

**BIONOMICS AND FERTILITY LIFE TABLE OF THE YELLOW MITE, *POLYPHAGOTARSONEMUS LATUS* (BANKS) (ACARI: TARSONEMIDAE) IN JUTE (*CORCHORUS OLITORIUS* L.) AT DIFFERENT TEMPERATURE-HUMIDITY**

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**ABSTRACT:** The jute yellow mite *Polyphagotarsonemus latus* constitutes one of the major pests of jute crop in Bangladesh. The objective of this work was to study the bioecology of the *P. latus*, to determine its temperature-humidity responses and its fertility life table in jute (*Corchorus olitorius* L.) var. O-9897. The incubation period of yellow mite on the variety O-9897 was 2.17 days for female and 1.98 days for male; larval period of 0.95 days for female and 0.80 days for male; Pupal period of 0.81 days for female and 0.70 days for male and egg to adult stage being 3.93 days for female and 3.48 days for male were highest in the 1<sup>st</sup> generation with temperature at  $24.92 \pm 0.27$  °C &  $46.78 \pm 1.28$  % relative humidity among three generations. After a pre-oviposition period of 0.99 days, the females deposited 2.30 eggs per day during 13 days, i.e., 29.86 eggs per female at similar condition in 1<sup>st</sup> generation. The highest longevity was observed 14.35 days for females in the 1<sup>st</sup> generation with temperature at  $24.92 \pm 0.27$  °C &  $46.78 \pm 1.28$  % and 10.44 days for males in the 2<sup>nd</sup> generation with temperature at  $28.51 \pm 0.26$  °C and  $66.65 \pm 1.27$  % relative humidity. In 2<sup>nd</sup> generation the intrinsic rate of increase (rm) was highest (0.389); finite rate of increase ( $\lambda$ ) was 1.48 individuals per female per day in 2<sup>nd</sup> generation. The mean generation time (T) was greater in first generation (8.12) and net reproductive rate (Ro) was observed 14.12 in second generation.

**KEY WORDS:** Jute, Tarsonemid, *Polyphagotarsonemus latus*, bioecology, life table of fertility.

The genus *Corchorus* is the most important family Tiliaceae, highlighting the jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) is the most important cash crop and one of the foreign currency earning sources of Bangladesh as the culture of higher expression of economy. Among the non-insect pests yellow mite, *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) is one of the most common and destructive pests of both the cultivated species of jute (*C. capsularis* L. & *C. olitorius* L.), which has been expanded in recent years in Bangladesh. It is a plague of frequent occurrence in various crops in tropical and subtropical regions, reported in more than 60 families of plants (Schoonhoven et al., 1978; Gerson, 1992; Peña & Bullock, 1994; De Coss-Romero & Peña, 1998). Infesta, preferably, the softer portions of the plants such as cotton (Cividanes et al., 1987), eggplant (Queiroz & Oliveira, 1992), jute (Hath, 2000) and grape (Haji et al., 2001) and is known by a number of common names. It is found in Australia, Asia, Africa, Europe, North America, South America, and the Pacific Islands. In India and Sri Lanka it is called the "yellow tea mite," while those in Bangladesh call it as "yellow jute mite." In some European countries it is called the "broad spider." In parts of South America it is called the "tropical mite" or the "broad rust mite"

(Anon., 2005), a very notorious pest and cause damage to both fibre and seed crops. It is spread by wind, plant structure infested and transported from one area to another, so the natural contact between the foliage of plants (Hugon, 1983), and also by Phoretic relationship with the aphid, *Myzus persicae* Schulzer and the whitefly *Bemisia* the genera and *Trialeurodes* (Fan & Petitt, 1998; Palevsky et al., 2001).

The damage is often termed as 'Telenga' or 'Telchita' disease in Bangladesh. It appears at the end of April but more active in mid May (Kabir, 1975). Generally, they suck the sap from the apical leaves of the plants, as a result, the young leaves wrinkle and curl down, color changes to copper or purplish, finally dry up and fall down (Siddique & Kabir, 1979). Due to the attack of this pest, the vertical growth of the internodes is suppressed thereby side branches are enhanced (Kabir, 1975). Moreover, they attack flower buds, thus, flowers can not bloom properly, and infested pods fail to form seeds (Kabir, 1975). Both yield and quality of fibre are reduced due to the attack of this pest. It was reported that about 38% of fibre yield is decreased by the attack of yellow mite under field condition (Anon., 1990).

The biology of *P. latus* was studied in some plants host, with the development of life tables fertility, as in lime (*Citrus* sp.) (Hugon, 1983), pepper (*Capsicum annum* L.) (Silva et al., 1998), cotton (*Gossypium hirsutum* L.) (Vieira & Chiavegato, 1998) and lemon (*Citrus limon* Burmman) (Vieira & Chiavegato, 1999). However, there are few studies on jute (*Corchorus* sp.) of this pest at the national and international.

