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The Emergence and Rmating Rhythms of *Trabala vishnou gigantina* (Lepidoptera: Lasiocampidae)

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Abstract: *Trabala vishnou gigantina* is a defoliator moth of the Lasiocampidae family (Lepidoptera). The eclosion, mating, oviposition and life span of the *Trabala vishnou gigantina* adults were investigated in the laboratory at 24±1 and 50±10% rh under 12L:12D. The results showed that emergence activity of *T. vishnou gigantina* occurred throughout the day, 71.45% of females and 67.68% of males emerged at night. Males emerged significantly earlier than females. The highest emergence frequency occurred at 1900-2200 h. The highest mating frequency occurred between 300-400 h for 2 days old moths and then decreased gradually. Females normally copulated only once in their whole life spans with several times for males. For most adults, the duration of mating was 14~16 h.

Key words: *Trabala vishnou gigantina*, rhythms, emergence, mating, females

INTRODUCTION

Trabala vishnou gigantina is a defoliator moth of the Lasiocampidae family (Lepidoptera). It is distributed mainly in Shaanxi, Qinghai, Gansu, Henan, Shanxi and Hebei Provinces in the autonomous regions of Inner Mongolia and Ningxia in China and can cause damage on various trees such as oak, chestnut, apple, hawthorn, walnut and sea buckthorn (Liu and Wu, 2006). The larvae of *T. vishnou gigantina* attack mainly the leaves then making them growth weak and eventually leading to the death of the plant. In recent years, *T. vishnou gigantina* populations have occurred in a large area in Wuqi county of Shaanxi Province in China which has aggravated the damage to seabuckthorn (*Hippophae rhamnoides* L.) populations and severely impaired the local eco-environmental construction and economic development based on this species. Tan reported that the antennae of male *Trabala vishnou gigantina* were pinniform and consisted of three segments: a scape, a pedicel and a flagellum. Spatial distribution of pupae and eggs were intense pattern (Zhang *et al*., 2012, 2013). Studies of the morphological characteristics and life history of *T. vishnou gigantina* have shown that *T. vishnou gigantina* has one generation per year. Eggs were found to overwinter on cocoon branch and leaf which hatch in late April. The newly hatched larvae undergo seven instars usually feeding on leaves. The larvae in the 1st to 3rd instars are aggregative and the larvae in the 4th instar begins to disperse. Pupation begins in late July on the lateral branches of tree, branches of shrub and weed and adults emerge from late August to late September. Adults are active during the night and have obvious phototaxis. The wingspan is 54-62 and 70-95 mm for males and females. The longevity of adults is 4.9 days on average and the fecundity is 290-380 per female (Tong, 1966).

At present, because of lacking effective control methods, chemical pesticide is widely used. However, long-term pesticide use will result in environmental deterioration and significantly increase the possibility of pesticide resistance development (Usmani and Shearer, 2001). Thus, the development of new control technology is imperative. Although, the morphological characteristics and life history of the moth has been intensely studied (Tong, 1966) there are currently no reports describing adult emergence and mating circadian rhythms. This information can provide useful data to researchers in developing integrated pest management strategies (e.g., monitoring activities and movements as well as the timing of insecticide treatments) (Downham *et al*., 2004). In particular, it can be used to determine the precise rhythm of sex pheromone release which are chemical signals emitted by insects in trace amounts that are usually species specific and are often utilized as trap

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attractants in the monitoring and control of pest species (Landolt and Phillips, 1997). Application of a synthetic sex pheromone has potential for monitoring and control (Finnegan and Chambers, 1993) and has a favorable effect in practical applications on lepidopteran insects in recent years (Naka *et al*., 2010; Do *et al*., 2011; Hoddle *et al*., 2011; Hummel *et al*., 2011; Peng *et al*., 2012; Chen *et al*., 2013). In this study, therefore researchers investigated the pattern of emergence and mating of adult.

MATERIALS AND METHODS

Insects: Matrue larvae of *T. vishnou gigantina* used in experiments were collected from seabuckthorn fields in Wuqi county, Shanxi Province, China in April 2011. They were taken back to the rearing room and reared to pupation. The food was replaced every day with a fresh supply. Adults were maintained in one mesh cage (50×50×50 cm) with fine nylon mesh to mate. The fresh cut of seabuckthorn branches (30 cm long) with fresh twigs and leaves were placed in cage. The rearing and following experiments on circadian rhythms were conducted in the rearing room at 24±1 and 50±10% relative humidity under L12:D12 with photophase starting at 0500 h. Two red-light bulbs (15 w) were used for visual observation during the dark period. Adults emerging between 0 and 24 h were considered as 1 day old.

