DEMOGRAPHIC PARAMETERS AND REPRODUCTIVE PERFORMANCE OF THE ASSASSIN BUG *Sycanus dichotomus* Stal. FED ON MEALWORM *Tenebrio molitor* L.

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ABSTRACT

The reproductive performance and demographic parameters of Sycanus dichotomus *Stal. fed on mealworm* Tenebrio molitor *L. were studied in the laboratory under the ambient environment of 28 ± 2°C, 70%-90% RH and 12 hr photoperiod. Eggs that were laid in tight clusters of 15-130 eggs per cluster hatched within a mean of 19 days with 6.27% hatchability. The majority of the eggs that were in small clusters were infertile, while larger uniform clusters contained a higher percentage of fertile eggs. There were five nymphal instars. All nymphal stages were reddish in colour. The mean longevity was two to three weeks each for the first to third instars, while at least one week each was needed for the fourth and fifth instars. The total developmental time from egg to adult took 87 days with the females reaching adulthood three days sooner than the male. Adult females survived for an average of 197 days with a median natural mortality (NM_{50}) value of 150 days, while the males endured for an additional 13 days with NM_{50} value of 165 days. Adults were observed to engage in repeated mating for one week before females proceeded to lay eggs by the third week of post-emergence, with oviposition duration lasting for 186 days. A mean total of 959 eggs were produced during a female's life-span. The age-specific life table revealed a high rate of combined first and second nymphal mortality, amounting to 63.0%. Pertinent life table parameters, R_o of 137, r_m of 0.190 and λ of 1.138, were achieved within a generation time of 38.2 weeks, allowing the population to double in 5.4 weeks.*

Keywords: cohort, demographic parameters, life table, reproductive performance, *Sycanus dichotomus*.

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INTRODUCTION

Oil palm is beset with many insect pests of which caterpillars and beetles are the most destructive of all. Outbreaks are usually sporadic, but can become frequent due to the destruction of natural enemies as a result of the use of broad-spectrum long-residual contact insecticides, consequently causing ecological disturbances and outbursts in pest numbers (Wood and Nesbit, 1969). The nettle caterpillars and bagworms are the most common culprits. They attack the foliage and easily build up in numbers due to the super-abundance of food. In general, the oil palm agroecosystem tends to be stable, hence an ecological-based control approach would be essential and more suitable for polyphagous general predators such as the assassin bug.

The assassin bugs (Hemiptera: Reduviidae) are an important group of predators found in the oil palm plantations of Southeast Asia (Wood, 1968; Sankaran and Syed, 1972; Wood, 1976; Tiong, 1979). Together with the pentatomid asopin bugs, they coexist at sites where there are oil palm caterpillars. Among the reduviids, *Sycanus dichotomus* Stal. is the most common species found feeding on the larvae of nettle caterpillars such as *Darna* spp. and *Setothosea asigna* (de Chenon *et al*., 1989; Singh,

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1992) and the bagworms such as *Mahasena corbetti* (Norman *et al*., 1998). However, according to de Chenon *et al*. (1989), *Sycanus dichotomus* is not a good bio-control candidate because it is generally less effective due to its slow feeding habit or its long handling time; the predator was observed to spend up to 5 hr feeding on a single larva.

Apart from its feeding behaviour, *S. dichotomus* plays a significant role in the biological control programme in oil palm. With its longer rostrum compared to other hemipteran predators, it can successfully attack the bigger late instar bagworms (Zulkefli, 1996) and presumably other larger sized oil palm caterpillars too. An effective bio-control effort strongly relies on the continuous presence of the predators in the pest's habitat, and to this effect intermittent release from laboratory mass-reared populations of *S. dichotomus* will help sustain the control programme. A good mass-rearing protocol would require information on the reproductive development and population biology of the insect in order to efficiently raise high numbers of healthy and high quality individuals. In addition, the success of mass-rearing would depend on the abundance and continuous supply of the prey. This article describes a rearing protocol for the assassin bug *S. dichotomus*, and reports a study on the population demographic parameters and reproductive performance of the assassin bug when fed on mealworm, *Tenebrio molitor*.

