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New Record of the Litchi Stink Bug, *Tessaratoma javanica* (Thunberg) Egg Parasitoids and their Natural Control Effect in Litchi Orchards from India

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With 6 figures and 1 table

Abstract: Litchi stink bug, LSB (*Tessaratoma javanica*) is a major insect pest of litchi in India and insecticidal control of this pest is non effective. Therefore, in present study, exploration of natural enemies of litchi stink bug and their effect on pest population was investigated for two years during 2012 and 2013. The LSB females were found to start laying eggs from February and peak activity was recorded in the month of March to April during both years. Three egg parasitoids of litchi stink bug were recorded, two were from the family Eupelmidae and one was from the family Encyrtidae of order Hymenoptera. Among parasitoids recorded, only two were identified up to species level namely *Anastatus bangalorensis* and *Anastatus acherontiae*. We are reporting these two parasitoids as new record from litchi stink bug (*T. javanica*). Maximum parasitized eggs were found in the month of March with 42.54% and 46.12%, respectively in insecticides free litchi orchard during 2012 and 2013 with major parasitization by *A. bangalorensis*. The egg parasitoids of litchi stink bug would be beneficial in the integrated management of the pest if mass reared and released in the litchi orchards.

Keywords: Anastatus bangalorensis, litchi, parasitoids, Anastatus acherontiae

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1. Introduction

Tessaratoma species complex is a serious problem of litchi and longan production in Australia, China, Vietnam, Thailand, Malaysia, Myanmar, Philippines and India (Butani 1977, Han et al. 1999, Menzel 2002, Lu et al. 2006, Schulte et al. 2006, Li et al. 2014). It is commonly known as litchi stink bug (LSB) which belongs to the family Tessaratomidae of insect's order Hemiptera. It comprises mainly three pest species *Tessaratoma javanica* (Thunberg), *Tessaratoma papillosa* Drury and *Tessaratoma quardata* Distant. Although, these species are present in different countries of Asia-Pacific region, the economic damage is species specific in different countries of the region. *T. javanica* is a serious problem in India, whereas *T. papillosa* is in China and South East Asia on litchi (Choudhary et al. 2013, Li et al. 2014). LSB is relatively a large bug, characterized by proportionately a small head, short labium and large sternal plate between middle and hind coxae. It is also a most common and significant pest in terms of pesticide usage in China (Li et al. 2014). In China, it has been estimated that *T. papillosa* may account 20–30% of litchi losses in normal years, and 70–90% of losses in the worst years (Gu et al. 2000, He et al. 2001, Li et al. 2014). The nymphs and adults of bug suck the sap of tender shoots, flowers and young fruits by stinging them with its mouthparts causing flowers and fruits to fall, the necrosis of young twigs and the blackening of fruit exocarp (Falkenstein 1925, Xie et al. 2004, Lu et al. 2006, Choudhary et al. 2013). They also feed on terminals of the plant shoot, leading to drying of shoot tips (Zhang & Quantick 1997). In India, LSB has not been considered as a serious pest of litchi before report by Choudhary et al. (2013).

Current control strategies of LSB involve spraying of chemical insecticide according to a pre-determined calendar, with little monitoring in China (Li et al. 2014). Presently, organophosphate (trichlorphon and chlorpyriphos) and pyrethroids (cypermethrin) are being used alone and in combination for the control of LSB in China and South East Asia (Li et al. 2014, Chen et al. 2009). Recent outbreak of LSB in East region of India (major litchi growing region) attracts the attention of researchers to find out safe ways to keep population below damaging level (Choudhary et al. 2013). In literature, parasitoids are the important natural mortality factor at egg stage of the LSB (Liu et al. 2000). The parasitoids recorded so far from LSB eggs are *Ooencyrtus phongi* Trjapitzin et al., *Anastatus amarus* (Subba Rao), *Anastatus japonicus* Ashmed, *Anastatus ramakrishnai* (Mani) and *Anastatus colemani* (Crawford) (Pu 1962, Nanta 1988, Leksawasdi & Kumchu 1991, Han et al. 1999, Liu et al. 2000). Among these, only *A. japonicus* has been utilized as biological control for *T. papillosa* in China, Hong Kong and Thailand, resulted in effective management of the pest (Nanta 1988, Leksawasdi & Kumchu 1991, Han et al. 1999). In Thailand, Nanta (1988) recorded 47.78% and 59.41% parasitized eggs of *T. papillosa* by *A. japonicus* and *O. phongi*, respectively. Use of chemical insecticides have recorded significant negative impact on emergence of *A. japonicus* and *O. phongi* from eggs of *T. papillosa* in chemically controlled orchards as compared to use of integrated pest management practices in China (Liu et al. 2000). Whereas, integrated pest management (IPM) strategy for *T. papillosa* in China and South East Asia involves reducing the overwintering adult population as much as possible before commencement of egg laying and after through