Emergence pattern: The number of emergences for each sex was recorded every day. Observations were started after the first emergence occurred. The total numbers of females and males used in this experiment were 313 and 441, respectively. The daily rhythm of emergence activity of both sexes was determined by hourly records from 0000-2400 h. The numbers of emerged females and males were recorded at 30 min intervals. The time difference of emergence between females and males was calculated by the weighted average method:

$$M_{difference\ (d)} = \text{The emergence of females } M♀ - \text{The emergence of males } M♂$$

$$M = \frac{(x_1 \times 1 + x_2 \times 2 + ... + x_n \times n)}{(x_1 + x_2 + ... + x_n)}$$

where, x_n is the number of the emergence of n day.

Mating behavior: Thirty pairs active 1 day old moths were kept in a mesh cage (50×50×50 cm) with a single transparent acrylic side that allowed observation to mate. They were provided with a diluted honey solution impregnated in a piece of cotton. Observations were started immediately after pairing. Mating rhythm was recorded every 30 min throughout the scotophase for 7 days. Mated pairs were transferred from the cage to a plastic cup (20 cm diam. 8 cm ht.) to facilitate measurement of copulation duration. The experiment replicated three times (three cages).

All calculations were performed with Microsoft Excel Software and statistical tests conducted with SPSS V. 17.0. The means were separated by Duncan's multiple range tests.

RESULTS

Circadian rhythm of emergence activity: Eclosion took 40 days for *T. vishnou gigantina* in the lab and occurred from the 21th August to the 30th September. The number of adults reached peak level in early September 2011 (62.07% of the total number of *T. vishnou gigantina* individuals that emerged) and decreased markedly in other time unit. Males emerged earlier than females (Fig. 1). It can be calculated from formula that males emerged 1.08 days earlier than females.

Figure 2 shows the emergence rhythm of *T. vishnou gigantina* females and males in 24 h. The emergence activity was observed throughout the day; 30.43% moths emerged during the photophase (0500-1900) and 69.57% of moths emerged during the scotophase (1900-0500). Adult emergence during scotophase was 71.45% for females and 67.68% for males. Emergence was significantly influenced by time of day ($F = 8.78$, $df = 23$, $p<0.001$) but was not significantly influenced by sex ($F = 0.85$, $df = 1$, $p>0.2$). The interaction between sex and time of day was also significant ($F = 7.36$, $df = 23$, $p<0.001$). Both sexes showed clear large and distinct peaks of emergence. For females, there was an emergence peak at 1900-2100 h and decreased sharply afterwards. For males, the peak level of emergence was observed at 1900-2100 h. The emergence was low throughout the photophase. Comparison of each time unit of both sexes showed that the differences between both sexes were statistically significant at 1900-2000 and 2000-2100 ($t>4$, $p<0.05$). The degree of difference was reduced during the other hours of either photophase or scotophase ($t<2$, $p>0.05$) (Fig. 2).

Sex ratio: The average sex ratio of reared adult *Trabala vishnou gigantina* female to male was 1:1.41 which showed the number of males was higher than females (Table 1). The change of number in lab was almost synchronous with the incidence of in field.

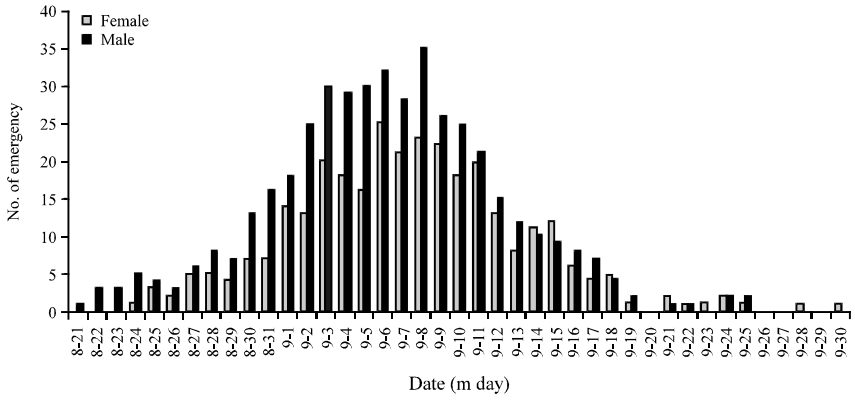

Fig. 1: Daily emergence rhythm of *Trabala vishnou gigantina* adults in the lab

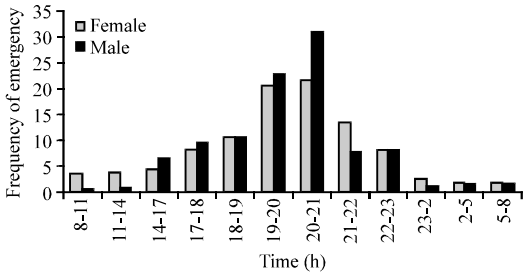

Fig. 2: Emergence rhythm of *Trabala vishnou gigantina* adults in 24 h

Table 1: Ratio of *Trabala vishnou gigantina* female to male moths in Wuqi, China (2011)