MATERIALS AND METHODS

The study was conducted in the Entomology Laboratory, Plant Protection Department, Faculty of Agriculture, Universiti Putra Malaysia, under an ambient environment of 26°C-30°C, 12 hr photoperiod and 60%-80% RH, monitored with a hygrothermograph.

Culture of Assassin Bug

A stock culture of the assassin bug, *S. dichotomus*, was maintained in the Entomology Laboratory. Adults were reared in a plastic aquarium tank measuring 15 × 8.5 × 8 cm. The bottom of the tank was lined with a nylon net and pieces of paper towels to facilitate cleaning. A piece of muslin cloth was spread between the lid and the tank to ensure containment of the bugs as well as to prevent invasion by other insects. Cotton pieces saturated with distilled water in a shallow Petri dish placed at the bottom of the tank served as the source of drinking water. Mealworms, *Tenebrio molitor* (L.), measuring 2.5 cm or more purchased from a neighbouring pet shop were provided *ad libitum* as food.

Newly laid egg batches collected from the walls of the rearing tank were transferred to a Petri dish lined with filter paper until they hatched. Upon hatching, the first instar nymphs were individually isolated with a sable brush into a plastic container measuring 5 cm in diameter by 4 cm in depth, and provided with a small piece of water-soaked cotton wool and mealworms as food. The water-soaked cotton wool and the food were replenished every two days. This culture was used for all the experiments as well as for colony maintenance. Only the last instar nymphs were reintroduced into the culture tanks because younger nymphs were usually attacked by the adults.

Life Cycle and Survivorship

To initiate the study, seven mated females of *S. dichotomus* from the stock colony were left in a plastic aquarium tank as previously described to allow for oviposition. Seventeen clusters of eggs were collected on the following day, and each cluster was transferred to a plastic cup (5 cm diameter × 4 cm depth) until they hatched. Upon hatching, the first instar nymphs were cared for individually in plastic cups each provided with a water-soaked piece of cotton wool. Mealworms were provided *ad libitum* with small-sized mealworms given to the first and second instars. Nymphal development was monitored daily including nymphal mortality; the presence of exuvium determined moulting, and hence the instar stage. Data on developmental duration, survival and progress in growth of each individual were recorded daily. From a population of 60 individuals that reached adulthood, a sex ratio of 1:1 was obtained from this study.

Age-specific Life Table

As soon as a female emerged, a male from the stock colony was introduced into the plastic cup with continuous provision of food and water. To initiate the life table study, egg clusters containing a total of 98 eggs were observed for development until the death of the last individual.

Fecundity, Survivorship and Demographic Parameters

To record for age-specific fecundity, a total of 49 young mated females were observed for survivorship, and weekly records of egg laying were kept until the last individual died. Calculations of pertinent demographic parameters were provided by Laughlin (1965) and Southwood (1978). The terminologies used in the life table analysis are explained in *Table 2*.

RESULTS AND DISCUSSION

Life Cycle and Survivorship

Mating in *S. dichotomus* involved a long process: a pair was observed to engage in repeated mating and stayed together for up to one week before the female proceeded to oviposit eggs. The eggs were laid in a cluster and they were cemented tightly to each other. A female could produce as many as four egg clusters in her life time. From the seven females, 17 clusters of eggs were produced, each cluster consisting of 15-130 eggs; altogether 957 eggs were laid. Hatchability was very low with only 60 eggs hatching from three clusters that contained fertile eggs: 30 out of 40, 22 out of 45, and 8 hatched out of 49 eggs; hence, a 6.3% hatchability. The remaining 14 clusters contained infertile eggs. The eggs hatched within the same day, and 19 days were required for incubation. Zulkefli *et al*. (2004) reported varied incubation periods of 11-39 days when *S. dichotomus* were fed live bagworm larvae. It was observed that the earlier laid uniformly shaped larger egg clusters contained more fertile eggs than the later laid non-uniformly shaped smaller clusters.