Tossa jute, *Corchorus olitorius* occupies 80 per cent of the jute growing area as opposed to 20 per cent by the white jute, *Corchorus capsularis* (Saha, 2000), but unfortunately the incidence of major pests is more on *C. olitorius* than on *C. capsularis*.

As a result, and to permit take appropriate measures for their control, are necessary detailed studies of its biology, to avoid the loss of production, where frequent use of pesticide to increase the cost of cultivation. In this work, held to study the bioecology and life table of jute yellow mite, *Polyphagotarsonemus latus* on jute (*Corchorus olitorius* L. var. O-9897).

## MATERIALS AND METHODS

The study was conducted in the laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) of Gazipur during the period from March 2009 to June 2010.

### Collection and rearing of *P. latus*

*Polyphagotarsonemus latus* were collected from the infested jute plant of the research field of Bangladesh Jute Research Institute, Dhaka in April 2009. The collected mites from infested leaves were transferred into the potted jute plants kept outside the laboratory. Fifteen plants were infested to have constant supply of mite for the study. New plants were contaminated through direct contact with plants used previously when necessary.

### Biology of *P. latus*

The duration of developmental stages was studied on the variety O-9897 leaf in laboratory. Excised leaves were made with mite free fresh jute leaf (*C. olitorius*). Each excised leaf pieces was square in appearance with 2 cm<sup>2</sup> area. The leaf pieces were placed on cotton bed in petri dish (9 cm dia.) facing under surface upward.

Two adult female *P. latus* was transferred to each piece for laying eggs. The adult female mites were collected from lab culture of *P. latus* maintained at the laboratory of the Department of Entomology by rearing infesting potted jute plants for more than three months.

The leaf squares containing adult females were checked after two hours of mite transfer. The mites were removed if at least one egg was found. In this way more than 30 eggs were collected on excised leaf square. One leaf square was maintained in each petri dish with a single egg. The petridishes were covered by lead and excessive moisture inside the petridish was removed naturally. The petridishes containing leaf square with egg were placed on laboratory shelf and leaves were checked after every 6 hours, until the emergence of the larvae. Then, they were transferred individually to new excised leaf square by camel hairbrush and observed at an interval of 6 hours which helped to determine the duration of the larval stages and pupae. The cotton beds were moistened with distilled water at each observation for moistening the excised leaves. Excised leaves were replaced by new one at every two days.

After emergence, males were observed separately at every 24 hours for determining their longevity. The females were allowed to mate with males obtained from the laboratory culture and observed at the same interval. The period of pre-oviposition, oviposition and post-oviposition, longevity, fecundity, sex ratio and fertility are determined. Males that died were replaced by fresh from the stock in excised leaf square. The room temperature and relative humidity content were recorded at 9.00 am and 5.00 pm. The experiment was conducted in three generations viz., 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> at mean temperature and relative humidity  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^{\circ}\text{C}$  and  $60.78 \pm 0.87\%$  respectively.

The duration of different developmental stages were recorded for three generations, corresponding temperature and RH were noted. Study was laid out in completely randomized design (CRD). The results were subjected to analysis of variance. Regression analysis for different variables was also performed. The means were compared by Turkeys' test ( $P = 0.05$ ) and 't' test ( $P = 0.05$ ), using the program MSTAT software (Steel and Torrie 1960).

### Life table of fertility of *P. latus*

The life table of *P. latus* at different generations was constructed from the life history and fecundity data. The actual death occurred at mature and immature stages were taken into account. The female survival rate at different room temperature and relative humidity was determined. Life tables were constructed using the survival data of a specific age class ( $l_x$ ) and the female offspring produced per female in each age class ( $m_x$ ). The net reproductive rate ( $R_0$ ), the mean generation time (T), the intrinsic rate of increase ( $r_m$ ), the doubling time ( $D_t$ ), and the finite rate of increase ( $\lambda$ ) were calculated using the method recommended by Birch (1948):

$$R_0 = \sum (l_x \times m_x)$$

$$T = \frac{\sum (x \times l_x \times m_x)}{\sum (l_x \times m_x)}$$

$$r_m = \ln(R_0) / T$$

$$D_t = \ln(2) / r_m$$

$$\lambda = \exp(r_m)$$

Here  $x$  is age  $l_x$ , the cumulative female survivorship, and  $m_x$ , the number of female descendants per female at  $x$ . Calculation of a corrected  $r_m$  value was performed by iteration. The method, aiming to find  $r_m$  for which  $(1 - \sum \exp(-r_m \times x) \times l_x \times m_x)$  is minimal, was given by Maia et al. (2000), where the base of natural

logarithms,  $x$  is the age of individuals in days,  $l_x$  is the age-specific survival rate and  $m_x$  is the age-specific fecundity rate. The population doubling time and the population trend index were also calculated. Different life table parameters of *P. latus* was calculated using the adult survival ( $l_x$ ), number of female progeny per day ( $m_x$ ) and female sex ratio with the help of QBASIC software (Jervis & Copland, 1996).

