SHORT COMMUNICATION

THE LIFE TABLE OF INDIAN MEAL-MOTH, *Plodia interpunctella* (HÜBNER) (LEPIDOPTERA: PHYCITIDAE) FROM TWO DIFFERENT WAREHOUSES IN MALAYSIA

Muhamad Noor Syafiq Omar[1] & Abdul Hafiz Ab Majid[1,2]*
[1]Household and Structural Urban Entomology Laboratory,
Vector Control Research Unit,
School of Biological Sciences,
Universiti Sains Malaysia,
11800 Minden, Penang, Malaysia
[2]Centre for Insect Systematics
Faculty of Science and Technology,
Universiti Kebangsaan Malaysia,43600 UKM Bangi,
Selangor,Malaysia
**Corresponding author: abdhafiz@usm.my*

ABSTRACT

Plodia interpunctella were collected from two warehouses in Penang, Malaysia namely Ray Synergy (RYA) and Lorong Perusahaan (CCW). There was a significant difference (F = 8.470; P<0.05) in the duration of total development time of different stages from larva to the adult for *P. interpunctella* reared in the laboratory from the RYA warehouse. The information on stored product insect pest diversity, environmental factors, and life cycle in rice storage warehouses is very important to implement effective pest management and controlling insect pest infestation in stored rice grains.

Keywords: *Plodia interpunctella;* store product pest; life table; warehouse; rice

ABSTRAK

Plodia interpunctella dikumpulkan dari dua buah gudang iaitu Ray Synergy (RYA) dan Lorong Perusahaan (CCW) di Pulau Pinang, Malaysia. Terdapat perbezaan yang signifikan (F = 8.470; P<0.05) antara jangka masa keseluruhan perkembangan tahap yang berbeza dari larva sehingga dewasa untuk *P. interpunctella* yang dibela di makmal dari gudang RYA. Maklumat mengenai kepelbagaian perosak serangga produk simpanan, faktor persekitaran dan kitaran hidup di gudang simpanan beras sangat penting untuk melaksanakan pengurusan perosak yang berkesan bagi mengawal serangan serangga perosak bijirin beras**.**

Kata kunci: *Plodia interpunctella;* serangga perosak gudang; jadual hidup; gudang; beras

INTRODUCTION

Insects can impact negatively on stored goods and agricultural commodities, as well as transmit disease to animals and humans. Each year, around 480 million metric tonnes of milled rice are produced globally (Muthayya et al. 2014). Infestation of a product that has been stored insect pests are capable of destroying 10% to 20% of agricultural products and warehouses (Khoobdel et al. 2011). According to Syarifah Zulaikha et al. (2018), stored grain losses of up to 13% has been documented.

Stored product pests can be discovered in various storage products in warehouses and even in homes (Hagstrum & Flinn 2014). Insect infestations in facilities hampered the effectiveness of pest management plans (Semeao et al. 2013). Adult insects with strong fliers can spread over and distribute pests in stored product, which is impacted passively or actively by grain storage movement (Srivastava & Subramanian 2016). It can be either major or minor pests to rice grains, depending on the severity of the infestation in the rice storage (Srivastava & Subramanian 2016). Life table analysis is important for determining the mortality of the insect population (Kakde et al. 2014).

Previous research has focused on the development and reproduction of *Plodia interpunctella* using various food sources and under variable environmental conditions (Arbogast 2007). Effective pest management programs on insect pests require understanding the ecology of a pest, the growth parameters, and reproduction. This study aims to determine the life cycle of stored product pests, an Indian meal moth (*Plodia interpunctella*) from two different warehouses in Malaysia.

MATERIALS AND METHODS

Plodia interpunctella larvae collected from Ray Synergy (RYA) and Lorong Perusahaan (CCW) warehouses in Penang, Malaysia were observed in the laboratory conditions at room temperature (28±2°C) and relative humidity (RH 70±10%). The study examined their life cycle from larvae to the adult stage. These larvae were placed in containers containing Thai White Rice 5% to provide food for this moth. This larva’s life cycle and mortality rate have been monitored in the plastic container.Three replicates were used in the laboratory conditions, and the temperature and humidity were recorded (Fulton & Sbur 2018). Life table parameters were analyzed based on the developmental periods, survivorship, life expectancy, and specific life tables of *P. interpunctella* on different warehouses (RYA and CCW). Life table parameters were derived using larvae of *P. interpunctella.* The development of immature stages was analyzed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Data were checked for normality prior to analysis. The obtained data were not normally distributed, they transformed and then subjected to One-Way ANOVA to determine the significant difference between immature stages of *P. interpunctella* and to evaluate the effects of two different field strains (RYA and CCW). Life table study was constructed and was used to analyze life table of insect using the parameters and formulae (Figure 1).