Sycanus dichotomus in this study produced five nymphal instars: N_1 took an average of 15 days, N_2 an average of 16 days, N_3 an average of 21 days, and N_4 an average of 7 days, but N_5 took an average of 7 days for females and 9 days for males, *i.e*. females reached adulthood two days sooner than the males. Hence, the duration from egg to adulthood averaged between 85 and 87 days. In general, the duration of N_1 to N_3 was similar to that reported by Zulkefli *et al*. (2004); however, in their case, the duration of N_4 was in excess of three weeks and N_5 took about five weeks when fed on larvae of the diamondback moth, *Plutella xylostella*, or the rice moth, *Corcyra cephalonica*. As such they reported a much longer duration of development from egg to adulthood: 204 days when fed on *P. xylostella* and 193 days on *C. cephalonica*.

TABLE 1. POPULATION PARAMETERS FOR *Sycanus dichotomus* FED ON MEALWORM, *Tenebrio molitor*

Parameter	Value
Median natural mortality (NM_{50}) (days): ♀	150.0
♂	165.0
Net reproductive rate (R_o)	137.0
Generation time (T) (weeks)	38.19
Innate capacity of increase (r_c)	0.129
Intrinsic rate of natural increase (r_m)	0.190
Finite rate of increase (λ)	1.138
Doubling time (DT) (weeks)	5.38

Adult survivorship of the assassin bug when fed on mealworms was comparatively longer than that reported by Zulkefli *et al*. (2004) who fed the nymphs with larvae of *P. xylostella* and *C. cephalonica*. The female: male longevity was 197: 210 days with NM_{50} of the female being 150 days and male 165 days (*Table 1*). The cumulative adult female mortality over time depicted a near Type I survivorship curve as described by Southwood (1978) (*Figure 1*). In comparison, when *S. dichotomus* was fed with *P. xylostella*, the female: male longevity

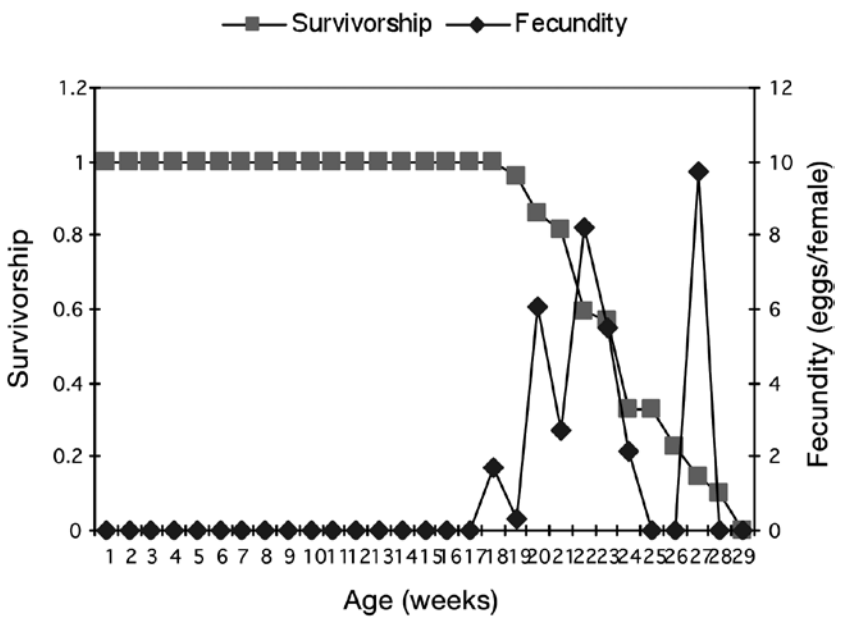

Figure 1. Age-specific survivorship of female Sycanus dichotomus *relative to its fecundity when fed on mealworm,* Tenebrio molitor.

