UNIVERSITI PUTRA MALAYSIA

BIOLOGICAL STUDIES OF TIGER MOTH (ATTEVA SCIODOXA MEYRICK.) [LEPIDOPTERA: YPONOMEUTIDAE] ON TONGKAT ALI (EURYCOMA LONGIFOLIA JACK.)

ANG CHIN HWE

BIOLOGICAL STUDIES OF TIGER MOTH (*ATTEVA SCIODOXA* MEYRICK.) [LEPIDOPTERA: YPONOMEUTIDAE] ON TONGKAT ALI (*EURYCOMA LONGIFOLIA* JACK.)

By

ANG CHIN HWE

A Project Report Submitted in Partial Fulfillment of the Requirement
for the Degree of Bachelor of Bioindustry Science in the
Faculty of Agriculture and Food Science
University Putra Malaysia Bintulu Campus

2007

Dedicated to

My Mother: Lim Yeok Fong

My Father: Ang Ling Hock

My Elder Sister: Ang Shiao Chee

My Younger Sister: Ang Shiao Chien

Thanks For Your Care and Support

ABSTRACT

A life cycle study of the Tiger moth, *Atteva sciodoxa* Meyrick., was carried out in the laboratory at an ambient temperature of 27±1°C, and 200 lux light density. The female moth was laid the eggs singly beneath the Tongkat ali leaves. The neonate of Tiger moth is white and translucent, while the last stage of instar larva is bright yellowish with horizontal black stripe along the dorsal of body. Generally, the metamorphosis of the Tiger moth is complete, passing through three distinct stages, egg, larva and pupa to the adult. The mean total development time from egg to adult for male and female of the Tiger moth were 31.0±3.5 days (range 29-33 days) and 35.2±3.3 days (range 34-38 days), respectively. The larvae of *A. sciodoxa* passed through five instars larval with the total development duration for male and female larvae is 19.7±1.8 days and 24.1±1.2 days, respectively. The total amount of leaf consumption during the immature stages was 0.176±0.044 g (range 0.135-0.206 g). The water content for young, mature, senescent leaves were 85.81%, 65.57%, and 59.89% respectively. The higher value in relative growth rate (RGR), efficiency in converting ingested food (ECI), and efficiency in conversion digested food (ECD) were shown that the larvae of *A. sciodoxa* were more preferred fed on young leaves of Tongkat ali.

ABSTRAK

Eksperimen tentang kitaran hidup kupu-kupu harimau (*Atteva sciodoxa* Meyrick.) telah dijalankan di dalam makmal dengan suhu bilik 27±1°C, dan 200 lux ketumpatan cahaya. Kupu-kupu betina ini didapati menelur merata-rata di bahagian bawah daun Tongkat ali. Ulat harimau yang baru lahir adalah kelihatan lut-sinar. Apabila ia membesar, warna badannya menukar kepada warna kuning dengan berjalur hitam disepanjang badannya. Secara umumnya, kupu-kupu harimau ini melengkapkan kitaran hidupnya melalui tiga peringkat yang utama, iaitu peringkat telur, peringkat ulat, dan pringkat kepompong menjadi dewasa. Masa bagi kupu-kupu jantan dan betina untuk melengkapkan kitaran hidupnya adalah 31.0±3.5 hari dan 35.2±3.3 hari. Kupu-kupu harimau ini mempunyai lima peringkat metamorfosis disepanjang peringkat ulatnya. Selain daripada mangkaji masa kitaran hidup, ulat harimau ini juga diuji dengan kuantiti daun yang telah dimakan oleh ulat pada peringkat-peringkat yang berbeza. Kandungan air yang wujud dalam daun muda adalah 85.81%, daun matang adalah 65.57%, and daun tua adalah 59.89%. Kandungan air pada daun ini akan menentukan faktor tumbersaran ulat harimau. Dengan menilaikan kadar tumbesaran, kadar peyerapan makanan, dan kadar pemakanan makanan, didapati bahawa ulat harimau lebih gemar memakan daun muda yang mengandungi kandungan air yang tinggi.

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I certify that this research project report entitled "Biological Studies of Tiger Moth (*Atteva sciodoxa* Meyrick.) [Lepidoptera: Yponomeutidae] on Tongkat Ali (*Eurycoma longifolia* Jack.)" has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Science, University Putra Malaysia Bintulu Campus.

Dr. Stephen Leong Chan Teck
Faculty of Agriculture and Food Science
University Putra Malaysia Bintulu Campus

Prof. Dato' Dr. Nik Muhamad Nik Ab. Majid
Dean of Faculty of Agriculture and Food Science
University Putra Malaysia Bintulu Campus

Date: 05/ 05/ 2007

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LIST OF ABBREVIATIONS

%	=	Percentage
mm	=	Mili meter
diam.	=	Diameter
T	=	Tree sample
g	=	Gram
h	=	hour
SE	=	Standard Error
°C	=	Degree of Celsius
df	=	Degree of freedom
ANOVA	=	Analysis of Variance
LSD	=	Least significant difference
$P_{0.05}$	=	Confidence interval at 5%
R2	=	Square of the Multiple Correlation
UPMKB	=	University Putra Malaysia Bintulu Campus
FRIM	=	Forest Research Institute Malaysia
MARDI	=	Malaysia Agricultural Research and Development Institute
RGR	=	Relative growth rate
RCR	=	Relative consumption rate
AD	=	Approximate digestibility
ECI	=	Efficiency of converting of ingested food
ECD	=	Efficiency of conversion of digested food

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CHAPTER 1

INTRODUCTION

Tongkat Ali, *Eurycoma longifolia* Jack has geographically distributed in Malaysia, Burma, Indochina, Thailand, Sumatra, Borneo, and the Philippines. This plant prefers acid and sandy soils at low altitude up to 700m above sea level and can grow up to a height of 10m with a branch diameter of about 10cm (Julisasi, 2000). Tongkat Ali is one of the most popular species of medicinal plants found naturally in Malaysia's tropical forest, also widely used as a tonic and is sometimes referred to as the "Malaysian ginseng". Its roots have traditionally been used for medicinal purposes, including aphrodisiac, antidotal, antihypertensive, antipyretic, febrifuge (Indu Bala, 2000). It has long been captured the local market and currently there are about 200 Tongkat Ali products, and most of them focusing and emphasizing on its aphrodisiac properties. Commercial products of Tongkat Ali is still in its infancy stage and most of the raw material used in herbal preparation are collected from the wild (Indu Bala, 2000).

