATERIALS AND METHODS

Newly emerged adults (50 males and 50 females) of *Culex fatigans* and *Anopheles stephensi* were selected from the laboratory colonies, released into separate mosquito cages (size: 30 × 30 × 45 cm) and maintained at

117

a temperature of $25 \pm 2° C$. The humidity averaged to $85 \pm 4\%$. The males were allowed to suck glucose (1%) from soaked cotton pads, while the females were fed every night for 8 hr on pigeon blood meal. Every evening hay infusion was provided in glass dishes for purposes of oviposition. The eggs laid by each species of mosquitoes were collected on the successive morning.

To observe the development, survival and life span of *Culex fatigans*, 5 egg rafts laid in hay infusion medium were allowed to hatch and the larvae were reared in trays with 2 l of the medium. Similarly, eggs of *Anopheles stephensi* were allowed to hatch in trays with 2 l of hay infusion and later, the larvae were reared in the same medium with a density not exceeding 300 larvae/l of the medium. The larval nutrition (Complan; Glaxo Products Private Ltd., Bombay) and the culture medium were changed on alternate days. The number of larvae in each stage of development was recorded daily at 8 a.m. and 6 p.m.; cast exuviae and dead larvae were removed and the newly emerged mosquitoes were released into fresh cages.

3. Results

The mean duration of each developmental stage of *Culex fatigans* and *Anopheles stephensi* are given in table 1. A noteworthy feature is that, while the culture medium and nutrition remained the same, *A. stephensi* took a shorter period of 17 days to complete the development than *C. fatigans* which required 19 days to emerge as adult. The highest survival rate of *C. fatigans* was observed in the pupal stage (96%; table 2). The values in the other developmental stages ranged from 89 to 95%. On the other hand *A. stephensi* exhibited the highest survival rate only in the IV instar stage (95%) of development. The survival rate in the pupal stage was significantly low (83%).

Table 1. Duration of life stages of *Culex fatigans* and *Anopheles stephensi* in hay infusion. Values in the parenthesis indicate the range.

Mosquito	Incubation period (day)	I Instar (day)	II Instar (day)	III Instar (day)	IV Instar (day)	Pupa (day)	Mean length of adult life (day)
Culex fatigans	1·5 (1–2)	2·5 (2–3)	3·0 (2–4)	4·5 (4–5)	5·5 (5–6)	2·0 (1–3)	14
Anopheles stephensi	1·5 (1–2)	2·5 (2–3)	2·5 (2–3)	3·5 (3–4)	4·5 (4–5)	2·5 (2–3)	15

Table 2. Survival pattern of immature stages of *Culex fatigans* and *Anopheles stephensi* in hay infusion.

Life stage	C. fatigans	A. stephensi
Egg	269±21	1472±143
I Instar	246±27	1316±181
II Instar	221±18	1260±94
III Instar	212±30	1171±68
IV Instar	196±94	1048±53
Pupa	181±15	1006±51
Adult emergence	175±29	843½±68

Table 3. Life table for the immature stages and adults. of *Culex fatigans* reared in hay infusion.

Life stage	x	lx	dx	px	qx
Egg	0·0	1000	86	0·914	0·086
I Instar	1·5	914	91	0·898	0·102
II Instar	4·0	821	32	0·961	0·039
III Instar	7·0	789	58	0·926	0·074
IV Instar	11·5	731	56	0·924	0·076
Pupa	17·0	675	23	0·967	0·033
Adult emergence	19·0	651	130	0·800	0·200
	20·0	521	192	0·631	0·369
	25·0	329	55	0·833	0·167
	30·0	274	91	0·667	0·333
	35·0	183	76	0·585	0·415
	40·0	107	43	0·598	0·402
	45·0	64	32	0·500	0·500
	50·0	32	32		
	54·0	0			

In order to obtain a better assessment of mortality at each stage of the life cycle of *C. fatigans* and *A. stephensi* life tables were constructed following the procedure of Deevey.[5] The *x* column (tables 3 and 4) represents the age of the individual in days at the beginning of the instars and *lx* column

Table 4. Life table for the immature stages and adults of *Anopheles stephensi* reared in hay infusion.