TABLE 2. TERMINOLOGIES USED IN LIFE TABLE ANALYSIS

Terminology	Description
x	The life stage, pivotal age for the age class (in days) or the age interval.
l_x	The number surviving at the beginning of the age interval 'x'.
d_x	The number dying during the age interval 'x'.
L_x	The number alive between the age 'x' and 'x+1', such that $L_x = (l_x + l_{x+1})0.5$.
T_x	The total number of individuals with age unit beyond age 'x', such that $T_x = L_x + L_{x+1} + \ldots + L_w$ where w is the last age interval.
e_x	The expectation of life remaining for individuals of age 'x', calculated as $e_x = T_x/l_x$.
$100q_x$	The percentage within-age mortality of the age interval 'x', calculated as $100q_x = (d_x/l_x)100$, also termed Apparent Mortality (AM).
RM	The percentage of Real Mortality, calculated based on the population density at the beginning of the generation, calculated as $RM = (d_x/l_o)100$.
IM	The Indispensable (*i.e.* irreplaceable) Mortality is the portion of generation mortality that would not occur if the apparent mortality (q_x) of an age interval was removed from the life system. It is assumed that the subsequent mortality factors will destroy the same percentage of the population independent of the change in population density. To determine IM, the following procedure is followed: a) Assume no q_x for the life stage in 'x'. Add the number of individuals that died (d_x) during the stage to the number of survivors $l_{(x+1)}$ in the next stage. b) Multiply this new value by q_x for this stage (x+1) and recalculate the number of survivors for the next stage $l_{(x+2)}$. c) Continue this process throughout the entire life table and determine the difference between the original number of survivors and the new value. d) Divide the difference by the initial population size, *i.e.* first age class, and expressed as percentage.

TABLE 3. AGE-SPECIFIC LIFE TABLE OF *Sycanus dichotomus* FED ON MEALWORM, *Tenebrio molitor*

x	l_x	d_x	L_x	T_x	e_x	$100q_x$	RM	IM
Egg	98	33	81.5	227.0	2.316	33.67	33.67	7.65
N1	65	31	49.5	145.5	2.238	47.69	31.63	13.95
N2	34	10	29.0	96.0	2.824	29.41	10.20	6.38
N3	24	3	22.5	67.0	2.792	12.50	3.06	2.19
N4	21	2	20.0	44.5	2.119	9.52	2.04	1.61
N5	19	4	17.0	24.5	1.289	21.05	4.08	4.08
Adult	15	15	7.5	7.5	0.5	100.0	15.31	-

Note: RM = real mortality; IM = indispensible mortality.

was 83:88 days, or 64:62 days when fed on larvae of *C. cephalonica*. The present study demonstrated that the mealworm was more nutritious and more suitable for culturing the assassin bug. The life cycle was completed in less than three months, while the extended adult life span was within six to seven months.

Age-specific Life Table

Table 3 shows the age-specific life table of *S. dichotomus* fed with mealworm, *Tenebrio molitor*. From an initial number of 98 eggs, 33 eggs failed to hatch, reflecting real mortality (RM) of 33.7%. The nymphal mortality rates of N_1 and N_2 were high with percent within age mortality (100qx) being 47.7 and 29.4, respectively, and having a combined RM value of 41.8%, thus leaving only 24 that survived out of 65 nymphs. It was observed that the early nymphal instars had some difficulty when feeding, taking some time to overpower the larger mealworms. It may be assumed that when they were fed with younger instars of the mealworm, the N_1 and N_2 mortality rate (D_x) would have been much reduced because they would then be expected to have easily overcome the smaller prey. Eventually, 19 individuals or about 21% were left to reach the final nymphal stage; however, the penultimate success to the adult stage was only 15 assassin bugs.

Fecundity, Survivorship and Demographic Parameters

Adults engaged in repeated mating throughout the first week before the females proceeded to lay eggs by the third week of adult emergence. The oviposition duration lasted for 27 weeks. High ovipositional activity stretched out over four weeks, *i.e.* 20^{th} to 23^{rd} weeks, totalling 755 eggs. A peak of 254 eggs per week (8.24 eggs per female) was recorded on the 22^{nd} week of oviposition (*Figure 1*). Thereafter, oviposition activity declined sharply recording 34 eggs (2.13 eggs per female) on the 23^{rd} week. On the last week (27^{th}) of oviposition, 68 eggs were laid by the seven surviving females, or 9.71 eggs per female. A total of 957 eggs were laid during the females' lifespan.

Pertinent life table parameters of adult females of *S. dichotomus* fed with larvae of *T. molitor* are reported in *Table 1*. The net reproductive rate (R_o) was calculated as 137 offsprings produced within a long generation time (T) of 38.2 weeks. The intrinsic rate of natural increase (r_m) was 0.190 with a doubling time (DT) of 5.4 weeks. The above parameters indicate that *S. dichotomus* would take a long time to establish itself in the field, even with the help of a readily available food source.

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