Three species of insects have been identified as pest on Tongkat Ali trees, namely scale insect, stem borer insect and Tiger moth (*Atteva sciodoxa* Meyrich.) [Lepidoptera: Yponomeutidae]. Tiger moth was the most destructive pest and caused severe damage to leaves and fruits of Tongkat Ali in Malaysia (Mohd. Noh, 2002). The larvae by its feeding habitat is destructive while the adults are not. Tiger moth was reported to infest 25% of Tongkat Ali trees per hectare at Bukit Hari plantation plot, Selangor (Mohd Ilham et. al., 2000).

The feeding preference of larvae are very closely related to the host intrinsic quality (nutritive value and water content) (Ahman, 1985). Since the amount, rate and quality of food consumed by a larva influence its performance including growth rate, consumption rate, final body weight, and the digestibility (Slansky and Scriber, 1985), an understanding of the nutritional indices would be useful. The concentration and composition of nutrients may differ with leaf age. So the degree of host preference also can be definitively correlated with it (Murugan, 1992).

Information regarding the life cycle of *A. sciodoxa* was not available. Therefore, the understanding of the life cycle of this pest could improve field control of *A. sciodoxa* for pest management program.

The objectives of this study were to investigate the life cycle of the Tiger moth and study the influence of different leaf age on growth of larvae Tiger moth in the laboratory.

CHAPTER 2

LITERATURE REVIEW

2.1 Economic importance of Tiger moth (*A. sciodoxa*) on *E. longifolia*

In Malaysia, the local herbal medicines (included Tongkat ali) are attributed to at least RM1.0 billion and is still growing rapidly (Ng and Azizol, 1999). Tongkat ali is one of the popular plants which find its use in herbal medicine. Traditionally attributed for its aphrodisiac properties, currently researches on the Tongkat ali plant also indicated its anti-malaria properties, fever treatment and its potential in killing cancerous cells. (Azmi et. al., 2002).

There were report from several plantation of Tongkat ali in Malaysia that the larvae of the Tiger moth (*A. sciodoxa*) has been found potentially infested several parts of Tongkat ali trees (25% of 1 hectare). It was caused economic losses for the planters. The outbreak of infestation by Tiger moth was caused severe damage on Tongkat ali trees that found in the plantation of FRIM (Mohd Noh, 2002). Besides, there were also reported from MARDI that the most susceptible pest infested the Tongkat ali trees was the Tiger moth (*A. sciodoxa*) (Indu Bala, 2000).

2.2 Biology of the *Atteva spp.*

2.2.1 Host range of Tiger moth (*A. sciodoxa*)

Three species of insects have been identified as pest on Tongkat Ali trees, namely scale insect, stem borer insect and Tiger moth (*A. sciodoxa*). The larvae of Tiger moth were found infested on the Tongkat ali at several portions of the plant (Mohd Noh, 2002). According to Indu Bala (2000), the Tiger moths were caused severe damages on the leaves and fruits during the cultivation of Tongkat ali in MARDI plantation. Extend to this investigation, infestation by the Tiger moth on other plants has not been reported from any others researchers (Indu Bala, 2000).

2.2.2 Life cycle of *Atteva* spp.

The eggs of *Atteva fabriciella* are laid singly or in groups on young bud and tender leaves. Normally the small, pale green eggs hatch out in two to tree days. Larval period extends for 13-28 days with five, and rarely six larval instar. Mature larva constructs a loose cocoon and pupates. Pupa is slender, orange brown to pale brown in color. Pupal period usually ranges from 4-14 days (David, 2004).

2.2.3 The habitat of the *Atteva* spp.

The larvae of *A. fabriciella* live in silken webs on the lower surface leaves of the tree *Ailanthus triphysa* and feed on them in the forest. This species is distributed all over India, Myanmar, Fiji, Java, Malaysia (David, 2004).

2.2.4 The feeding habit of the *Atteva* spp.

The moth are usually small and brightly colored. The larvae feed on the tender leaves and other soft tissue of the terminal portion of *A. triphysa*. Larvae web around the tender leaves and feed from within. Younger leaves are usually preferred. The number of larvae at a time in a web may vary from 6-10. When the tender leaves are fully eaten up, larvae may also bore into the soft tissues of the terminal portion and cause partial or complete damage to the terminal bud resulting in the formation of epicornic branches. In mature trees, larvae also cause damage to the inflorescence and tender fruits, thereby affecting seed production. The host plant of the *A. fabriciella* is *Quasia indica* (Simaroubaceae – same family to which *Ailanthus triphysa*) (David, 2004).

2.3 Feeding preference of larvae

The feeding preference of larvae was an adaptive advantage by reducing fitness losses associated with dispersal (Papaj and Prokopy, 1989). The plant quality which influence the feeding preference of larvae was determined by the nutritional value and water content of plant tissue as well as by the concentration of secondary metabolites (Slansky and Rodriquez, 1987). Due to the insect cannot synthesize all essential nutrients for their survival and reproduction, they need nutrients from plant materials in exact quantity for the maintenance of their life style. The feeding of larvae are also suggested to be unaffected by or attracted to the defense compound of their host-plant (Leimu, 2005). The measurement for the efficiency of food utilization has been developed by Slansky and Scriber (1985), including relative growth rate (RGR), relative consumption rate (RCR), approximate digestibility (AD), efficiency of converting of ingested food (ECI), efficiency of conversion of digested food (ECD).