## RESULTS AND DISCUSSION

### Bioecology of *P. latus*

*P. latus* passes through 4 biological stages; egg, larva, pupa or quiescent nymph and adult stages (Plate 1). The eggs are white, spherical and covered with tubers give rise to larvae hexapod opaque white color. After a period of activity, the larvae become motionless, resulting in the pupae from which adults emerge, translucent white soon after hatching and thereafter, with a bright yellow color. In females, the fourth pair of legs is reduced to a simple structure and elongated, while the male is strong and robust (Jeppson et al., 1975). Reproduction is sexual, but the occurrence of arrhenotokous parthenogenesis. The male has the habit of carrying the future of female pupa, holding it to the genital papilla. In this operation, the fourth pair of legs only serves as a lever when you lift it from the substrate (Vieira & Chiavegato, 1998). The duration of the stages of egg, larva, pupa and egg-adult period for females and males were higher in mean temperature and relative humidity at  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  and  $46.78 \pm 1.28\%$ , dropping to  $28.51 \pm 0.26^\circ\text{C}$  and  $66.65 \pm 1.27\%$ . However, in 3<sup>rd</sup> generation the mean temperature and relative humidity of  $30.28 \pm 0.21^\circ\text{C}$  and  $60.78 \pm 0.87\%$  there were small increases in the duration these phases, except larval & pupal period. The length of the period egg to adult was  $3.93 \pm 0.02$ ,  $2.97 \pm 0.03$  &  $3.10 \pm 0.06$  days for females and  $3.48 \pm 0.02$ ,  $2.66 \pm 0.02$  &  $2.90 \pm 0.02$  days for males at mean temperature and relative humidity of  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^\circ\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^\circ\text{C}$  and  $60.78 \pm 0.87\%$  during 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, respectively (Table 1, 2,  $P=0.05$ ). The developmental period decreased linearly (negative) and significant ( $P=0.05$ ) with those increasing temperature and relative humidity (Figure 1, 2, 3, 4).

Rodrigo et al. (2006) obtained incubation, larval, pupal and egg-adult period of 2.4, 1.0, 0.8 & 4.5; 1.6, 0.9, 0.7 & 3.5 and 1.8, 0.9, 0.6 & 3.5 days for females and 2.2, 0.8, 0.7 & 4.1; 1.5, 0.7, 0.6 & 3.1 and 1.8, 0.7, 0.6 & 3.4 days for males in grape at  $25^\circ\text{C}$ ,  $28^\circ\text{C}$  and  $32^\circ\text{C}$ , respectively with relative humidity of  $65 \pm 10\%$ . The present result may be discussed with the findings of other authors. Vieira (1995) in young fruits of lemon (*Citrus limon*) ( $T = 27.2 \pm 0.5^\circ\text{C}$  and  $\text{RH} = 68.2 \pm 1.2\%$ ), obtained values of egg, larva, pupa and egg to adult 2.2, 0.8, 0.7 and 3.7 days for females and 2.2, 0.7, 0.7 and 3.6 days for males, respectively.

The duration of egg, larva, pupa and egg to adult females and males of *P. latus* were differed significantly (Table 3,  $P=0.05$ ) at the mean temperature and relative humidity of  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^\circ\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^\circ\text{C}$  and  $60.78 \pm 0.87\%$  in three generations, respectively except egg and pupal period of 3<sup>rd</sup> generation.

Silva et al. (1998) found reduction of duration between egg to adult for males and females of *P. latus* infesting peppers with increasing temperature from  $20^\circ\text{C}$  to  $30^\circ\text{C}$ , and the results were similar to those obtained in the present study. In lime, the duration of egg to adult period was 8.5 days at  $25^\circ\text{C}$  (Hugon, 1983), 4.1 days on cotton (Vieira & Chiavegato, 1998) at  $28.5^\circ\text{C}$  and 3.6 days for males and 3.7 days for females at  $27.1^\circ\text{C}$  in lemon zest (Vieira & Chiavegato, 1999).

The pre-oviposition, oviposition and post-oviposition were also affected by temperature and humidity, differing significantly between the mean temperature and relative humidity of  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^{\circ}\text{C}$  and  $60.78 \pm 0.87\%$  in three generations and the same happened with the parameter longevity of female and male. The fecundity was 29.86, 26.14 & 13.86 eggs/female decreased significantly at temperature and relative humidity of  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^{\circ}\text{C}$  and  $60.78 \pm 0.87\%$  in 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, respectively (Table 4). The regression analysis, the oviposition period decreased linearly (negative) with increasing temperature-RH (Figure 5).

