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Life table of *Synthesiomyia nudiseta* (Van der Wulp) (Diptera: Muscidae) under uncontrolled laboratory environments – a preliminary study

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Abstract. The life history of the male and female of the indoor forensic fly, *Synthesiomyia nudiseta* was studied under fluctuating temperature of indoor environments and analysed based on the age-stage and two sex life table. The life cycle of *S. nudiseta* was 14.0±1.0 days from the egg stage to adult emergence. The population parameters calculated were; net reproduction rate (R_o= 108.6), mean generation time (T_o= 12.2), intrinsic rate of increase (r_m= 0.38), and finite rate of increase (λ= 1.46). The pre-oviposition period (APOP) was 6.0± 0.1 days. All population parameters suggested that *S. nudiseta* exhibits the r-strategist characteristics.

INTRODUCTION

The muscoid dipterous flies are of medical importance in many parts of the world not only for transmitting various pathogens and being domestic nuisance but also play a significant role as forensically important fly species in crime investigation (Greenberg, 1991; Sukontason *et al.*, 2006). *Synthesiomyia nudiseta* is a necrophilous forensic fly from the family Muscidae. In Thailand and Malaysia, this species had been reported to infest human corpse indoors only (Baharuddin *et al.*, 1994; Lee *et al.*, 2004; Nazni *et al.*, 2007; Sukontason *et al.*, 2007). In the year 2009, Kumara *et al.* (2009) had published the immature life cycle of this species in Malaysia. However, their adult life table which determine the population growth of this species was unexplored in the indoor tropical climate of Malaysia. Previously, the life table studies of this species have been reported by researchers in different bio-geographic regions (Rabinovich, 1970; d' Almeida *et al.*, 1997; Kruger *et al.*, 2002). An established life table of a population can be used to understand the growth, survival and fecundity of a particular species of interest (Abou Zied *et al.*, 2003). In this study, the life table of *S. nudiseta* was constructed based on the age-stage, two sex life table analysis which included both males and females in the calculations to establish the population parameters of this species.

MATERIALS AND METHODS

Rearing

The experiment was conducted in the insectarium of the School of Biological Sciences, Universiti Sains Malaysia (USM), Penang (5° 21' North, 100° 18' East). The stock colony of *S. nudiseta* (between 10 to 15 filial generation) was retrieved from the Department of Forensic Medicine, Penang Hospital and kept in a cage 43 cm (height) x 43 cm (length) x 43 cm (wide). The colony was provided with sucrose and water. The population analysis was based upon a cohort of 100 individuals. A piece of beef meat (25g) was introduced into the colony to obtain the eggs. After 24 hours, the beef and the deposited eggs were removed from the colony. From these deposited eggs, 100 eggs were individually retrieved from the beef and placed on a piece of fresh beef (10g) using a fine forcep. A wet paper towel was placed on the surface of the beef to maintain the moisture of the beef. Later, the fresh beef with the single egg was placed into a small plastic cup. This plastic cup was placed into a larger container (10.5 cm in diameter and 11.0 cm in height) and covered with muslin sheets individually. A total of 100 plastic cups and containers were prepared. At the post-feeding stage, soil was added into the container for pupation. When the adult emerged, they were identified by sexes, paired (male-female) and placed in a plastic container (10.5 cm in diameter and 11.0 cm in height)supplied with water, sucrose and a piece of beef. Those adults not paired were placed into the colony. At the time of food replacement, mortality of the fly by sexes and the number of eggs laid per day were noted. These eggs were later counted under stereomicroscope (Olympus). Throughout the period of study, the temperature and relative humidity of the insectariums were recorded daily using a psychrometer (G.H Zeal Ltd., London). The experiment was repeated twice, consecutively.

Data analysis

The formulae as follows (modified from Gabre *et al.*, 2005 & Reisen *et al.*, 1979);

1. Pre-adult survival rate define as the percentage of larvae successfully hatched from the total number of eggs sampled

Pre-adult survival rate

$$= \frac{\text{total mean number of larvae hatched successfully from both experiment}}{\text{total number of eggs sampled}} \times 100\%$$

2. Age-specific survival rate (l_x) is the mean probability that an adults will survive to age x and was calculated by pooling all individuals of both sex.

$$l_x = y_x / y_o$$

Where; y_x = mean number of surviving adult flies at age x,
y_o = total number of adult flies used in the experiment.