The study of larvae *Daphnis nerii* showed that the relatively higher value in RCR, RGR, and AD of the larvae when fed on young leaves of *Nerium oleander*. This was considered that the larvae were more preferred fed on young leaves (Murugan, 1992). Study the feeding preference of the Apollo butterfly (*Parnassius apollo* spp. *frankenbergeri*) showed that the fastest growth of larvae was observed in group fed on the most preference leaves (*Sedum telephium*) (Nakonieczny, 2004).

CHAPTER 3

MATERIALS AND METHODS

3.1 Life cycle studies of Tiger moth in laboratory

This study was carried out in the laboratory with an ambient temperature of 27±1°C, 70-80 percent of RH and 200 lux light density.

3.1.1 Establishment of laboratory colony of *A. sciodoxa*

Forty larvae of Tiger moth (*A. sciodoxa*) were collected from the trees (Tongkat ali) infested with Tiger moth at the botanical park in University Putra Malaysia Bintulu Campus (UPMKB). Larvae were brought back to laboratory and reared on the fresh leaves of Tongkat ali in plastic container (110mm X 90mm). All the larvae were maintained until adult emergence and transferred into rearing container (370mm x 200mm x 270mm). The rearing container with the upper opening was covered by a rearing net (Figure 1) (3mm size) whilst bottom side with SCA hygiene paper. Adult moths were fed with 10% honey solution as food which was sprayed on the SCA hygiene paper.

A potted Tongkat ali (*E. longifolia*) sapling (approximately 200mm high in a 150 mm diam. pot) was placed inside the rearing container (Figure 2). The pot was initially washed and disinfected by 70% alcohol to avoid cross-contaminated from soil to colony of adults in the rearing container. All the moths were allowed for mating inside the rearing container. The eggs laid on

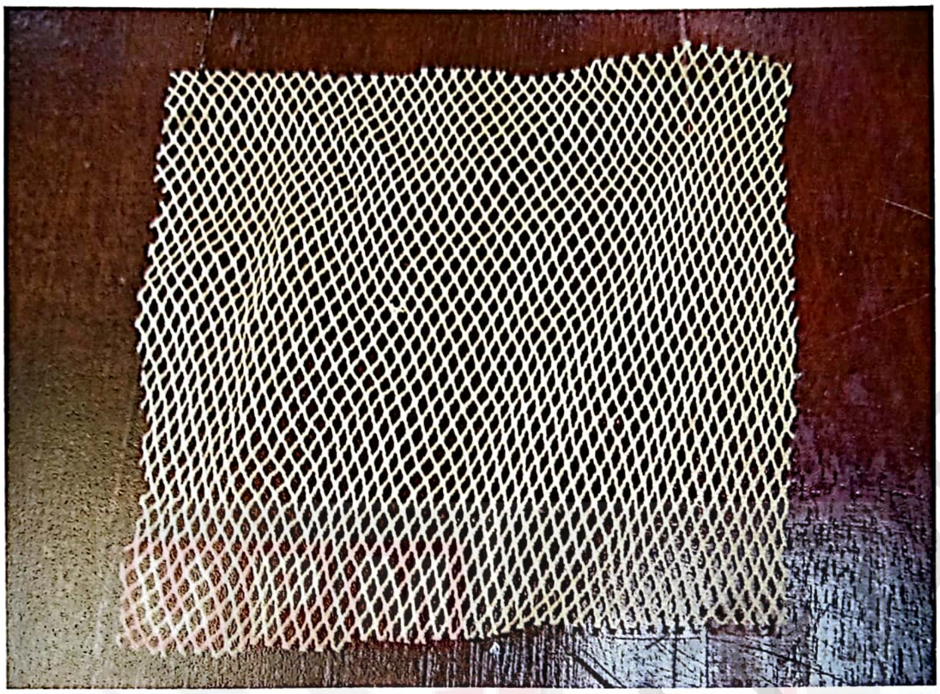

Figure 1. Rearing net (3mm size diam.)

Figure 2. A potted Tongkat ali sapling in the rearing container

the leaves by the female moth were observed for a period of 12 hours interval (8.00 am and 8.00 pm). The proportions of infertile eggs and of viable eggs that hatched were recorded for 60 randomly selected eggs.

3.1.2 Developmental stage of immature in the life cycle study

The eggs which laid at the same day were placed on moist filter paper in petri dish and date were recorded (Figure 3). The date hatched for each neonates (newly hatched larvae) were recorded separately to determine the duration of the egg stage. The neonates were transferred individually into plastic container (110mm X 90mm) by using fine camel hairbrush. A Whatman No. 90 filter paper was placed at the bottom of the lower half of plastic container. To prevent the escape of hatched neonates and provided better aeration, the opening of the plastic container was covered with SCA hygiene paper held in place by rubber bands (Figure 4).

Ten larvae were recorded every morning (8.00 am until 9.00 am) to determine the developmental duration from the larval stages to adult emergence. To determine the sexes of the larvae, all the larvae were maintained in the plastic container until the adult emergence. The host leaves were fed and replaced by fresh ones every day. A visual observations were made on the egg stage, immature stage, pupal stage, and the adult. The total developmental period from egg to adult stage was calculated separately for both male and female.