Rodrigo et al. (2006) reported that the pre-oviposition, oviposition and post-oviposition period was 1.8, 26.3, 1.8; 0.3, 14.5, 1.1 and 1.1, 5.8, 0.9 days, respectively at 18 °C, 25 °C and 32 °C in grape with relative humidity of  $65 \pm 10\%$ .

Vieira (1995) obtained identical results when *P. latus* was grown on leaves of cotton (*Gossypium hirsutum*) and young fruits. He found pre-oviposition period of 1.1 & 0.9 days, oviposition duration of 6.8 & 8.9 days, rate of fertility of 29.6 & 24.9 eggs and longevity of female 10.0 & 13.6; male 8.8 & 12.0 days. In lemon Sicilian, at 27.1°C, the periods of pre-oviposition, oviposition, fecundity and longevity of male and female were 1.0, 10.5 days, 58.9 eggs per female, 12.0 and 13.4 days, respectively (Vieira & Chiavegato, 1999).

The graph of rhythm and posture oviposition and survival rate of female *P. latus* is shown in figure 6. After pre-oviposition period oviposition peak of 3.29 eggs/in the 6<sup>th</sup> day at temperature 25.75°C & 50.00% RH. In the 1<sup>st</sup> generation with corresponding temperature and relative humidity of  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ . The survivorship of female was 50% at 13<sup>th</sup> days, 54% at 13<sup>th</sup> days and 49% at 7<sup>th</sup> days in the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, where corresponding mean temperature and relative humidity was  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^{\circ}\text{C}$  and  $60.78 \pm 0.87\%$ , respectively. The maximum oviposition of 3.29 eggs obtained on the 6<sup>th</sup> day with temperature at 25.75°C & 50.00% RH, 3.14 eggs on the 6<sup>th</sup> day with temperature at 28.75°C & 66.00% RH and 2.71 eggs on the 5<sup>th</sup> day with temperature at 30.75°C & 60.50% RH in the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, respectively with corresponding temperature and RH of  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm 1.27\%$ ,  $30.28 \pm 0.21^{\circ}\text{C}$  and  $60.78 \pm 0.87\%$ . In bean, at temperatures between 22°C and 28°C, Schoonhoven et al. (1978) found peak oviposition of 4.9 eggs / female for nine days. In pepper at 25°C, the maximum oviposition of 5.0 eggs was obtained on the eighth day and 54% of survival of females at 13 days (Silva, 1995). In cotton at 28.5°C, Vieira & Chiavegato (1998) recorded 4.8 eggs on the fifth day and 50% survival at 11 days. In lemon zest, Vieira & Chiavegato (1999) found 6.5 eggs / female for four days and 50% survival at 15 days at a temperature of 27.1°C.

### Life table of *P. latus*

The sex ratio of *P. latus* of 1: 4 (male : female) was used for the life table calculation and the life table parameters are given in table 6. The gross reproductive rate (GRR) was 23.88, 20.90 and 11.08; net reproductive rate ( $R_0$ ) 14.00, 14.12 and 3.94; capacity for increase ( $r_c$ ) 0.28, 0.28 and 0.16; intrinsic rate of increase ( $r_m$ ) 0.325, 0.389 and 0.207; cohort generation time ( $T_c$ ) 9.34, 8.11 and 7.65 days; mean generation time( $T$ ) 8.12, 6.81and 6.62 days; finite capacity for increase ( $\lambda$ ) 1.38, 1.48 and 1.23; doubling time (DT) 2.13, 1.78 and 3.35 days in the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, respectively. The mean temperature and relative humidity was  $24.92^{\circ}\text{C} \pm 0.27^{\circ}\text{C}$  and  $46.78 \pm 1.28\%$ ,  $28.51 \pm 0.26^{\circ}\text{C}$  and  $66.65 \pm$

1.27%,  $30.28 \pm 0.21^\circ\text{C}$  and  $60.78 \pm 0.87\%$  in 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations, respectively.

The values of gross reproductive rate (GRR), cohort generation time ( $T_c$ ) and mean generation time (T) decreased with the increasing temperature from  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  to  $28.51 \pm 0.26^\circ\text{C}$  and  $30.28 \pm 0.21^\circ\text{C}$ . The net reproductive rate ( $R_o$ ), intrinsic rate of increase ( $r_m$ ) and finite capacity for increase ( $\lambda$ ) was increased with increment of temperature from  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  to  $28.51 \pm 0.26^\circ\text{C}$ , then decreased in 3<sup>rd</sup> generation with the temperature of  $30.28 \pm 0.21^\circ\text{C}$ , although the average length of generation was lower at  $30.28 \pm 0.21^\circ\text{C}$ . Capacity for increase ( $r_c$ ) is same in 1<sup>st</sup> & 2<sup>nd</sup> generations with the temperature at  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  &  $28.51 \pm 0.26^\circ\text{C}$ , then decreased in 3<sup>rd</sup> generation with the temperature of  $30.28 \pm 0.21^\circ\text{C}$  and doubling time (DT) of *P. latus* was decreased with the increased temperature from  $24.92^\circ\text{C} \pm 0.27^\circ\text{C}$  to  $28.51 \pm 0.26^\circ\text{C}$ , then increased in 3<sup>rd</sup> generation with the temperature of  $30.28 \pm 0.21^\circ\text{C}$  (Table 5).