manual removal of adults, use of chemical insecticide spray in spring, injection of Azadirachtin to plant and successive releases of egg parasitoid *A. japonicas* (Li et al. 2014).

With recent outbreak of LSB, *T. javanica* in Jharkhand (India), the present investigation was carried out: 1) to explore the effective natural enemies which can be used as management options; and (2) effect of insecticide spray on the natural parasitization.

2. Materials and Methods

2.1. Exploration of natural enemies

The different stages of *T. javanica* were collected from litchi orchards in Jharkhand region of India during 2012–2013 and kept under the laboratory conditions at ICAR RCER, Research Centre, Ranchi. A total of 1,400 field collected eggs of LSB were kept in a batch of 56 eggs/ Petri plate (diameter 90 mm) for the emergence of egg parasitoids. Whereas, field collected all five different stages of nymphs (n = 1,000) of litchi stink bugs were also kept in the batch of 10 nymphs/ Petri plate. Eggs and nymphs were observed daily for emergence of any natural enemies. The identification of insect parasitoids was carried out with the description given by Narendran (2009).

2.2. Seasonal distribution of *T. javanica* eggs

Data on number of egg batches present in orchard were recorded from insecticides free orchard during year 2012 and 2013. Number of egg batches was counted on randomly selected twig from each direction of plant. Data were recorded from five randomly selected plants in each row which replicated five times on weekly basis.

2.3. Effect of insecticides spray on abundance and parasitism of LSB's parasitoids

Two homogenous litchi orchards with a distance of 10 km were selected from research farms of National Repository of Subtropical Fruits at ICAR, RCER, Research Centre, Ranchi, Jharkhand, India (23° 45' N latitude, 85° 30' E longitude, elevation 620 m AMSL). The age of both the orchards was 26–28 years old and planted at 10 m × 10 m plant to plant and row to row distance in randomized block design. From the selected orchards, one was free from application of pesticides and other one with regular applications of pesticides as recommended to control of litchi pest and followed by farmers (Table 1) (Singh et al. 2012). There was no record of inoculative or inundative release of any bio-control agent in both the orchards.

The freshly laid egg masses were marked by plastic tags on branches of litchi tree. The marked egg masses were left in field for natural parasitization up to 10 days and

Table 1. List of pesticide used for control of litchi pests.

Month	Stage of crop	Spray of pesticides	Rate (Per liter of water)	Targets pests
September	Second vegetative flush	Propargite	2 ml	Erinose mite
October	Before third vegetative flush	Hexythiazox	1.5 ml	Erinose mite
November	Third vegetative flush	Dichlorvos	1.5 ml	Semi-loopers (leaf feeders)
December	Before flower bud initiation	Dicofol	2.0 ml	Erinose mite
Jan – Feb		No spray	–	
March	After fruit set	Cypermethrin	1.0 ml	Litchi fruit borers
April	Fruit growing stage	Indoxacarb	0.5 gm	Litchi fruit borers
May	Fruit maturity stage	Halt	1.0 gm	Litchi fruit borers
Jun – Jul		No spray		
August	First vegetative flush	Carbaryl	1.5 gm	Litchi leaf roller

then collected before hatching. Same procedure was followed for both the orchards from February to June during years 2012 and 2013. The collected eggs were kept individually in a glass vial of 15 mm diameter in growth chamber at temperature 25 ± 2 °C, relative humidity 60 ± 5% and 12:12 h (photophase : scotophase) photoperiod until the parasitoids or LSB nymphs emerged. The unhatched or those not produced parasitoids were counted under the head of unhatched eggs.