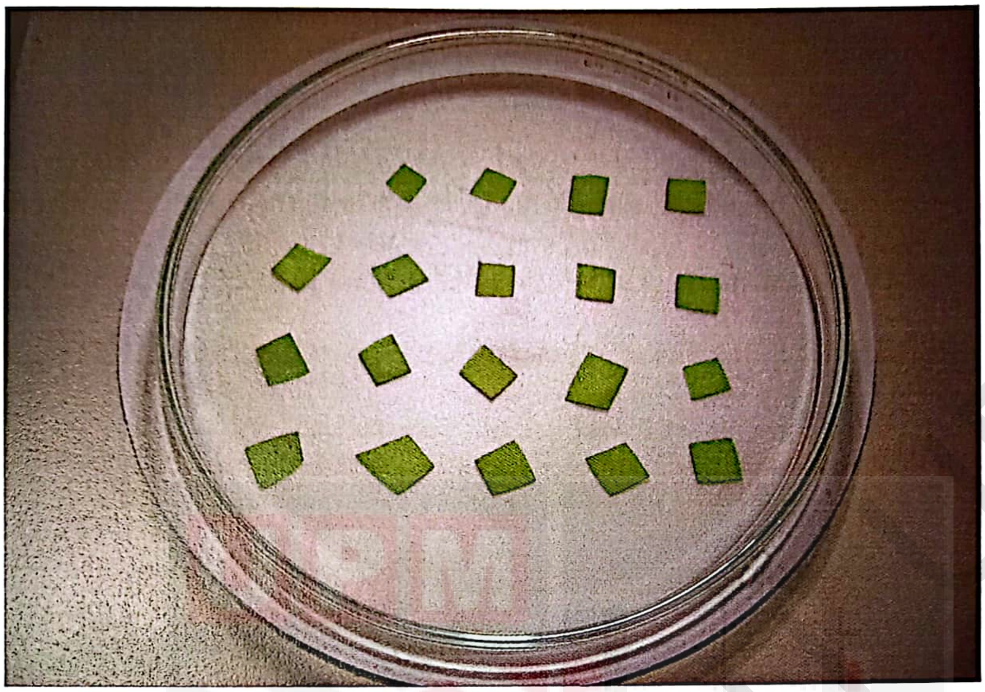

Figure 3. The eggs on the leaves placed on the moist filter paper

Figure 4. The plastic container

3.1.3 Determination the number of instar larval

The growth stages of instar larvae were based on the head capsule shed periodically. The different sizes of head capsule collected were indicated the difference stages of instar larvae (Galway, 2005). To determine the number of instar larvae, sizes of the head capsule were measured on the width at the widest point for every head capsule. Every larval stage were measured for ten replicates. The measurement was estimated under microscope with calibrated ocular micrometer.

3.1.4 Feeding of different immature stages in leaf consumption

The experiment was conducted with 10 replications. Leaves of *E. longifolia* were kept in the airtight plastic bag and brought back to the laboratory. The collected leaves were firstly immersed into distilled water to stop the transpiration and maintained the moisture content as recommended by Tyree, et. al. (2002). Fifteen collected leaves were weighed. Ten weighed leaves used for larvae feeding and five weighed leaves used for control. All the larvae were maintained with the host leaves in the plastic container until pupal stage. All the leaves were sprayed with distil water before fed to the larvae. The remaining leaves after being fed to the larvae at the end of each day together with control leaves were oven dried under 70°C for 48 hours and reweighed as recommended by Nathan (2005). The amount of leaves consumed were based on dry weight basis, where estimated by subtracting the dry weight of fed leaves from the dry weight of control leaves (Henn, 2000). Leaf consumptions of each immature stages was recorded separately for a period of 24 hours interval and the dry weight basis were used by the following formula: (Dry weight of leaf consuming per day = Dry weight of control leaf – Dry weight of fed leaf).

3.2 Quantitative food utilization

Fifteen newly moulted fifth instar larvae (replications) were starved for 4 hours. After starving, the larvae were allowed to feed on weighed quantities of their respective host leaves, young, mature and senescent for a period of 24 hours and reweighed to give the fresh weight gained during the period of study. Sample larvae were weighed oven dried (48 h at 60°C) and reweighed to establish a percentage dry weight conversion value in order to estimate the dry weight of the experimental larvae. The remaining leaves after being fed to the larvae at the end of each day together with control leaves were oven dried under 70°C for 48 hours and reweighed. The quantity of food ingested was estimated by subtracting the diet (dry weight) remaining at the end of experiment from the total dry weight of diet provided. Feaces were collected daily and weighed, then oven dried and reweighed to estimate the dry weight of excreta.

The procedure for measuring the efficiency of food utilization by the larval has been adopted and were calculated in the traditional manner. Relative growth rate (RGR) = P / TA, Relative consumption rate (RCR) = E / (T – A), Approximate digestibility (AD) = 100 (E – F) / E, Efficiency of converting of ingested food (ECI) = 100 P/ E, Efficiency of conversion of digested food (ECD) = 100 P / (E – F), where A = mean dry weight of larva during T, E = dry weight of food eaten, F = dry weight of feaces produced, P = fresh weight gain of larva, T = duration of experimental period (Nathan and Kim, 2005).

3.3 Statistical analysis

The NCSS computer package was used for the analysis of variance. Data of the mean of duration development for the male and female moth were subjected to analyze in unpaired *t*-test with confidence interval at 5%. The data were subjected to one-way analysis of variance (ANOVA). The experiment design for width of head capsule, leaf consumption and the quantitative food utilization were complete randomize design (CRD) and all the mean were separated by using the Fisher's LSD test with confidence interval at 5%.

CHAPTER 4

RESULTS

4.1 The development duration of the life cycle of Tiger moth

Generally, there are egg stage, five instar larvae, pupal stage, and the adult found in the life cycle of Tiger moth. The developmental period from egg to adult for male and female was 31.0±3.5 days and 35.2±3.3 days, respectively (Table 1). The development duration in the egg stage and the pupal stage were not significantly different between the male and female (T_{cal}=2.4, df=18, $P \leq 0.05$).