The values of  $r_m$  and  $\lambda$  to  $25^\circ\text{C}$  these studies were similar to those found by Silva et al. (1998), on pepper. There was also similarity with the results found in cotton (Vieira & Chiavegato, 1998) and lemon zest (Vieira & Chiavegato, 1999), but the work was carried out at temperatures of  $27.1$  and  $28.5^\circ\text{C}$ . Hugon (1983) built a table for fertility life at  $25^\circ\text{C}$ , with values of  $R_o$ , T,  $r_m$  and  $\lambda$  of 17.58, 6.71, 0.427 and 1.53, respectively. Li & Li (1986), in pepper, determined values of  $R_o$  from 18.06 to  $20^\circ\text{C}$ , 30.9 to  $25^\circ\text{C}$  and 13.54 to  $30^\circ\text{C}$ , which was well above but Hugon (1983), in citrus, observed a reducing the value of  $R_o$  4.66 at  $30^\circ\text{C}$ , and a value of 17.58 to  $25^\circ\text{C}$ , similar that obtained in this study. These authors also confirmed the reduction in the duration a generation with increase of temperature. Values of  $r_m$  obtained by Li & Li (1986) was 0.18 at  $20^\circ\text{C}$  and 0.32 at  $25^\circ\text{C}$  were almost consistent with the present results, however discordant, to the value of 0.29 obtained in temperature of  $30^\circ\text{C}$ . Hugon (1983) observed also a small reduction in the values of  $\lambda$  (finite capacity of increase) between the temperatures of  $25$  (1.53) and  $30^\circ\text{C}$  (1.39).

The temperature and relative humidity affected directly the biological parameters of the immature stages and the adult stage of *P. latus*, influencing consequently the parameters of life table. The result of present investigation agreed with the findings of the above results. All above results shows the great effect of temperature and relative humidity on the development and fecundity of *P. latus* and other species of tarsonemid. This experiment also found the significant effect of temperature and relative humidity on the developmental stages of *P. latus*. The higher temperature reduced the duration of developmental stages. By analyzing the parameters obtained the life table of fertility *P. latus*, noted that the jute was an extremely favorable to the population development of the species in which high rates of increase ( $r_m$  and  $\lambda$ ) were associated with longer duration of generation (T). However, due to a lower survival, resulted in lower rates net reproduction.

So the present results suggest that favourable temperature of *P. latus* was  $24.92 \pm 0.27^\circ\text{C}$  to  $28.51 \pm 0.26^\circ\text{C}$ , which is very similar to the findings of other investigators on different species of yellow mites.

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Table 1. The mean length (days  $\pm$  SE) of immature stages and duration from egg to adult of female *P. latus* in three generations under laboratory condition.

Generation	Egg	Larva	Pupa	Egg-adult	Temperature (°C)	RH (%)
1 <sup>st</sup>	2.17 $\pm$ 0.01a	0.95 $\pm$ 0.01a	0.81 $\pm$ 0.01a	3.93 $\pm$ 0.02a	24.92 $\pm$ 0.27	46.78 $\pm$ 1.28
2 <sup>nd</sup>	1.45 $\pm$ 0.01c	0.81 $\pm$ 0.01b	0.72 $\pm$ 0.02b	2.97 $\pm$ 0.03b	28.51 $\pm$ 0.26	66.65 $\pm$ 1.27
3 <sup>rd</sup>	1.71 $\pm$ 0.03b	0.74 $\pm$ 0.03b	0.64 $\pm$ 0.03b	3.10 $\pm$ 0.06b	30.28 $\pm$ 0.21	60.78 $\pm$ 0.87

Means followed by same letter in column do not differ by Tukey's test (P = 0.05).

Table 2. The mean length (days  $\pm$  SE) of immature stages and duration from egg to adult of male *P. latus* in three generations under laboratory condition.

Generation	Egg	Larva	Pupa	Egg-adult	Temperature (°C)	RH (%)
1 <sup>st</sup>	1.98 $\pm$ 0.01a	0.80 $\pm$ 0.01a	0.70 $\pm$ 0.01a	3.48 $\pm$ 0.02a	24.92 $\pm$ 0.27	46.78 $\pm$ 1.28
2 <sup>nd</sup>	1.35 $\pm$ 0.01c	0.70 $\pm$ 0.01b	0.61 $\pm$ 0.02b	2.66 $\pm$ 0.02c	28.51 $\pm$ 0.26	66.65 $\pm$ 1.27
3 <sup>rd</sup>	1.66 $\pm$ 0.04b	0.67 $\pm$ 0.02b	0.56 $\pm$ 0.08b	2.90 $\pm$ 0.02b	30.28 $\pm$ 0.21	60.78 $\pm$ 0.87

Means followed by same letter in column do not differ by Tukey's test (P = 0.05).