3. Fecundity (f_{x4}) is the number of eggs laid daily were counted and divided by the numbers of surviving females, to provide data on number of eggs per female per day.

$$\text{Fecundity } (f_{x4}) = \frac{\text{Total number of eggs laid of day } x}{\text{Total number of surviving adult females on day } x}$$

4. In two sex life table analysis, the male population are taken into consideration and thus, the sex ratio (RS) are calculated for each day (Carey, 1993);

$$\text{Sex ratio (RS)} = \frac{F}{M + F}$$

Where, F = number of female flies alive per day
M = number of male flies alive per day

5. Age-specific fecundity (m_x) is mean number of eggs laid per pair aged x days.

$$m_x = \text{Fecundity } (f_{x4}) \times \text{Sex Ratio (RS)}$$

6. The net reproductive rate (R_o) = $\sum l_x m_x$

7. The mean generation time (T_o) = $\frac{\sum l_x m_x}{Ro}$

8. The intrinsic rate of increases (r_m)=

$$\frac{\ln Ro}{To}$$

9. The finite rate of increase (λ) was estimated from $\lambda = e^{rm}$.

Statistical analysis

The age-specific survival rate and adult longevity between males and females were subjected to Student's t-test to compare if there were any significant differences between the sexes. If the age-specific survival rate and adult longevity values was normally distributed, Student's t-test was used. On the contrary, if the values were not normally distributed, Wilcoxon Signed-Rank test was used. All statistical analysis was performed using JMP 8.0.1 software (SAS Institute).

RESULTS

Throughout the study, the mean temperature and relative humidity of the insectarium was 26 ± 2.5ºCand 76 ± 10%, respectively. The immature life cycle of *S. nudiseta* from the egg stage until adult emergence was 14.0 ± 1.0 days. The pre-adult survival rate of *S. nudiseta* for both experiment was 34.5 ± 4.5% (mean ± SE) (Table 1). The age-specific survival rate (l_x) for *S. nudiseta* was shown in Figure 1 and there was no significant difference found between the males and females(Wilcoxon Signed-Rank test, p >0.319). The survival curve indicated that the age-specific survival rate decreased as the adults aged. The mean longevity of the adult males was 20.0 ± 16.0 days, whereas the mean longevity of the adult females was 20.5 ± 17.5. These mean longevity were found to have large standard error as some of the adult female and male died as early as Day 3 and Day 4, respectively. There was no significant difference in longevity between the males and females (Student's t-test, p > 0.579).

The adult pre-oviposition period (APOP) of female *S. nudiseta* was 6.0 ± 0.1 days. The total number eggs counted from both experiments were 3239 eggs from 31 paired adults. The oviposition period was between day 6 and day 24 after emergence (Figure 2). The mean fecundity was 29.4 ± 27.8 eggs per female with highest fecundity observed on day 11 (57.2 ± 26.7 eggs per female), whereas the lowest fecundity was on day 23 (1.6 ± 1.4 eggs per female). Meanwhile, the mean age-specific fecundity was 13.4 ± 12.3 eggs per pair. Similar to mean fecundity, the highest age-specific fecundity observed on day 11 (25.7 ± 10.5 eggs per pair), whereas the lowest age-specific fecundity was on day 23 (0.83 ± 0.8 eggs per pair). Both mean fecundity and mean age-specific fecundity showed high standard error because in both experiments, no eggs were laid for 6 days during the oviposition period.Additionally, the mean fecundity also was not constant and fluctuated throughout the oviposition period (Figure 2).

The net reproductive rate (R_o) of *S. nudiseta* was 108.6 eggs per pair. The mean generation time (T_o) for *S. nudiseta* was 12.2 days. The intrinsic rate of increase (r_m) and the finite rate of increase (λ) was 0.38 and 1.46, respectively (Table 2).

DISCUSSION

In this study, the age-specific survival rate and the age-specific fecundity of *S. nudiseta* were calculated based on adults of both sexes. Similar calculation was also used to determined the life table of *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae) (Gabre *et al.*, 2005) and the *Lucilia cuprina* (Wiedemann) (Diptera: Calliphoridae) (Abou Zied *et al.*, 2003).