2.4. Data analysis

The effect of insecticides applications on LSB egg parasitoids was calculated by following formula:

Per cent increase of egg parasitoids in insecticide free orchard $= \frac{(P_n - P_c)}{P_n} = \times 100$,

whereas:

P_n = per cent egg parasitism in insecticide free orchard in a given standard meteorological week and

P_c = per cent egg parasitism in insecticide applied orchard in a given standard meteorological week.

3. Results

3.1. Natural enemies recorded from *T. javanica*

Three parasitoids were recorded from eggs of *T. javanica* in this study. Among these, two were from the insect's family Eupelmidae and one was from Encyrtidae of order Hymenoptera. Eupelmid parasitoids were identified on the basis of description given by Narendran (2009) as *Anastatus bangalorensis* Mani & Kurian (1953) (Fig. 1) and *Anastatus acherontiae* Naraynan et al. (1960) (Fig. 2). *A. bangalorensis* and *A. acherontiae* are new record from *T. javanica*. Recorded encyrtid was identified under genus *Ooencyrtus* but species yet to be confirmed.

Fig. 1. Adult female of *Anastatus bangalorensis* Mani & Kurian (1953).

Fig. 2. Adult female of *An astatus acherontiae* Naraynan et al. (1960).

3.2 Seasonal distribution of *T. javanica* egg on litchi

T. javanica females were found to began laying eggs on flower panicles and under surface of leaves in early and mid of February during 2012 and 2013, respectively in this region of India (Fig. 3). The maximum eggs were found in the month of March to mid April in both the years and then decreasing trends were observed for freshly laid eggs. Fresh laid egg batches were found up to last week of June but few in numbers.

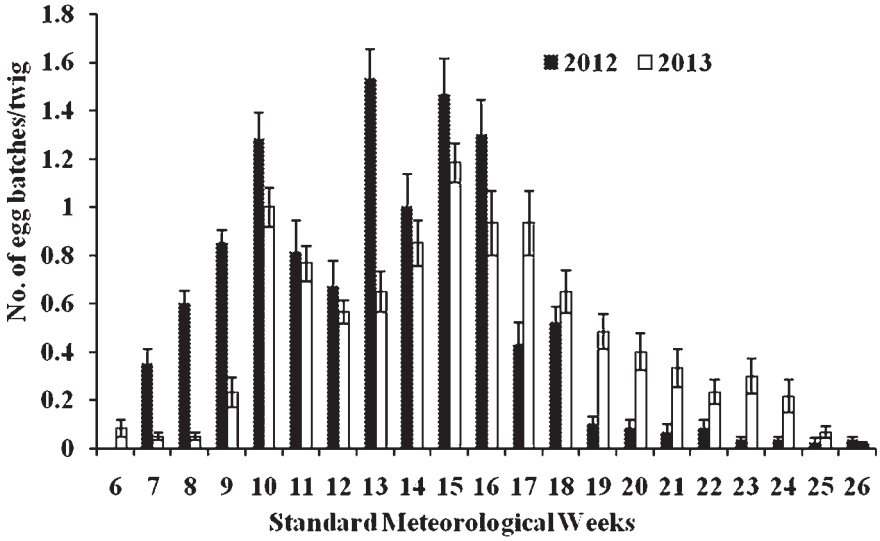

Fig. 3. Seasonal availability of number of egg batches of *T. javanica* per twig on litchi plants (2012 and 2013).