There were significant difference between the male and the female larvae in the duration of the total larval stages (T_{cal}=2.4, df=18, $P \leq 0.05$). The total development duration for the female moth was higher than the male moth.

Table 1 Mean developmental periods (days) of immature stage of *Atteva sciodoxa* on Tongkat Ali leaves at 27±1°C

Sex	**Life stages of A. sciodoxa (Days) Mean ± SE**								
	Egg stage	Instar larvae					Total larval stages	Pupal stage	From egg to adult
		1	2	3	4	5			
Male	5.2±0.4 a	4.7±0.8 b	2.5±0.5 b	2.1±0.3 b	3.5±0.5 b	6.9±0.3 a	19.7±1.8 b	6.1±0.3 a	31.0±3.5 b
Female	5.0±0.0 a	5.5±0.5 a	4.5±0.8 a	3.8±0.6 a	3.9±0.6 a	6.4±0.5 a	24.1±1.2 a	6.1±0.3 a	35.2±3.3 a

Means followed by the same letters are not significantly different at $P \leq 0.05$ by using paired *t*-test to compare the treatment down the column ($T_{0.05, 18}=2.101$)

4.2 Determination the number of instar larvae

There were five instar larvae of the Tiger moth recorded. The total mean width of the head capsule for first instar, second instar, third instar, fourth instar, and fifth instar were 0.31±0.00, 0.46±0.03, 0.78±0.04, 1.21±0.06, and 1.97±0.10, respectively (Table 2). The increase in the width of head capsule were significant from the first instar to the fifth instar ($F=2405.9$, $df=4$, $P\leq0.05$). It was observed that after the larvae shed its head capsule, the head region will turned color from yellow into black for a few hours.

Table 2. Measurement of head capsule on *A. sciodoxa*

Instar	**Head capsule width (mm) Mean ± SE**
1	0.31 ± 0.00 e
2	0.46 ± 0.03 d
3	0.78 ± 0.04 c
4	1.21 ± 0.06 b
5	1.97 ± 0.10 a

Means followed by the same letters are not significantly different at $P\leq0.05$ (Fisher's LSD multiple comparison test).

4.3 Description of the Tiger moth

4.3.1 Oviposition preference

From the observation in the laboratory colony, the female moths were preferred to lay their eggs beneath the leaves of Tongkat ali. Since most of the eggs were found in the morning around 8.00 am and this lead to assume that the female Tiger moths laid their eggs during the night time.

4.3.2 Egg

The eggs were laid singly on the leaf. The surface chorion of the egg is pitted and the newly hatched eggs were translucent. The egg was ovate to elliptical in shape (Figure 5). Seventy eight percent of the eggs observed were viable and twenty two percent of them failed to hatch (n=60). The viable eggs were considered as fertile eggs while the non-fertile eggs were failed to hatch. The fertile eggs will remain its original feature on the chorion of the egg while the non-fertile will changed its color into yellow. The eggs laid singly on the host leaf and usually few in number on one leaf.

4.3.3 Larvae

There were five instar larvae for the Tiger moth. The larvae formed slight web around the leaves during the immature stage. The newly hatched larvae were translucent and white in color (Figure 6). Its head capsule was black in color and the mobility is limited on the leaf where the eggs laid. As the larvae grows, the head capsule were shed periodically. In the second instar larvae (Figure 7),

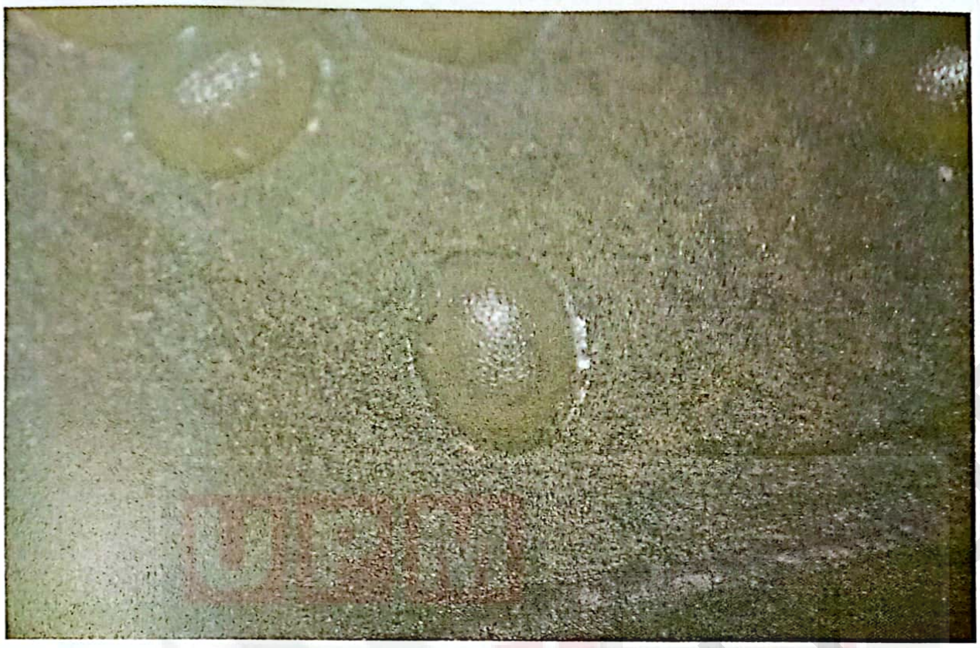

Figure 5. The fertile eggs of *A. sciodoxa* (zoom 30x)