Table 3. The mean length (days $\pm$  SE) of immature stages and duration from egg to adult in female and male *P. latus* for three generations under laboratory condition.

Generation	Sex	Egg	Larva	Pupa	Egg-adult	Temperature (°C)	RH (%)
1 <sup>st</sup>	♀	2.17 $\pm$ 0.01a	0.95 $\pm$ 0.01a	0.81 $\pm$ 0.01a	3.93 $\pm$ 0.02a	24.92 $\pm$ 0.27	46.78 $\pm$ 1.28
	♂	1.98 $\pm$ 0.01b	0.80 $\pm$ 0.01b	0.70 $\pm$ 0.01b	3.48 $\pm$ 0.02b		
2 <sup>nd</sup>	♀	1.45 $\pm$ 0.01a	0.81 $\pm$ 0.01a	0.72 $\pm$ 0.02a	2.97 $\pm$ 0.03a	28.51 $\pm$ 0.26	66.65 $\pm$ 1.27
	♂	1.35 $\pm$ 0.01b	0.70 $\pm$ 0.01b	0.61 $\pm$ 0.02b	2.66 $\pm$ 0.02b		
3 <sup>rd</sup>	♀	1.71 $\pm$ 0.03a	0.74 $\pm$ 0.03a	0.64 $\pm$ 0.03a	3.10 $\pm$ 0.06a	30.28 $\pm$ 0.21	60.78 $\pm$ 0.87
	♂	1.66 $\pm$ 0.04a	0.67 $\pm$ 0.02b	0.56 $\pm$ 0.08a	2.90 $\pm$ 0.02b		

Means followed by same letter in column do not differ by Tukey's test ( $P = 0.05$ ).

Table 4. The mean length (days $\pm$  SE) of pre-oviposition, oviposition, fecundity and longevity of female and male *P.latus* for three generations under laboratory condition.

Generation	pre-oviposition	oviposition	post-oviposition	fecundity	longevity(♀)	longevity(♂)	Temperature (°C)	RH (%)
1 <sup>st</sup>	0.68 $\pm$ 0.01 b	12.68 $\pm$ 0.02 a	0.99 $\pm$ 0.01 b	29.86 $\pm$ 0.18 a	14.35 $\pm$ 0.04 a	8.89 $\pm$ 0.19 b	24.92 $\pm$ 0.27	46.78 $\pm$ 1.28
2 <sup>nd</sup>	0.99 $\pm$ 0.02 a	11.08 $\pm$ 0.05 b	1.78 $\pm$ 0.08 a	26.14 $\pm$ 0.17 b	13.85 $\pm$ 0.08 b	10.44 $\pm$ 0.14 a	28.51 $\pm$ 0.26	66.65 $\pm$ 1.27
3 <sup>rd</sup>	0.93 $\pm$ 0.01 a	5.53 $\pm$ 0.13 c	0.91 $\pm$ 0.04 b	13.86 $\pm$ 0.19 c	7.38 $\pm$ 0.13 c	4.66 $\pm$ 0.16 c	30.28 $\pm$ 0.21	60.78 $\pm$ 0.87

Means followed by same letter in column do not differ by Tukey's test ( $P = 0.05$ ).

Table 5. Life table parameters of *Polyphagotarsonemus latus* during 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> generations.

Life table parameters	Generations		
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
Gross reproductive rate ( $GRR = \sum m_x$ )	23.88	20.90	11.08
Net reproductive rate ( $R_0 = \sum l_x m_x$ )	14.00	14.12	3.94
Capacity for increase ( $r_c = [\log_e R_0]/T_c$ )	0.28	0.28	0.16
Intrinsic rate of increase ( $r_m$ )	0.325	0.389	0.207
Cohort generation time ( $T_c = \sum x l_x \times m_x / \sum l_x m_x$ )	9.34	8.11	7.65
Generation time ( $T = [\log_e R_0] / r_m$ ) days	8.12	6.81	6.62
Finite capacity for increase ( $\lambda = \text{anti } \log_e r_m$ )	1.38	1.48	1.23
Doubling time ( $DT = \log_e 2 / r_m$ ) days	2.13	1.78	3.35
Temperature (°C)	24.92 $\pm$ 0.27	28.51 $\pm$ 0.26	30.28 $\pm$ 0.21
RH (%)	46.78 $\pm$ 1.28	66.65 $\pm$ 1.27	60.78 $\pm$ 0.87

