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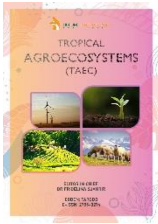

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REVIEW ARTICLE

A REVIEW ON BIOLOGY, AND INTEGRATED MANAGEMENT PRACTICES OF LITCHI STINK BUG (*TESSARATOMA PAPILLOSA* DRURY HEMIPTERA: TESSARATOMIDAE)

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ABSTRACT

Litchi stink bug is a major pest of litchi (*Litchi chinensis* Sonn) and native to tropical Asia which reduces the yield by 20-90% based on infestation. As litchi is one of the major sub-tropical fruit crops of Nepal, this pest has become a major challenging in attainment of the potential yield of litchi. The management of this pest on a long run in a sustainable way requires a clear understanding on identification as well as morphological characters, biology and life history of the pest. In this regard, this article attempts to review the works done till date on the taxonomy, biology, and management of the pest.

KEYWORDS

Intergrated Pest Management, Litchi, Pest, Yield

1. Introduction

Among biotic stresses, insect pests are the major limiting factors for healthy and profitable litchi production (Srivastava et al., 2020). Litchi Stink Bug (or Logan Stink Bug) *Tessaratoma papillosa* Drury (Hemiptera: Tessaratomidae) is one of the most widespread and destructive pest species of *Litchi chinensis* Sonn in tropical Asia and majorly occurs in Southern China, Vietnam, Thailand, Myanmar, the Phillippines, Nepal and India (Schulte et al., 2006; Menzel, 2002; Papademetriou and Dent, 2002). The stink bug *T. papillosa* belongs to the Pentatomidae family that can release their foul-smelling fluids in response to disturbance or aggression (Wu et al., 2017). It is reported to be widespread in Guangdong and Guangxi in China (CABI, 2020). Choudhary et.al in 2012 reported an outbreak of Litchi Stink Bug (*T.javanica*) in Jharkhand India during February 2011 in which females were reported to have high fecundity and caused severe damage (>80%) to the litchi crop.

Liu, 1965, reported that *T.papillosa* fed on 21 species of plants but primarily on *Litchi chinensis* and *Dimocarpus longan.* Other hosts include Citrus, Banana, Olive, Plum, Prune, Peach and European Pear, Pomegranate (Australian Government , 2004; Waite, 2005). Both nymphs and adults suck the sap of young leaves and young twigs which may wilt and die as a result, as well as feeding on new buds, flowers and developing fruits (Li et al., 2014). It prefers feeding on younger softer tissues bearing flowers rather than older branches due to the presence of higher water, nitrogen and soluble sugars in younger flowering branches than in older ones and also the pest encounters less physical resistance on feeding softer flowering branches as reported by (Liu and Gu, 2000). *T. papillosa* normally reduces fruit yield by 20-30% and may reduce it by 80-90% if the infestation is heavy (CABI, 2020).

2. Morphology and Identification

The group tessaratomidae was first recognized as a higher taxon by Stal. (1864-1865). According to Rolston et.al, 1993 the group consists of three subfamilies comprising 49 genera and 235 species (Schuh and Slater, 1995). The key identifying feature is post-margin of pronotum is strongly protrudented backward and covered basal meso-scutellum, head and basal pro-thorax extended downward, lateral margin of pronotum prominent but smooth (Ho and Youngfa, 2010). The general outline of the body in pentatomoids is often elongated and much longer than wide. Adults are yellow brown and shield like in shape. Females are 24-28mm long and 15-17mm wide and are larger than the males.

Head is dorso-ventrally flattened and laterally carinate in most of the pentatomoids. Mandibular plates are well developed reaching or surpassing the clypeus. There is the absence of post-ocular tubercles and the absence of the neck. The antinifeous tubercles are placed laterally on the head and completely visible in the dorsal view. Tubercles are ventral on the head and partially obscured by the by the mandibular plates. Compound eyes are divided in the sagittal plane with distinct dorsal and ventral surface, as a result of the lateral expansion of the head and the pronotum, the corium at the base and the abdomen. The lenses of ocelli are present in most of the pentatomoids. Antenna is four segmented and apparently five segmented antenna is a result of fragmentation of the pedicel at the final moult is found in majority of pentatomoids. The pronotum with humeral and posterior angles developed is found. Three segmented tarsi are widespread in pentatomoids. A group of modified setae found on the inner surface of fore-tibia is a unique feature of higher pentatomoids. Claws are flattened with large bases tapering from base to apex (Grazia et al., 2008). The detailed structure is shown in the figure 1.