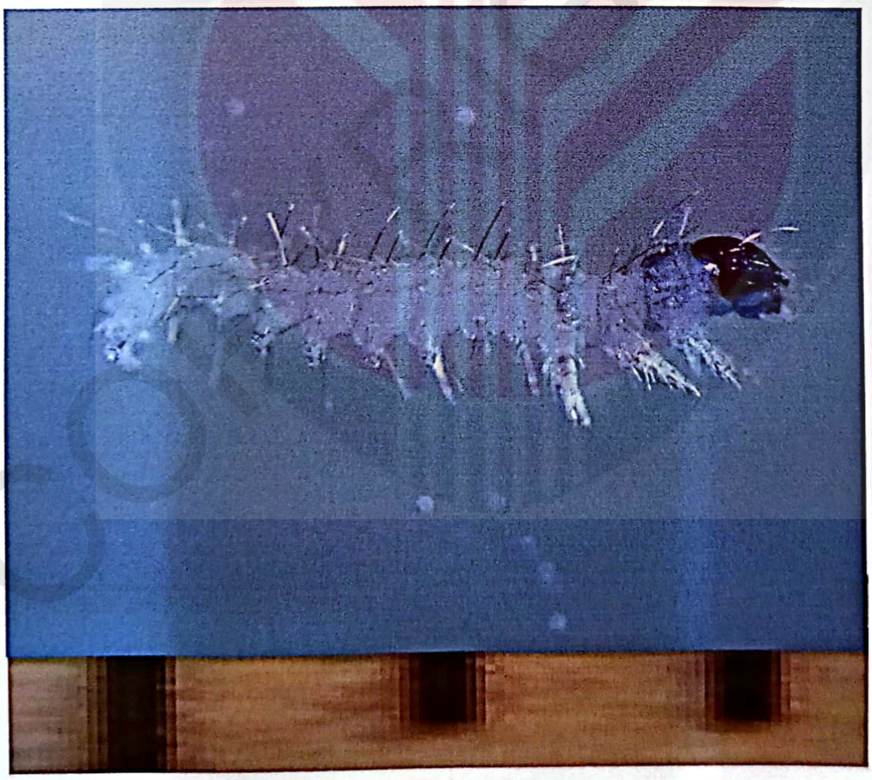

Figure 6. The first instar larva (*A. sciodoxa*)

Figure 7. The second instar larva (*A. sciodoxa*)

a light yellowish color on the body were developed. In the third instar larvae (Figure 8), the body color was also light yellowish in color and the horizontal black stripes were developed over the dorsal body of larvae. In the fourth instar larvae (Figure 9), the body color was turned into dark yellowish. The fifth instar larvae were bright yellow in color with horizontal black stripe over the dorsal body of larvae (Figure 10).

4.3.4 Pupa and adult

The fully grown larvae stopped feeding before pupating. The pupae were spindle shape, dark yellow in the early pupa, and black color on the head region (Figure 11). The pupa was suspended in the web and changed it's color into yellowish-brown when the adult ready to emerge (Figure 12). The front wings of the adult were brownish orange with white dotted (figure 13).

Figure 8. The third instar larva (*A. sciodoxa*)

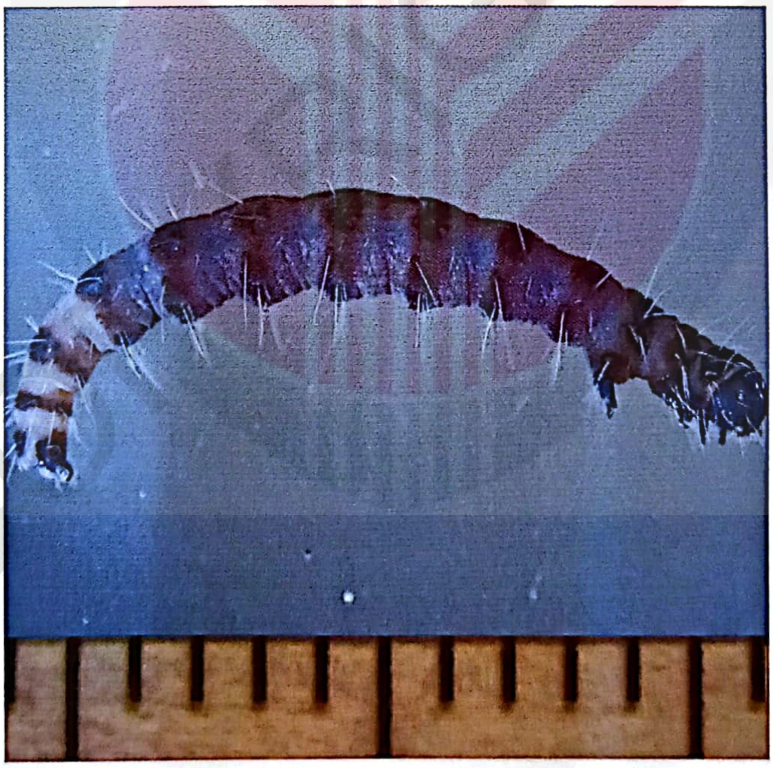

Figure 9. The fourth instar larva (*A. sciodoxa*)