As the paired adults were kept separately, there was no possibility of cross mating. This allowed for the determination of the adult

Table 1. The sampling summary of both experiments which were conducted consecutively

Experiment	No. of eggs sampled	Hatched larvae	Paired Adult		Unpaired Adult	Pre-adult survival rate (%)
			Males	Females		
1st experiment	100	39	17	17	5 males	39
2nd experiment	100	30	14	14	2 females	30
Total	200	69	31	31	7	34.5 ± 4.5

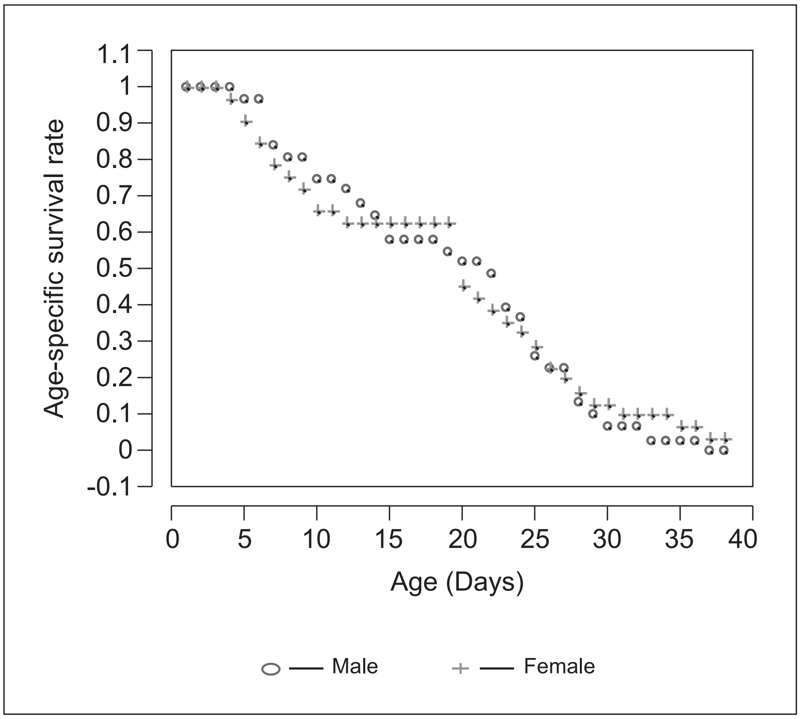

Figure 1. Age-specific survival rate (l_x) of *S. nudiseta* at 26±2.5ºC and 70±10% relative humidity

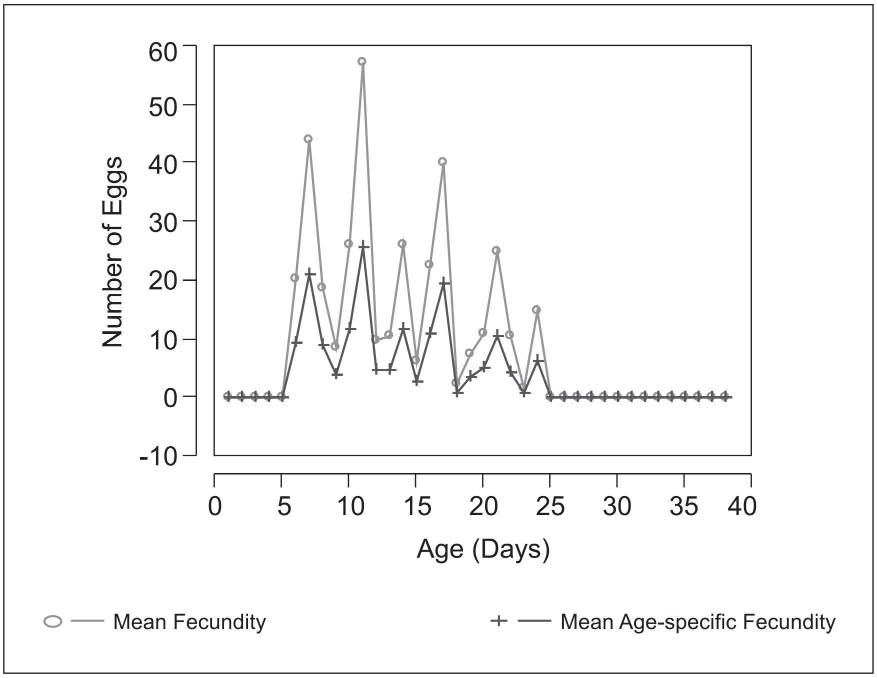

Figure 2. The mean fecundity (f_{x4}) and mean age-specific fecundity of *S. nudiseta* at 26±2.5ºC and 70±10% relative humidity