Symbols and formulae used to construct life table.

Symbols	Description	Formulae
n	Duration in days	
x	Age interval in days	
N_x	The number surviving at the beginning of age x	
d_x	The number dying during the age interval x	
l_x	The probability of being alive or surviving to age x	N_x/N_0
$_np_x$	The probability of surviving during the age interval	N_{x+1}/N_x
$_nq_x$	The probability of dying during the age interval	d_x/N_x
$_nd_x$	The fraction of the original cohort that die between the interval	d_x/N_0
$_nL_x$	The fraction of surviving during the interval per individual	$(l_x - {}_nd_x/2)(n)$
T_x	The total number of days lived beyond age x	$\sum L_x$
e_x	The life expectancy of an individual alive at age x	T_x/l_x
m_x	The eggs produced per surviving female	Eggs/2
GRR	Gross reproductive rate	$\sum m_x$
R_0	Net reproductive rate	$\sum l_x m_x$
T	Mean generation time	$\sum(xl_x m_x/R_0)$
r_m	Intrinsic rate of increase (female/female/day)	$\ln R_0/T$
λ	Finite rate of increase (female/female/day)	e^{rm}
DT	Doubling time	$\ln 2/r_m$

Figure 1. Symbols and formula used to construct life table of insects

(Source: Abd Rahim et al. 2016)

RESULTS AND DISCUSSION

Insect pest of *P. interpunctella* from different warehouses were reared on Thai white rice 5% under laboratory conditions. The survivorship curve (l_x) and life tables of larva to adult stage for the Indian meal moths reared on Thai White rice 5% from the different warehouses were combined and illustrated in abridged form (Table 1). *Plodia interpunctella* reared in CCW warehouse had the highest immature survivorship (~60%), while *P. interpunctella* reared RYA

Additionally, the life expectancy column (e_x) (Table 1) showed interesting life history characteristics of *P.a interpunctella*. At early stage, *P. interpunctella* larva from the CCW warehouse showed a life expectancy of 100 days and 88.5 days for RYA, respectively. The result also showed that no mortality in larval stage for both warehouses. However, the number of individuals entering the adult stage varied, with *P. interpunctella* reared from RYA warehouse recorded the lowest number with six individuals, followed by *P. interpunctella* reared from CCW warehouse with nine individuals.

Plodia interpunctella reared in the laboratory from CCW warehouse developed more slowly (~34 days) compared to those reared in the RYA warehouse (~32 days) (Figure 2). Overall, there was a significant difference (F = 8.470; $P<0.05$) in the duration of total development time between larva and adult stages for *P. interpunctella* reared in the laboratory from RYA warehouse, while there was no significant difference (F = 3.128; $P>0.05$) in the duration of total development time between larva and adult for *P. interpunctella* from CCW warehouse (Table 2).

Table 1. Abridged survivorship life tables for the immature stages of *Plodia interpunctella* reared in the laboratory from RYA and CCW warehouse

Warehouse	**x**	**Life Stage**	**nx**	**dx**	**Ix***	**qx**	**Lx**	**Tx**	**ex***	**Stage mortality (%)**
RYA	3	Larva	15	0	1.00	0	15	88.5	88.5	0
	6	Larva	15	0	1.00	0	15	73.5	73.5	0
	9	Larva	15	0	1.00	0	15	58.5	58.5	0
	12	Pupa	15	4	1.00	0.267	13	43.5	43.5	26.67
	15	Pupa	11	1	0.73	0.091	10.5	30.5	41.78	6.67
	18	Pupa	10	4	0.67	0.400	8	20	29.85	26.67
	21	Adult	6	0	0.40	0	6	12	30	0
	24	Adult	6	0	**0.40**	0	6	6	15	0
	3	Larva	15	0	1.00	0	15	100	100	0
CCW	6	Pupa	15	3	1.00	0.200	13.5	85	85	20
	9	Pupa	12	0	0.80	0	12	71.5	89.375	0
	12	Adult	12	1	0.80	0.083	11.5	59.5	74.375	6.67
	15	Adult	11	0	0.73	0	11	48	65.75	0
	18	Adult	11	2	**0.73**	0.182	10	37	50.68	13.33
	21	Adult	9	0	0.60	0	9	27	45	0
	24	Adult	9	0	0.60	0	9	18	30	0
	27	Adult	9	0	**0.60**	0	9	9	15	0

x- age interval in days, nx-number of surviving at the beginning of age x, dx- the number dying during during the age interval x,
*Ix-survivorship, qx-the probability of dying the age interval, Lx-the probability of being alive or surviving to age x, Tx-the total number of days lived beyong age x,
*ex-life expectancy