3.3. Impact of insecticides on abundance and parasitism of LSB's parasitoids

A similar pattern of egg parasitism and hatchability of LSB egg masses was observed from both the orchards during 2012 and 2013 (Fig. 4). Three species of parasitoids were observed from eggs of *T. javanica* collected from unsprayed as well as insecticide sprayed orchard. Eclosion of nymphs and emergence of parasitoids was started from third week of February in both the studied years. Parasitisation of *T. javanica* eggs by *A. acherontiae* was similar in trend as *A. bengalorensis* but low in incidence. Maximum parasitized eggs were found in insecticides free orchard during March, 2012 and 2013 with 42.54% and 46.12%. The maximum parasitization in eggs of *T. javanica* was observed by *A. bengalorensis*. The emergence time of *Ooencyrtus* spp. was very late in comparison to *A. bengalorensis* and *A. acherontiae*. The rate of parasitization by *Ooencyrtus* spp. was about 30% in the *T. javanica* eggs laid in the month of June during both the years. Data on hatching per cent revealed that egg parasitoids have real influence on reduction to the hatch percentage of *T. javanica* eggs in both the years in insecticide free orchard.

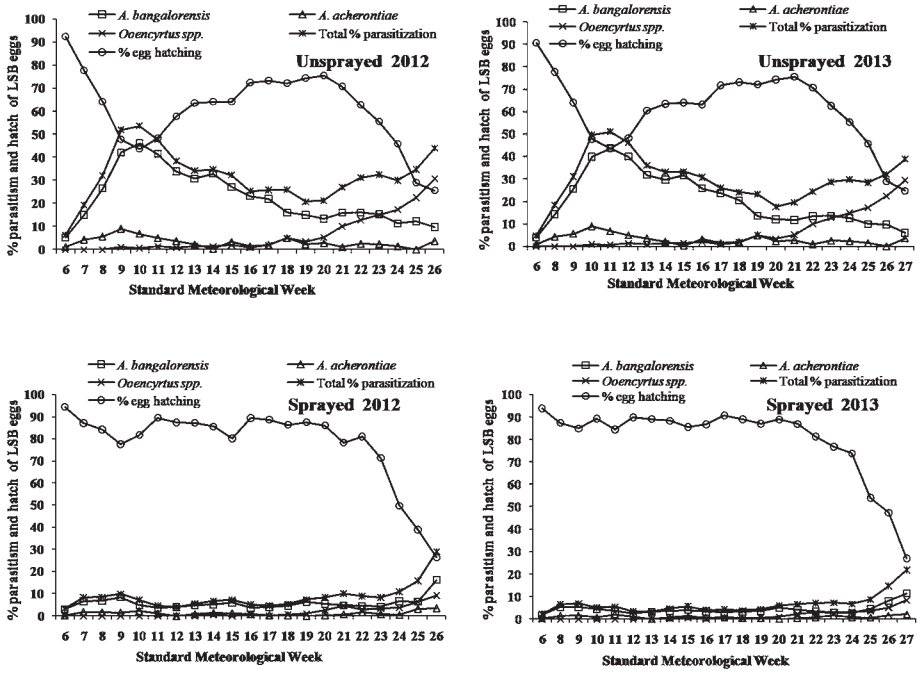

Fig. 4. Egg parasitism and hatch percentage of *T. javanica* eggs in insecticides sprayed and unsprayed litchi orchard during 2012 and 2013.