	Number of moth emerged		
Dates	Female	Male	Sex ratio (female/male)
Aug. 21-31	34	69	0.49
Sep. 1-10	190	278	0.68
Sep. 11-20	80	88	0.91
Sep. 21-30	9	6	1.50
Total	313	441	0.71

Circadian rhythm of mating behavior: The mating of 1 day old moths did not occur during all the time. The highest mating frequency occurred at 300-400 h for 2 days old moths (Fig. 2). The mating of 2-6 days old moths can be observed during 0000-0500 h. The mating peaks of 2-4 day old moths were focused at 300-400 h and the peaks were advanced with ages for 5 days old moths (Fig. 2). Ratio of mating peak period to whole mating percentages was >90%.

The mating frequencies were 60.67, 48.34, 45.52, 56.58 and 45.41% for 2-6 days old moths (Fig. 3). For most adults, the duration of mating was 14~16 h Young and old moths generally spent more time in mating than middle-aged moths. The mating frequency of *Trabala vishnou gigantina* was age-dependent. The mating frequency was 0 at 1 day old, reached a maximum at 2 days old and thereafter decreased gradually with age.

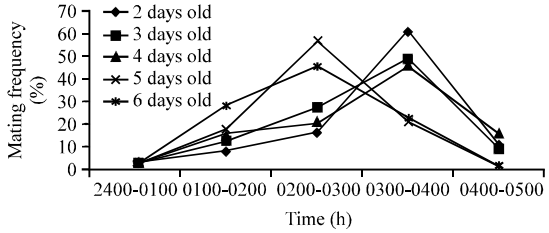

Fig. 3: The effect of age and time on the mate percentage of *Trabala vishnou gigantina* during 0000-5000 h

DISCUSSION

Researchers found that adults emerged from the middle of April to the late of September, it was favorable for the controlling of the adults, especially using of sex pheromone. At the same time, researchers also noticed that males emerged 1.08 days earlier than females. It is similar to the results in the study of the congeneric species *Euproctis pseudoconspersa* (Wang *et al*., 2003). The phenomena is also present in *Spodoptera littoralis* (Binyameen *et al*., 2013), *Chilo suppressalis* (Xiao and Hu, 2010), *Helicoverpa armigera* (Mironidis *et al*., 2010), *Plutella xylostella* (Guo and Qin, 2010). The sex pheromone only trapped males of adult (Finnegan and Chambers, 1993), therefore, this rerult would be better to guid the field application then increase the number and the ratio of attraction.

The mating of *Trabala vishnou gigantina* Yang took place at might with the highest peak at 3:00-4:00. The result could provide guidence on how to extract sex pheromone and what time to disrupt mating artificially. It is of interest that *T. vishnou gigantina* Yang mated from the second night after emergence. Mating rates were highest in 2 days old females and then decreased markedly. This suggests that the mating of *Trabala vishnou gigantina* Yang is to be age-dependent. Females normally copulated only once in their whole life spans

with several times for males. Many findings of other moths *Parocneria orienta* *Agrius convolvuli* (Jiang *et al*., 2009) *Chilo suppressalis* were similar to ours. The reason of the rerult may be also explained by Foster. He confirmed that mating triggered a permanent inactivation of pheromone production in the female.

In the study, the results of laboratory observation were consistent with field survey. But some of adults always did not occurred mate. This may be attributed to that the rearing cage is too small and the changes of environment conditions affected their behaviors.

CONCLUSION

The present findings on the patterns of adult's emergence and mating will be useful to establish techniques for isolating and extracting the sex pheromone, facilitate field evaluation of the sex pheromone and finally develop integrated pest management strategies. In order to apply these parameters more broadly, further studies are needed for field evaluation in general for different geographical populations and under various environmental conditions. Although, this study has provided the preliminary investigation about the emergence and mating of *Trabala vishnou gigantina* Yang, further detailed investigation is necessary to understand the effects of photoperiod, sex ratio, population density, space types, temperature and humidity range on emergence and mating.

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