Life stage	x	lx	dx	px	qx
Egg	0·0	1000	106	0·894	0·106
I Instar	1·5	894	38	0·957	0·043
II Instar	4·0	856	60	0·929	0·071
III Instar	6·5	796	84	0·894	0·106
IV Instar	10·0	712	29	0·959	0·041
Pupa	14·5	683	110	0·838	0·162
Adult emergence	17·0	573	55	0·904	0·096
	20·0	518	170	0·671	0·329
	25·0	348	106	0·695	0·305
	30·0	242	110	0·508	0·492
	35·0	123	49	0·601	0·399
	40·0	74	74		
	44·0	0			

the numbers surviving to the age x and is headed by a number 1000. The dx column represents the number of deaths between the ages x and $x + 1$, *i.e.*, the real mortality. px column indicates the probability that the larva of the age x survives to the age $x + 1$. Finally qx column represents the probability that a larva of the age x dies before reaching the age $x + 1$, clearly $qx + px = 1$. It is seen from dx column for *C. fatigans* (table 3) that there was no significant differences in the mortality rate of the different larval instars while *A. stephensi* exhibited a heavy mortality rate (16·1%; table 4) in the pupal stage. When the number of survivors (lx column) were plotted against the age of the species the shape of the curve indicated the distribution of mortality and age. When the values for *C. fatigans* and *A. stephensi* were plotted, thus (figure 1) the curves exhibited negatively skewed rectangles indicating severe mortality of aged individuals than the immature. The total life span of immature stages of *C. fatigans* was 19 days while that of the adult was only 14 days and the first oviposition by the adult female occurred on the 5th day of emergence. *A. stephensi* also showed a shorter terrestrial life span (15 days) than that of aquatic life (17 days). The first oviposition by the adult female occurred on the 5th day of emergence.
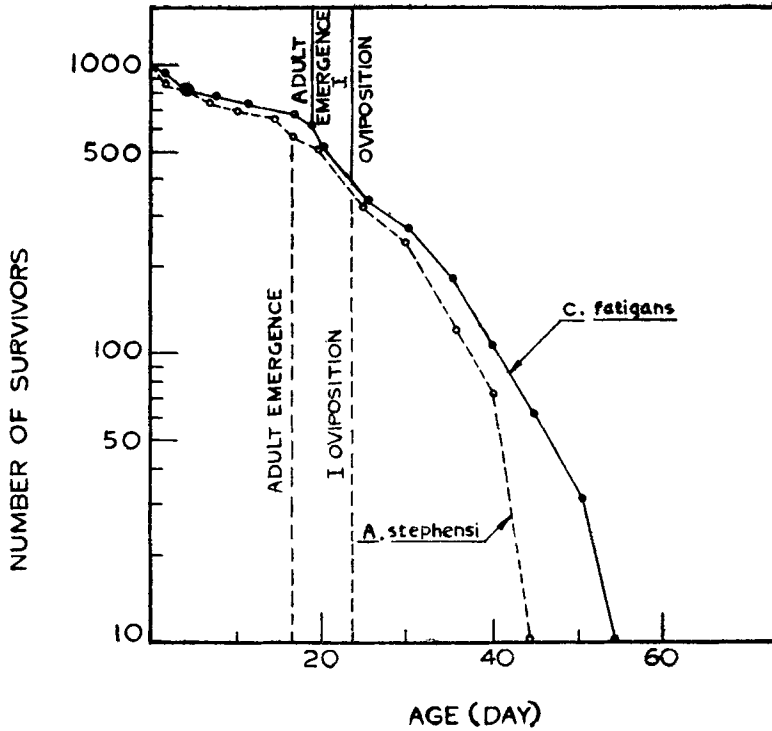
Figure 1. Survivorship curves for immature and adult stages of *Culex fatigans* and *Anopheles stephensi* reared in hay infusion.