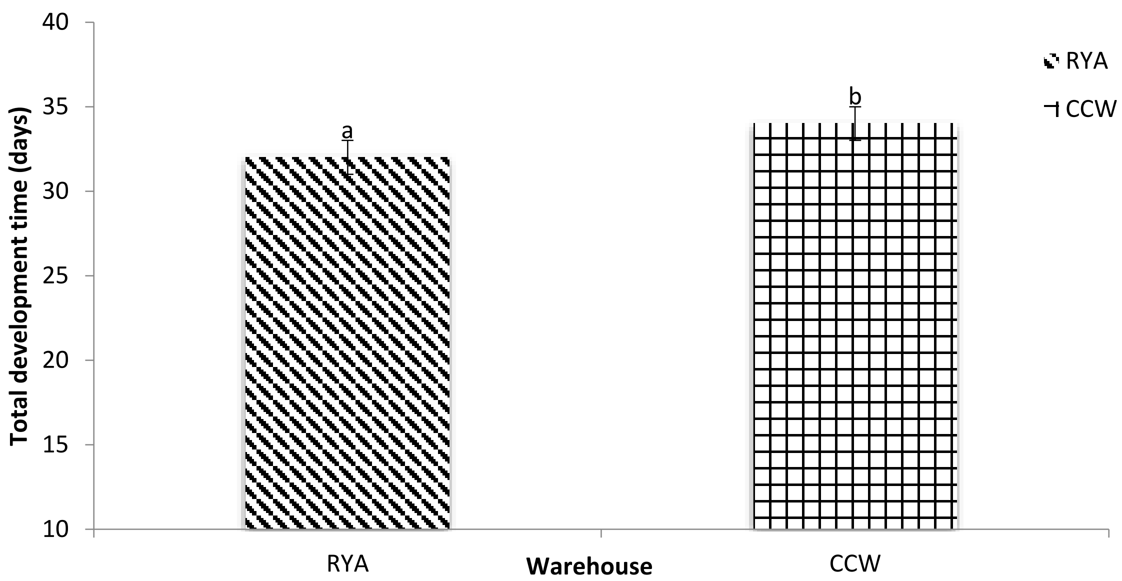

Figure 2. Mean duration of total development from larva to the adult of *Plodia interpunctella* with different alphabet had a significant different in RYA warehouse. One-way ANOVA, Tukey HSD (P<0.05)

Table 2. *P*-value of one-way ANOVA between total development times of difference stages of *Plodia interpunctella* from difference warehouse

Warehouse	df	F	Sig.
RYA	2	8.470	**0.018**
CCW	2	3.128	0.117

Plodia interpunctella from the RYA and CCW warehouses have a life expectancy (e_x) of 20 days. While *P. interpunctella* taken from CCW warehouse showed a higher chance of surviving to adulthood (73%) and were expected to live an additional 13 days once reaching the adult stage, while *P. interpunctella* from the RYA warehouse had a lowest chance of reaching adulthood (40%) and were expected to live an additional 3 days once they reached adulthood. In this study, *Plodia interpunctella* from the RYA and CCW warehouse had a life expectancy of 88.5 and 100 days, respectively. Different results indicated that the life expectancy (ex) of newly emerged adults for *P. interpunctella* (Figure 3, Table 1) was ranged between 16.30 and 16.90 days and between 16.60 and 18.40 in the presence of *A. kuehniella*, and afterwards decreased at all host densities (Arbogast 2007). In other study, Barbarin et al. (2013) reported that different strains of bed bugs had varying life expectancy.

Figure 3: Habitus of adult *Plodia interpunctella*

In this study, *P. interpunctella* in the CCW warehouse exhibited the highest immature survivorship than those from the RYA warehouse. The life cycle of *P. interpunctella* is affected by many factors such as host plants and environmental conditions (Razazzian et al. 2015). The highest temperature was recorded in RYA warehouse was 33.0°C, which may affect the life cycle of *P. interpunctella*. Elevated temperature can affected the overall development of an insect (Jactel et al. 2019). *Plodia interpunctella* is found on various host but does not develop equally well on all of them (Arbogast & Chini 2005). Other insects' life cycle also showed changes in the development time depending on food sources they consume or eat (Abd Rahim et al. 2016). According to Sahito et al. (2017), the highest survival rate of 88% for *Oryzaephilus surinamensis* was recorded on Kupro and the lowest survival rate of 46.51% on Dadhi varieties. As a result, the immature stages of *P. interpunctella* can be influenced by many factors based on different warehouse.

CONCLUSION

In conclusion, *P. interpunctella* in the CCW warehouse exhibited a significantly longer total development time compared to the RYA warehouse. These findings are useful to predict the growth development of *P. interpunctella* populations, and can be used as references for its management control.

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