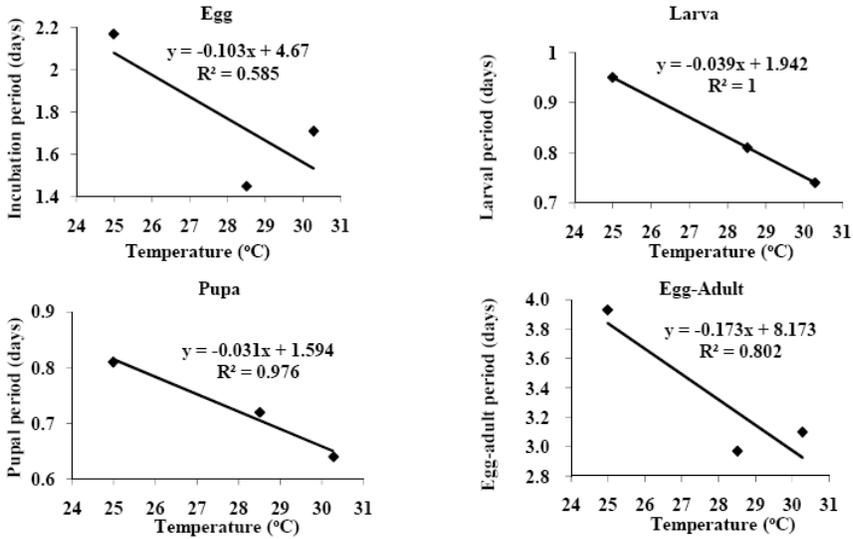


Figure 1. Regression between temperature (°C) on egg, larval, pupal and egg to adult period of female *Polyphagotarsonemus latus*.

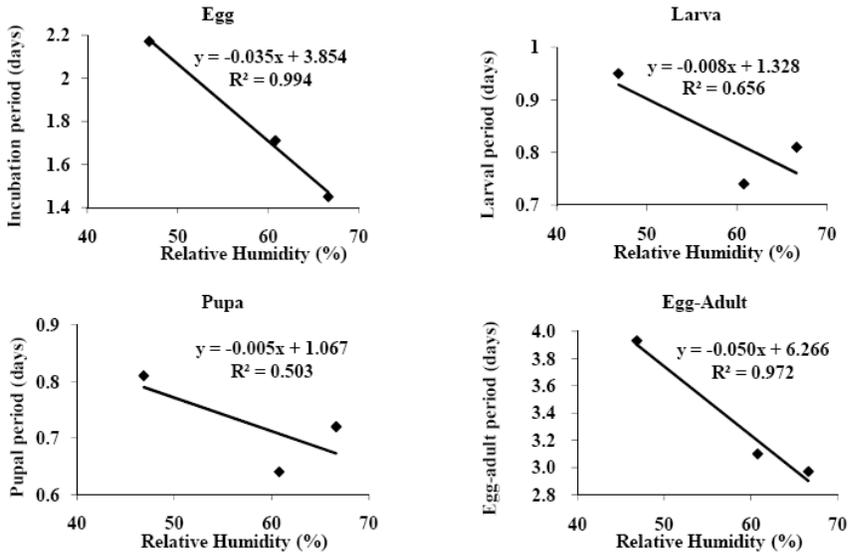


Figure 2. Regression between relative humidity (%) on egg, larval, pupal and egg to adult period of female *Polyphagotarsonemus latus*.

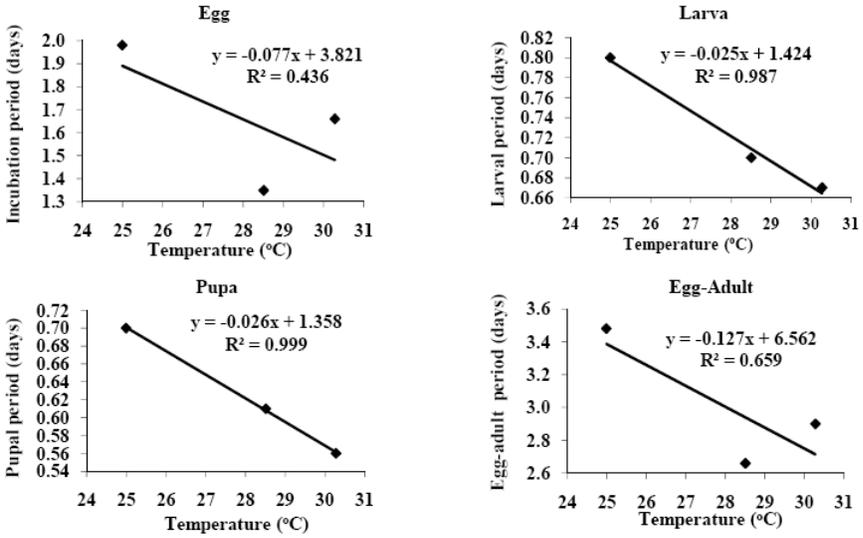


Figure 3. Regression between temperature (°C) on egg, larval, pupal and egg to adult period of male *Polyphagotarsonemus latus*.