4. DISCUSSION

The above results indicate that, given an ideal condition and surplus food, *Culex fatigans* and *Anopheles stephensi* develop faster and show higher survival rate. Such high survival rates of these two species of mosquitoes reared in hay infusion can hardly be expected in natural conditions. Rajagopalan et al.,[6] observed a low percentage (27·3) of adult emergence in *C. fatigans* in a cess pool where near optimum conditions prevailed. In contrast to this, there was 65% adult emergence in the present study. The low rate of survival observed in nature may be due to a variety of factors like, adverse climatic conditions, inadequate food supply, high larval density, competition, parasites, pathogens and predators. Deevey[5] proposed three types of survivorship curves: (1) positively skewed rectangle indicating high mortality of young individuals, (2) diagonal representing constant mortality at all ages and (3) negatively skewed rectangle indicating high mortality of aged individuals. Both *C. fatigans* and *A. stephensi* show curves similar to the type 3 indicating high mortality of aged individuals. Service[1] constructed a life table for *A. gambiae* from a loca-

lity in Kisumu (Kenya) and reported heavy mortality of I instar larvae due to intense predation by species of *Lycosid* spiders, *Dolicophodids*, Octhera (Ephidrids) and Notonectids. The present results when compared with those of Service[1] indicate that predators may influence the age structure of a prey population in nature (*see* also Connell[7,8]). Working on the life span of natural populations of *Aedes aegypti* Southwood *et al.*,[3] observed heavy mortality in the IV instar and they attributed this mortality due to excess conspecies density. The data reported for the two species were recalculated and have been plotted in figure 2. It may be seen that for every 1000 eggs incubated, 680 individuals emerge as adults both in *C. fatigans* and *A. stephensi*, while this number is only 39 in *A. gambiae* inhabiting the natural fields of Kisumu.[1] The survivorship curve gets almost shifted from type 1 to 3 suggesting that the larvae of *A. gambiae* are continuously predated by the aquatic predators in the habitat. The differences observed between the present study for *A. stephensi* (where there were no
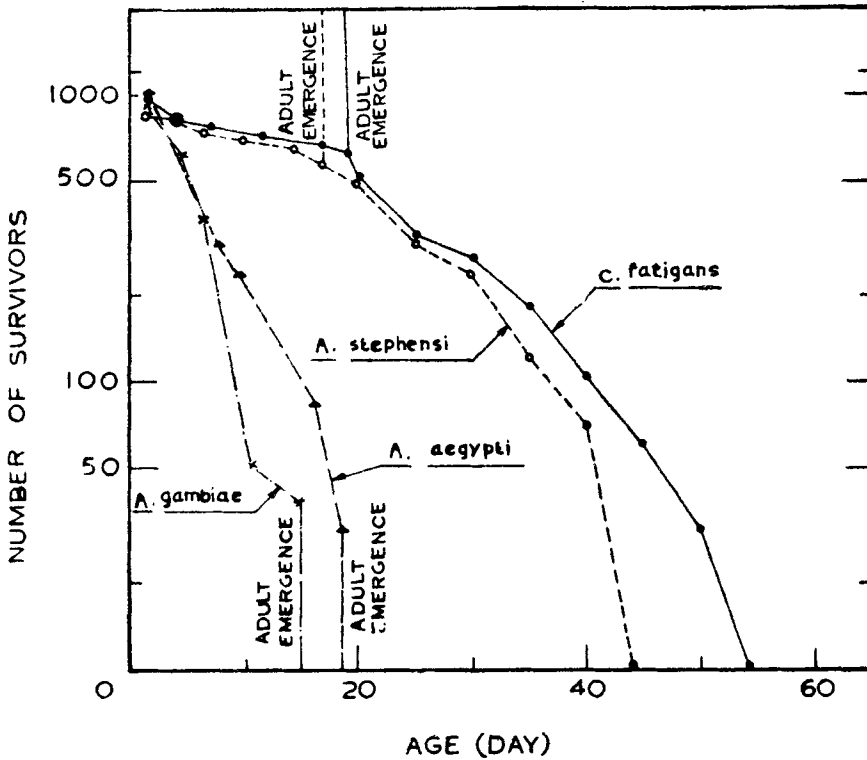

Figure 2. Survivorship curves for immature and adult stages of *Culex fatigans* and *Anopheles stephensi* reared in hay infusion compared with survivorship curves of *Aedes aegypti* and *Anopheles gambiae* from natural populations,

predators) and the one obtained for *A. gambiae* will give us an idea of the mortality affected by the predators in natural habitats. Not only the predators, but also the density of the mosquito larval population cause continuous and intensive mortality especially during the later (IV instar and pupal) stages when the medium is deficient in nutrients and/or is concentrated with excretory products of the larvae[9].

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