CHAPTER 2 : DEMOGRAPHIC STUDIES OF FRUIT-FLY (*BACTEROCEA PAPAYAE*)

2.1. Introduction

Demographic information are available for several tephritid species, for examples, the Mexican fruit fly *A. ludens* (Darby and Kapp, 1934; Baker *et al.*, 1944), the Caribbean fruit fly, *A. suspensa* Loew (Lawrence, 1979), the Mediterranean fruit fly *C. capitata* (Shoukry and Hafez, 1979; Carey 1982, 1983, 1984; Vargas *et al.*, 1984), the Queensland fruit fly *D. tryoni* (Pritchard, 1970; Fitt, 1983) the olive fly *Dacus oleae* Gmelin (Manikas, 1974; Kapatos *et al.*, 1977). Demographic studies had also been carried out on several *Bacterocera* species. For example, the melon fly, *B. cucurbitae* (Carey *et al.*, 1985; Ichinose and Nakasone, 1979), the Malaysian fruit fly *B. latifrons* (Vargas and Nishida , 1985) and *B. dorsalis* (Foote and Carey, 1987). This research examined and built up demographic data base for *B. papayae* in Malaysia for the purpose of effective pest management.

Longevity is a major component of generation time(T) which is a fundamental demographic parameter used to determine spraying interval for the eradication of fruit flies (Chua, 1991b). Longevity of released sterile flies, which determine number and age of the released population and relative longevity of male and female flies determined the sex ratio of the population (sex ratio at different age groups).

The objectives of this study are to determine demographic parameters and survivorship of *B. papayae*.

2.2. Materials and Methods

Twenty-five males and females were taken out from the previous culture of fruit flies and kept in separated cage. They were supplied with protein hydrolysate, honey and water which were replaced every 3 days.

The roof of cage were hanged with red and green chillies (obtained from Institute of Biological Science Experimental Farm (IBSEF) in the campus of University Malaya) for female to oviposit. Chillies were changed every 24 hours, the eggs were counted by using camel hair paint brush and binocular microscope. The laboratory temperature and relative humidity varied between 25.0 to 27.0 °C and 79% - 85% respectively during the experimentation with a natural photoperiod. The experiment continued until all male and female flies died. The entire experiment was repeated in order to minimise the error.

Analytical methods.

The total number of daughters expected to be produce by one female (m_x) and the probability of number of survival of female flies (l_x) at each age interval (×) of one day was calculated using the method described by Birch, (1948). The value of m_x were obtained based on the assumption that the sex ratio was 1:1. The net reproductive rate (R_o) is the number of daughter produced per female per generation ($\sum l_x m_x$). The intrinsic rate of increase (r_m) was calculated as follows:

$$r_m = e^x R_O / T$$

$$R = \sum l_x m_x$$

$$T = \sum l_x m_x \times / \sum l_x m_x$$

The finite rate of increase (λ) was calculated using this equation :

$$\lambda = \log \quad \log R \quad r_m$$

Table. 1 Formulae for the calculations of fruit flies' reproductive parameters .

Biological trait	Parameters	Formula
Survivorship	Expectation of life at eclosion	$\sum\limits_{x=1}^{\omega} l_x$
	Expectation of life at 50% mortality (days)	$\sum\limits_{x=61}^{\omega} l_x\,(x=61)$
Fecundity	Gross fecundity (eggs)	$\sum\limits_{x=\alpha}^{\beta} h_x . m_x$
	Net fecundity (eggs)	$\sum\limits_{x=\alpha}^{\beta} l_x . m_x . h_x$
	Average number of eggs per day	$\sum\limits_{x=\alpha}^{\beta} m_x / (\omega - \varepsilon)$
	Mean age fecundity schedule (days)	$\sum\limits_{x=\alpha}^{\beta} x \times l_x . m_x \Big/ \sum\limits_{x=\alpha}^{\beta} l_x . m_x$
Egg hatchability	Gross hatchability (%)	$\sum\limits_{x=\alpha}^{\beta} x \times h_x \Big/ \sum\limits_{x=\alpha}^{\beta} h_x$
	Net hatchability (%)	$\sum\limits_{x=\alpha}^{\beta} x \times h_x . l_x \Big/ \sum\limits_{x=\alpha}^{\beta} h_x . l_x$
Fertility	Gross fertility (eggs)	$\sum\limits_{x=\alpha}^{\beta} x \times h_x . m_x \Big/ \sum\limits_{x=\alpha}^{\beta} h_x . m_x$
	Net fertility (eggs)	$\sum\limits_{x=\alpha}^{\beta} x \times l_x . h_x . m_x \Big/ \sum\limits_{x=\alpha}^{\beta} l_x . h_x . m_x$
	Average number of fertile eggs per day	$\sum\limits_{x=\alpha}^{\beta} h_x . m_x / (\omega - \varepsilon)$

x= age in days
ε =age of eclosion
α = first day laid eggs
β = last day laid eggs
ω = last day of life
lx = probability of individual attaining age
hx = fraction of eggs that hatch
mx = number of eggs (female laid) at age x

and calculation as was described by Keyfitz, (1977) and Pollard, (1973) as shown in Table 1.