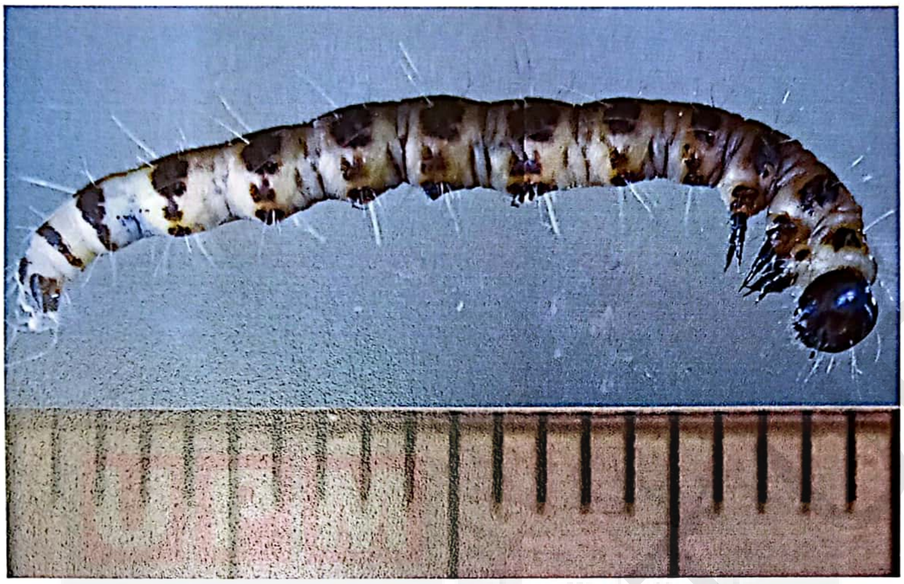

Figure 10. The fifth instar larva (*A. sciodoxa*)

Figure 11. The early pupa (*A. sciodoxa*)

Figure 12. The pupa ready to emerge

Figure 13. Female moth (*A. sciodoxa*)

4.4 Leaf consumption measurement of immatures

Table 3 shows that the significantly increase of leaf consumption of immatures from the first instar to the fifth instar (F=146.07, df=4, P≤0.05). The mean total leaf consumed from the first instar larvae to the fifth instar larvae was 0.176±0.044 g. All the larvae were fed on fresh young leaves of Tongkat ali. There were no significant different in leaf consumption for the first, second and third instar larvae (F=146.07, df=4, P≤0.05), but an increase began from the third instar of larvae onwards. The fifth instar larvae consumed a significant higher portions of leaves as compared to the first, second third, and fourth instar larvae (F=146.07, df=4, P≤0.05). The larvae were stopped feeding during the pupal stage.

Table 3. Measurement of leaf consumption of male larvae (*A. sciodoxa*)

Instar	Leaf consumption (g) Mean ± SE
1	0.005 ± 0.001 c
2	0.004 ± 0.001 c
3	0.008 ± 0.004 c
4	0.030 ± 0.008 b
5	0.129 ± 0.030 a
Total	0.176 ± 0.044

Means followed by the same letters are not significantly different at *P≤0.05* (Fisher's LSD multiple comparison test).

4.5 Quantitative food utilization of the larvae

Data on the comparative food utilization of fifth instar larvae was provided in table 4. In this experiment, the highest percentage of water content was the young leaves (85.81%) and followed by mature leaves (65.57%) and senescent leaves (59.89%). The relative growth rate (RGR), efficiency in converting ingested food (ECI), and efficiency in conversion digested food (ECD) for the young leaves was significantly higher as compared to the mature leaves and senescent leaves ($F=310.73$, $df=2$, $P\leq0.05$), respectively. There were slightly different in the relative consumption rate (RCR) among the leaf age. The fresh weight gained of larvae were increased significantly from young leaves to senescent leaves ($F=398.7$, $df=2$, $P\leq0.05$).

Table 4. Food utilization efficiencies of 5th instar larva of *A. sciodoxa* on different staged leaves of *E. longifolia*

Host leaves	Efficiency food utilization Mean ± SE				Fresh weight gained (g)	Water content (%)
	RGR (g)	RCR (g)	ECI (%)	ECD (%)		
Young	3.95±0.39 a	0.0233±0.0016 ab	132.48±17.13 a	502.36±100.91 a	0.031±0.004 a	85.81
Mature	1.18±0.34 b	0.0268±0.0061 a	32.96±11.42 b	132.77±59.77 b	0.008±0.003 b	65.57
Senescent	0.51±0.47 c	0.0196±0.0102 b	13.42±8.52 c	22.28±15.28 c	0.003±0.002 c	59.89

Means followed by the same letters are not significantly different at $P \leq 0.05$ to compare the treatment down the colomn (Fisher's LSD multiple comparison test).

CHAPTER 5

DISCUSSION

5.1 Developmental stage of immature in the life cycle study

The Tiger moth complete its life cycle in 31±3.5 days and 53.2±3.3 for the male and female moth, respectively. The duration consumed in the egg stage and pupal stage were not significant different between the male and female moth. It shown that the different development duration between the male and female moth were particularly unaffected by the duration of the egg stage and pupal stage. The developmental duration in the larval stage for males and females were occupied about 63.5%, and 68.9% from the total developmental duration, respectively. It was particularly caused by shorter development duration in the male larvae stages. The female larvae developed slower than male larvae in the laboratory because they needed more time to acquire enough nutritional compound especially in nitrogen source from the diet for development of ovaries and eggs (Nation, 2002).

5.2 Determination of the number of instar larvae

Five instar larvae were recorded which were defined by the black head capsule shed after fully grown of each stages. Generally, the head capsule can provide the physical protection on the anterior part of the larvae. After the head capsule shed, the larvae were reforming the new head capsule to increase their size

(Barlow, 1982). This larger larvae were allowed to consume more diet for storing up of food before pupation (Bong, pers. comm., 2007).

5.3 The oviposition preference of Tiger moth

The female moths were preferred to lay their eggs beneath the young leaf of Tongkat ali as to avoid parasitism in the natural environment (Chapman, 1980). The selection of a suitable oviposition site by the female is of great importance since it must ensure that the eggs are adequately protected from the environment and that the correct food will be available for the relatively immobile larvae when they emerge (Chapman, 1980). The purpose to lay the eggs less in number on one leaf was to avoid the newly hatched larvae to compete for the host leaf.