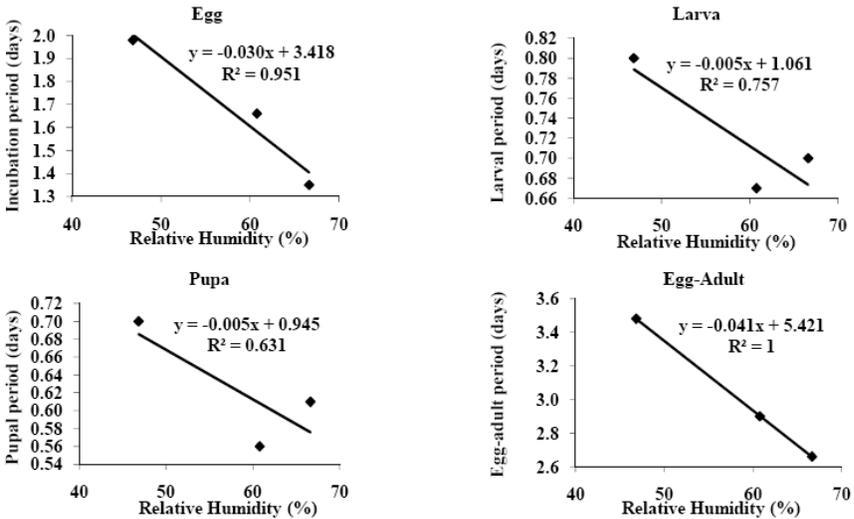


Figure 4. Regression between Relative humidity (%) on egg, larval, pupal and egg to adult period of male *Polyphagotarsonemus latus*.

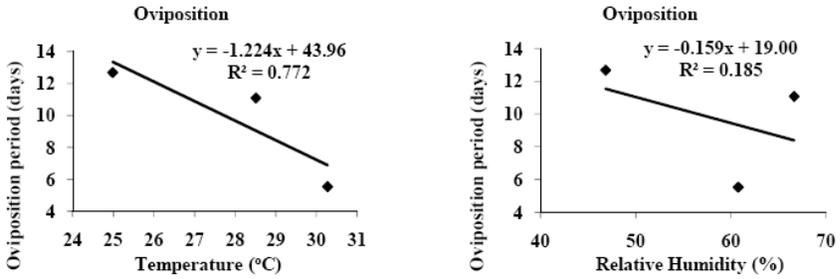


Figure 5. Regression between temperature (oC) and relative humidity (%) on oviposition period of *Polyphagotarsonemus latus*.

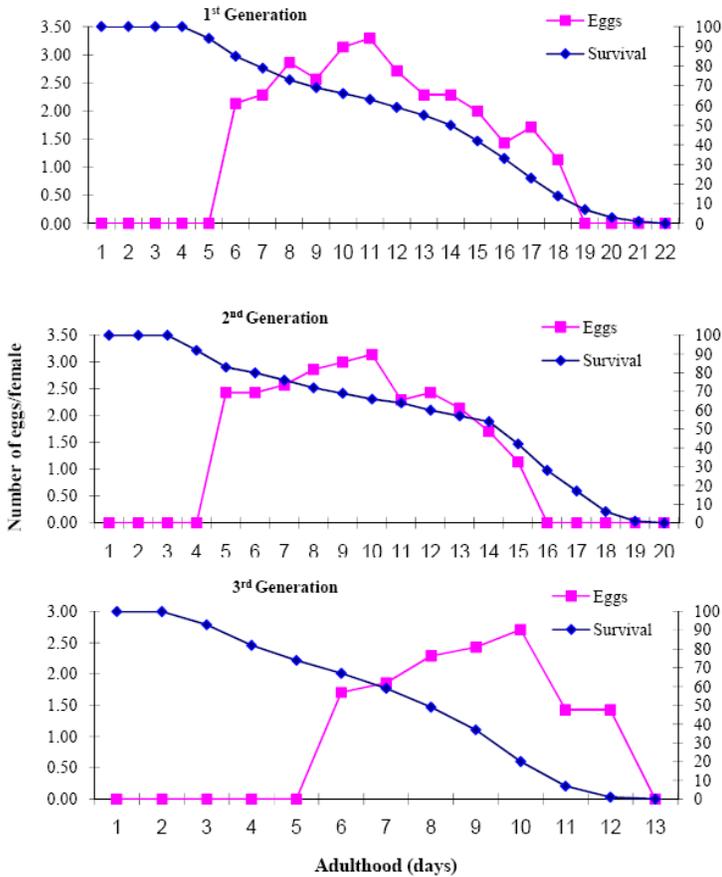


Figure 6. Oviposition and survival rate of female in three generations under laboratory condition.



Plate I. Developmental stages of *P. latus*.