2.3. Results

2.3.1 Adult longevity

Figure 1 showed survivorship curves of female and male flies in the laboratory. The females lived a shorter life when compared to males. The first female death was recorded on day 25 and male on day 38. Fifty percent female and male flies died on day 60 and 71 respectively.

2.3.2 Fecundity

The female *B. papayae* started laying eggs around day 4 and continued daily egg productions. Observation were made from day 22 and stopped on day 120 (Figure 2). The average number of eggs laid per day per female was 5.60 ± 0.02 while the maximum was 34.00 ± 2.50 eggs on day 26 . The mean net fecundity 158.50 eggs. The number of eggs laid per day fluctuated around a mean of 16.90. However after day 65, it decreased gradually with age of the females.

2.3.3 Egg hatchability and fertility

The hatchability of eggs declined with increase in age of females (Figure 2). For the first 26 days of oviposition, the hatchability was more than 50%. The maximum hatchability was 97%. After day 60, hatchability declined to zero. The net hatchability was 46.2 % while the average number of eggs per day was 3.3.
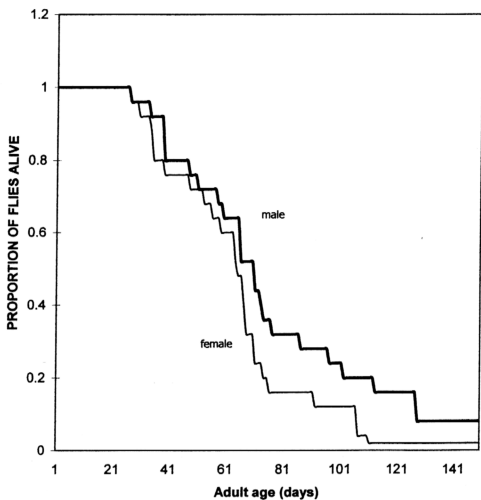
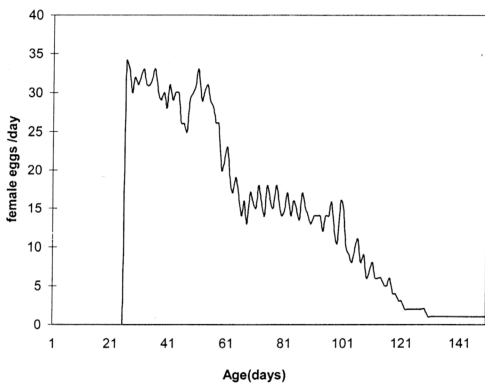**Figure 1. Survivorship of adult** *Bactrocera papayae* .

Figure 2. Oviposition of female *Bactrocera papayae*.

Table 2. Parameters and other statistics on reproduction and survivorship of *Bactrocera papayae* reared in the laboratory on 3:1 sugar : peptone, water and honey.Gross value take consideration adult mortality , while net value do not. Fecundity refers to total eggs production while the fertility considers the eggs hatched only .

Biological test	Parameters	Female	Male
Survivorship	Expectation of life at eclosion	49.1	84.4
	Expectation of life at 50% mortality (days)	16.4	22.0
	Day 50% mortality	61.0	71.0
Fecundity	Gross fecundity (eggs)	426.0	
	Net fecundity (eggs)	170.0	
	Average number of eggs per day	5.6	
	Mean age fecundity schedule (days)	59.5	
	Day of first oviposition	4.0	
	Maximun eggs per day	34.0	
	Days of last eggs laid	121.0	
Egg hatchability	Gross hatchability (%)	60.2	
	Net hatchability (%)	46.2	
Fertility	Gross fertility (eggs)	50.8	
	Net fertility (eggs)	44.1	
	Average number of fertile eggs per day	3.3	

2.3.4 Life history parameters

The pre-adult survival rates were: eggs, 0.66 ±0.01; larvae, 0.64 ± 0.02 pupae, 0.88 ± 0.0.3 (Table 2). The developmental duration for eggs was 2.5 days, larvae 10 days and pupae 11 days.

2..3.5 Life table parameters

Table 3 represents the life table parameters. The finite rate of increase (λ) was 1.1, while the intrinsic rate of increase (r) was 0.115 . The net reproductive rate (R_o) was 170 female eggs per female. The generation time (T) was 44.9 days.