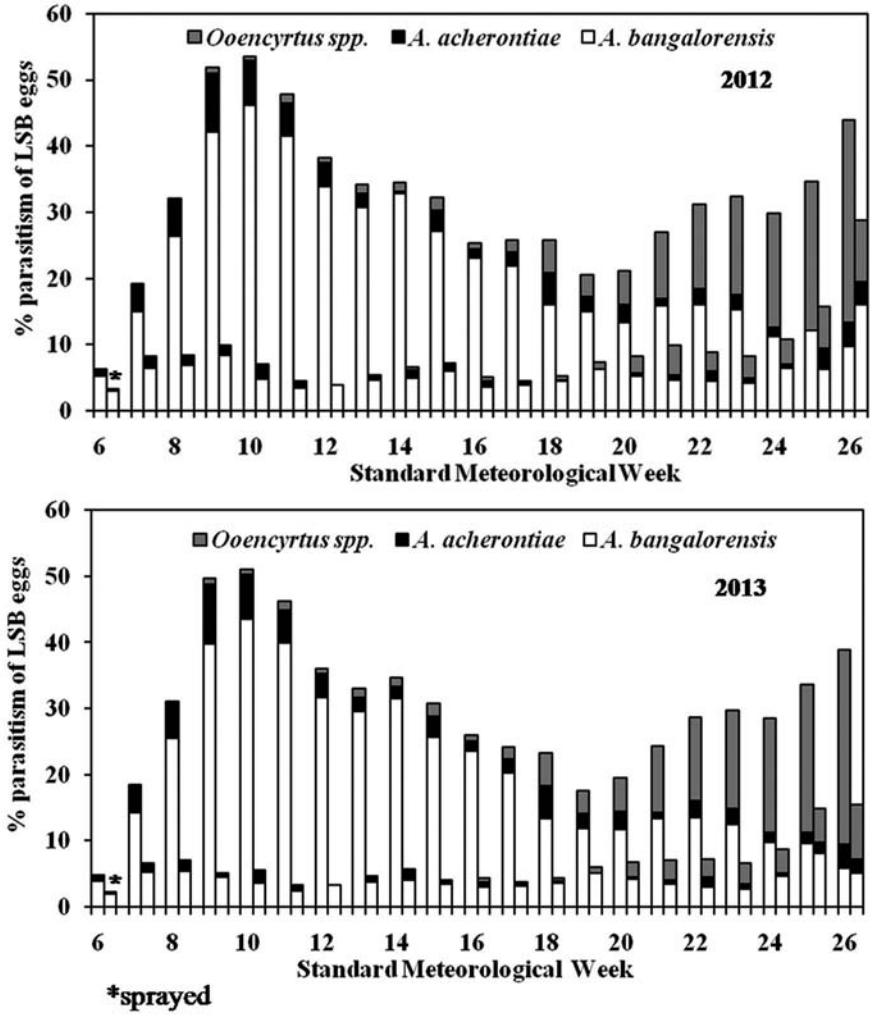

Fig. 5. Percent egg parasitism rate of *T. javanica* by different parasitoid in sprayed and unsprayed litchi orchard during 2012 and 2013.

In insecticides treated orchards, insecticides/acaricides sprayed as followed by the farmers in which first spray commenced with first marking of egg batches in the orchard. The results showed that rate of egg parasitism by all the parasitoids decreased enormously in insecticide treated litchi orchards (Fig. 5). Hence parasitism to eggs could not able to reduce the hatch per cent of LSB eggs in the insecticide applied orchard. Data revealed that negative effect of insecticidal spray on parasitoids were during month of March and April when maximum egg batches observed in the orchards. The experimental data also showed that *A. banglorensis* and *A. acherontiae* were found to parasitize *T. javanica* eggs in early season but at the time of maximum

laid eggs in the season by *T. javanica*. However, low parasitism was recorded by all three parasitoids in the insecticide applied litchi orchard during both the years (Fig. 5). Insecticidal sprays applied to litchi for the management of insect pest except LSB reduced parasitization to LSB eggs by different parasitoids recorded in this study. However, insecticidal application did not affects hatching of LSB eggs under field conditions. Yield data revealed increase in litchi yield per tree in insecticidal sprayed litchi orchard as compared to unsprayed litchi orchard (Fig. 6). It may be due to the reduction of other pest population which also affects the litchi fruit production.