Table 2. The population parameters of *S. nudiseta* at 26 ± 2.5ºC and 70 ± 10% relative humidity

Population parameters	Value*
Net reproductive rate (R_o)	108.6
Mean generation time (T_o)	12.2
Intrinsic rate of increase (r_m)(d^{-1})	0.38
Finite rate of increase (λ) (d^{-1})	1.46

* Data were calculated by using all paired individuals from both experiment

pre-oviposition period (APOP). From both experiments, the APOP of *S. nudiseta* was 6.0 ± 0.1 days which was similar to APOP of *C. megacephala* at the room temperature of 26ºC and relative humidity of 75 ± 5% (Gabre *et al.*, 2005). On the other hand, Rabinovich (1970) found that the oviposition period for *S. nudiseta* was 7.6 ± 0.4 days and 10.3 ± 0.3 days at the constant temperature of 28ºC and 20ºC, respectively. Differences were also found in longevity of the males and females in the other studies reported. Rabinovich (1970) at the constant temperature of 28ºC found the longevity of male and female was 34.6 ± 18.7 days 31.1 ± 15.8 days, respectively. However, in the current study, the longevity of both males and females were lower compared with the study conducted by Rabinovich (1970). In these circumstances, there are a number of possible explanations to be considered. First, the current study was conducted under fluctuating temperatures of indoor environments. Second, there were differences in methods of rearing the paired adults in the current study compared with the other studies. Third, the differences in the genetic pool for this species from different biogeographic region should be taken into account.

In the current study, the net reproduction rate (R_o) of *S. nudiseta* was 108.6 eggs per pair. By comparing with the study reported by Rabinovich (1970), where the R_o of *S. nudiseta* was 286 eggs per female at the constant temperature of 28ºC and relative humidity of 70%. These R_o may differ in different studies as some researchers only considered the females, whereas in this paper both males and females were considered. According to Chi & Yang (2003), when the researchers analysed the raw data based on the traditional female age-specific life table where the development rate of the male was ignored, it would lead to error in calculating the population parameters such as the net reproductive rate (R_o), the intrinsic rate of increase (r_m) and the finite rate of increase (λ). In addition, in this study, the paired females were observed to lay eggs in the absence of males (males died). Thus, this showed that the first mating would enable the dipteran to inseminate the eggs throughout its life span. According to Brown (2001), the dipterans showed discrete ovarian cycle and Abou Zied (2001) proved that the dipteran has limited tendency to mate more than once.

The population parameters calculated in this experiment suggested that *S. nudiseta* is a r-strategist population as postulated by Pianka (1970). Those characteristic of the r-strategist in current study were based on high intrinsic rate of increase (r_m= 0.38 d^{-1}) and finite rate of increase (λ= 1.46) accompanied by a short mean generation time (T_o= 12.2 days) and high net reproductive rate (R_o= 108.6 eggs). The high value of intrinsic rate of increase (r_m) is also considered as an evolutionary adaptation to the existing fluctuating environments (Reisen *et al.*, 1979). Price (1997) mentioned species with a higher value of r_m usually will have higher mortality or low survival rate. This might explain the high mortality that occurred for *S. nudiseta* in current study which has high r_m value (Table 2). It was stated that the intrinsic rate of increase (λ) will be more useful in term of comparing the population growth of different species than in R_o (Price, 1997). For comparison, the intrinsic rate of increase (λ) for *L. cuprina* (Diptera: Calliphoridae) and *C. megacephala* (Diptera: Calliphoridae) was 0.24 and 0.22, respectively (Abou Zied *et al.*, 2003; Gabre *et al.*, 2005). Those species that had high λ suggested the species has a rapid population growth (Kruger *et al.*, 2008) and by comparing with other species, *S. nudiseta* was found to have a rapid population growth.

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