5.4 The description of larvae

The larvae of Tiger moth were formed a slight web during its larval stage. The slight web will provided the larvae with sufficient space in their mobility and as to avoid from natural enemies (Galway, 2005). The alternative way to avoid the natural enemies, such as birds, the body of larvae were possessed a high degree of coloration as to provide a sign of warning and non-favorable food color to their enemies (Rosella, 1999).

5.5 Leaf consumption measurement of immatures

The measurement of leaf consumption by the immatures were carried out in the laboratory. Rearing of the larvae in the laboratory has some advantages over the field population as reported by Galway (2005), that the immatures of *Poliopaschia lithochlora* particularly growth better by comparing the second generation of pupae were significantly larger than first generation pupae in laboratory.

The leaf consumed by the larvae were increased from the first instar larvae to the fifth instar larvae. The larger larvae (fifth instar) were consumed highest amount of leaves because they needed more energy for mobility in searching food (Ambrose, 2004). Besides, the larvae also required source of protein which needed for organ development (Nation, 2002). They were stored up the nutrient gained from the host leaves during their larvae stages due to they stopped feeding during the pupal stage (Bong, pers. comm., 2007). The nutritional which stored up were partially used for adult ecdysis during the pupal stage (Nation, 2002).

5.6 Quantitative food utilization of the larvae

According to Murugan (1992), it has shown that food consumption of the larvae *Daphnis nerii* was age-correlated in the different ages of leaves (*Nerium oleander*). The percentage of water content were decreased from the young leaves to the senescent leaves. These indicated that the water stored in young leaves was highest and followed by mature and senescent leaves.

From the laboratory results, showed that the increase value of fresh weight gained (P) were attributed to high value of RGR, ECI, and ECD which presented in the young leaves. This would lead to assume that the larvae were preferred fed on young leaves (Nakonieczny, 2004). The higher values of ECI and ECD presented in the young leaves were basically enhanced by the higher water contained in young leaves (Murugan, 1992). It would increased the ingested and digested of protein by the larvae who use to trigger the secretion of juvenile hormone (JH), thus increase the value of RGR (Nation, 2002).

Larvae have the greater value in RCR when fed on young leaves as compared to senescent leaves. Generally, larvae feeding on protein-rich host plants were consumed more plant material than those feeding on the protein-deficiency host plants (Mattson, 1980). For instances, it would assume that the young leaves contained higher protein source as compared to senescent leaves.

The higher of water content presented in young leaves were attributed to higher fresh weight gained by the larvae, thus, increased the value of RGR, ECI, ECD. This implied that the increase water content of diet might result in an increased efficiency of diet utilization and more rapid growth (Murugan, 1992).

CHAPTER 6

CONCLUSION

The metamorphosis of the Tiger moth (*A. sciodoxa*) is complete, passing through three distinct stages, egg, larva, and pupa to the adult. Tiger moths were undergone five instar larvae. The female moths were took longer time to complete its life cycle compared to male moths. The development duration in the larval stage for the male and female of Tiger moth were 19.7±1.8 days and 24.1±1.2 days, respectively. The fifth instar larvae were consumed the highest amount of leaves as compared to other instars. An assessment of quantitative food utilization appeared to be a useful parameter in deciding the food quality. The larvae of *A. sciodoxa* were found preferred fed on young leaves due to its higher water content stored in the leaves.

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APPENDICES

Appendix A1: ANOVA Table for Measurement of Head Capsule

Source	df	SS	MS	F
Instar larvae	4	17.961	4.49	2494.444*
Error	45	0.082	0.0018	
Total	49	18.043		

$F_{0.05,4,45} = 4.58$

Appendix A2: ANOVA Table for Measurement of Leaf Consumption of Male Larvae

Source	df	SS	MS	F
Instar larvae	4	0.115	0.02875	147.017*
Error	45	0.0088	0.00019555	
Total	49	0.1238		

$F_{0.05,4,45} = 4.58$

Appendix A3: ANOVA Table for Measurement of Relative Growth Rate (RGR)

Source	df	SS	MS	F
Leaf age	2	100.1792	50.0896	310.729*
Error	42	6.7705	0.1612	
Total	44	106.9497		

$F_{0.05,2,42} = 3.22$

Appendix A4: ANOVA Table for Measurement of Relative Consumption Rate (RCR)

Source	df	SS	MS	F
Leaf age	2	0.0003834	0.00019172	3.988*
Error	42	0.00020194	0.00004808	
Total	44	0.0024028		

$F_{0.05,2,42} = 3.22$

Appendix A5: ANOVA Table for Measurement Efficiency in Converting Ingested Food (ECI)

Source	df	SS	MS	F
Leaf age	2	122316.429	61158.214	369.56*
Error	42	6950.569	165.489	
Total	44	129266.999		

$F_{0.05,2,42} = 3.22$

Appendix A6: ANOVA Table for Measurement Efficiency in Conversion Digested Food (ECD)

Source	df	SS	MS	F
Leaf age	2	1896421.313	948210.656	203.34*
Error	42	195851.685	4663.135	
Total	44	2092272.998		

$F_{0.05,2,42} = 3.22$

Appendix A7: ANOVA Table for Fresh Weight Gained Measurement

Source	df	SS	MS	F
Leaf age	2	0.006507	0.0032535	398.71*
Error	42	0.0003427	0.00000816	
Total	44	0.0068498		

$F_{0.05,2,42} = 3.22$

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled **"Biological Studies of Tiger Moth (*Atteva sciodoxa* Meyrick.) [Lepidoptera: Yponomeutidae] on Tongkat Ali (*Eurycoma longifolia* Jack.)"** by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Campus and published in form approved by the Faculty.

ANG CHIN HWE

Date: 05/ 05/ 2007