2.4. DISCUSSION

B. papayae show a wider range of the life table parameters (Table 3), compared with the other species. All the data are for progenies of females, emerged from wild host fruits and reared on natural host (except adults, which were reared on honey and protein hydrolysate as food). It is well known that laboratory strains are more fecund and live longer. It has also been shown that the life table parameters depend on the type of host fruits used, for example as shown by Chua, (1991a) for *B. Mal A* and Carey *et al.,* (1985) for *B. cucurbitae* which preferred jack fruit, Carey, (1984) for *C. capitata,* Foote & Carey (1987) for *B. dorsalis* and Liedo *et al.,*(1993) for *Anastrepha*.

The intrinsic rate of increase, for *B. papayae* was similar to *B. Mal A* ex Starfruit, *B. latifrons, B. cucurbitae* (Table 3) also similar result reported by Carey, (1984) for *C. capitata*. However, when compared to *B. Mal A* ex Chua, (1991b) and *B. dorsalis* reared on mango (Foote and Carey, 1987), the rate is much higher for *B. dorsalis.*

The finite rate of increase,for *B. papayae* was higher due to the nutrition as the individual in population with good nutrition would produce more eggs and live

Table 3. Population parameters (mean of two replicates) of *B. papayae*. Values for other *Bactrocera* spp. are included for comparison

Parameters	*B. papayae*	*B. latifrons[1]*	*B. Mal A[2]*	*B. dorsalis[3]*	*B. cucurbitae[4]*
Intrinsic rate of increase (r_m)	0.115±.0001	0.09	(i) 0.104 (ii) 0.059	0.038	0.113
finite rate of increase (l)	1.113±0.001	1.09	(i) 1.109 (ii) 1.061	1.039	1.12
Net reproductive rate (R_o)	170 ± 18.5	61.1	(i) 167.5 (ii) 31.7	60	90.6 - 220.1
Mean Generation time (T)	44.9 ± 0.9	48.1	(i) 52.5 (ii) 56.5	107	58.6 - 46.8
Cross fecundity	426	NA	(i) 660 (ii) 363	242	1293
Net fecundity	158.5	256*	(i) 580 (ii) 250	120	709
temperature (^{0}c)	25 – 27	26.6 ± 0.5	(i) 28 - 30 (ii) 28 - 30	32 ± 2	25 + 2
humidity (RH) %	79 – 84	60 ± 5	(i) 75 - 85 (ii)75 - 85	72 ± 6	60 + 10

* female caged individually
NA : not available
1= *Bacrocera latifrons* (Vargas and Nishida, 1985). Host fruit : chilli
2= *Bactrocera Mal A* (Chua, 1991a). Host fruit : (i) starfruit, (ii) guava.
3= *Bactrocera dorsalis* (Foot and Carey, 1987). Host fruit : mango.
4= *Bactrocera cucurbitae* (Carey et al., 1985). Host fruit : cucumber, papaya, egg plant.
Parameter values depend on host used.

.However, egg production and longevity are also related to food supply (Bateman and Sonleitner, 1967; Newell and Haramoto, 1968; Hendrich *et al.*, 1993; Chua, 1992, Hendrich and Prokapy, 1994; Liedo and Carey, 1994; Liedo and Carey, 1996).

The finite rate for increase was higher than *B. latifrons*, *B. Mal A*, *B. dorsalis*, and *B. cucurtbitae*. This may be due to the ratio of birth to death higher than that of *B. latifrons*, *B. Mal A*, *B. dorsalis* and *B. cucubitae*, at short time according to Pielou, 1985 theory where components of growth rate, intrinsic birth (b) and death (d) rates are viewed as capita probabilities. Thus over a short time interval, an individual has probability of giving birth (b) and probability of dying (d) and its ratio (b/d) will provide a first approximation of how much greater the probability of giving birth compared to dying in a short interval . The net reproductive rate is also higher (Table 3) and could relate to food supply.

In terms of gross fecundity, the value for *B. papayae* (426 and 158.5 eggs, respectively Table 3) is higher than *B. dorsalis,* but lower than *B. cucurbitae*, *B. Mal A* (I) while net reproductive rate (170) was 1-2 fold higher in *B. papayae*, similar studies carried out with three species of *Anastrepha* fruit flies *A. ludens* (Loew), *A. obligua*(Macqart), and *A. serpentina*, gross fecundity: 1597.2 – 1194.3, 1376.3 – 1182.7, and 882.9 – 488 eggs respectively, were 2-3 fold higher than *B. papayae* while net reproductive rate 118.85, 140, and 90.28 lower. In *B. dorsalis* the number of eggs recorded per day decreased with age (Carey *et al.*, 1988). This could be due to fewer eggs being deposited per female as seen for *B. papayae* and *B. dorsalis* (Carey *et al.*, 1988).

The male of *B. papaya* out lived the females which could be due to higher explained by energy cost in egg production in later compared with sperm production in former as explened by Vargas and Carey, (1987) for *C. capitata*.