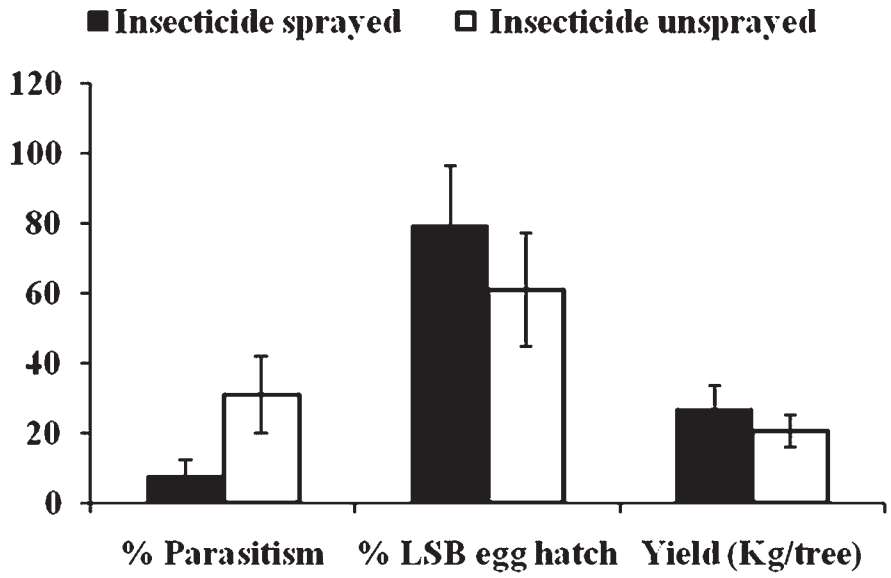

Fig. 6. Overall impact of insecticides spray on parasitism and egg hatch of LSB and yield of litchi orchard.

4. Discussion

Presently, *T. javanica* is not a major pest of litchi in India but the recent outbreak observed in the Jharkhand state (Choudhary et al. 2013), this pest would enormously affect the litchi cultivation in India (2nd largest producer of litchi in the world) warrants to develop integrated pest management modules for the sustainable litchi production in the country. Presently, it seems very difficult to manage this insect by chemical insecticides as the litchi (cross pollinated crop) needs insect pollinators mostly honey bees for pollination which takes place during last week of February to 2nd week of March. The population of *T. javanica* increases with the emergence of inflorescence.

Therefore, any insecticidal application for the management of the pest will affects the population of insect pollinator in the field.

A. bangalorensis and *A. acherontiae* are the new records from *T. javanica* eggs as natural enemies (egg parasitoids). Earlier *A. bangalorensis* was recorded from the eggs of *Halymorpha marmoreal* F. (Heteroptera: Pentatomidae), whereas *A. acherontiae* was reported from *Acherontia styx* (Westwood) (Lepidoptera: Sphingidae) (Mani & Kurian 1953, Narayanan et al. 1960, Narendran 2009). Earlier in India, *Anastatus colemani* and *Ooencyrtus phongi* were recorded from *T. javanica* which causes up to 52.90% and 55.70% egg parasitization, respectively (Gautam et al. 2004). Whereas, *A. japonicus* and *O. phongi* were recorded from the eggs of *T. papillosa* (another species of litchi stink bug) in China and the rate of eggs parasitization was 18.40% and 30.40%, respectively (Liu et al. 2000). In the present study, *A. japonicas* and *A. colemani* were not recorded from the eggs of *T. javanica*, it may be due to the species difference of the litchi stink bug. The rate of egg parasitism and emergence of parasitoids was found highly exaggerated by insecticide applications. In chemical insecticides treated litchi orchards, rate of *T. javanica* egg parasitism was much lower than the untreated litchi orchard. It indicates that repeated application of insecticides in litchi orchards has immense negative effect on egg parasitoids populations. Whereas, yield of litchi orchard sprayed with insecticides were more in comparison to unsprayed litchi orchard. This suggests that different biotic stress is also affecting the yield of litchi along with LSB. It is observed that timing of maximum egg lying by LSB and rate of parasitism have not synchronized to reduce the population below economic threshold level.

The classical biological control of *T. papillosa* utilizing *A. japonicus* and *O. phongi* has resulted in effective management in China, Hong Kong and Thailand (Nanta 1988, Leksawasdi & Kumchu 1991, Han et al. 1999). But we found that lack of proper mass rearing techniques and spray modules to avoid direct contact between insecticides and parasitoids. So, the new record of *A. bangalorensis* and *A. acherontiae* as egg parasitoids of *T. javanica*, needs studies on mass rearing protocol and synchronized field release techniques of parasitoids so that effective integrated management strategies could be designed in near future for effective management of *T. javanica* along with other biotic stress.

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