3. Distribution and Ecology

3.1 Biology and life cycle

Tessaratoma papillosa has one generation per year and overwinters as adults. The overwintering adults in spring do not mate immediately as their reproductive organs are not matured. Female mate multiple times and lay up to 14 egg masses, each mass containing 14 eggs on the lower surface of leaves (Tran et al., 2019). The life cycle of *Tessaratoma papillosa* consists of 3 stages: eggs, nymphs and adults. After egg -laying, the female

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remains motionless for several weeks. The eggs will hatch in about 10 days. Just before hatching, the eggs become pink or purplish. Just at emergence, the nymphs have middle of the upper side light green and the rest including legs and antennae are light pink. Nymphs are smaller in size but shape and color is just like the adults. Nymphs molt as many as five times to reach adulthood as shown in figure-2 (Persaud, 2022). Each process of the molting stage is called an instar. Adults develop from last instar nymphs and finally wings are developed in adults. Nymphs are wingless. There is a great increase in size from first to the final molt but no change in shape and color.

The five nymphal stages last for approx. 11, 7, 8, 13 and 26 days respectively where progressive growth is during 2nd-3rd nymphal stages, which are critical stages for growth and development (Sharma et al., 2015). In four stages of the nymphs, the head and thorax are practically in the same plane with the abdomen whilst the whole insect is very flat and thin in section. At the last molting, the head and the thorax bend downward. The just emerged adult is unable to use its stink glands for 2 days (soft stage) though gradually becoming harder later. The life cycle completes in 140-145 days (Sharma et al., 2015). The life cycle of many stink bugs is dependent on host plant phenology (Shoeman, 2014). It over-winters as adult and hibernating individuals are found aside from *Litchi chinensis*, Euphorbia longan, Cinnamomum, etc. The hibernating adults begin to oviposite in the upper half of March, with peak at end of March and to middle of May. Since then, the eggs gradually decrease in number and brought to a conclusion at the end of August.

3.2 Nature of feeding and damage symptoms

Both nymphs and adults suck the sap of young leaves and young twigs which may wilt and die as a result, as well as feeding on new buds, flowers and developing fruits (Li et al., 2014). It prefers feeding on younger softer tissues bearing flowers rather than older branches due to the presence of higher water, nitrogen and soluble sugars in younger flowering branches than in older ones and also the pest encounters less physical resistance on feeding softer flowering branches as reported (Liu and Gu, 2000). However, they feed on all types of branches: flowering, tender and tough branches of host plant litchi (Yufang and Dexiang, 2000). Their feeding behavior in pre-overwintering and reproductive is very different. 50 to 70% and 100 % of adults were found feeding on all three types of branches in their pre-overwintering and reproductive stages respectively (Banjade et al., 2023). The pre-feeding period of the stink bugs on flowering and tender branches is much shorter than the tough ones.

The mouth part is piercing and sucking type. The labium is elongated and acts as a sheath. This encloses the mandibles and maxillae which are modified as stylet for piercing. The maxillae have two tubes running along their length. Salivary fluid is pumped down the salivary duct and liquefied food is pumped up the food canal. The tips of the stylet have minor teeth for Piering the plant tissue. The saliva contains enzymes or toxins that can distort plant cells to permit the stylets to penetrate down and reach phloem for sucking the sap (Kumar, 2018).

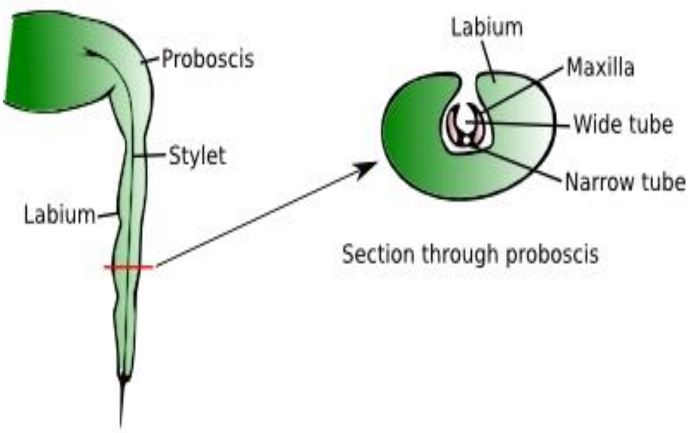

Figure 1: Mouth parts of a true bug (source: Amateur Entomologists' Society)

Attacked shoots will wither or in extreme cases may die. The damage on fruits from the punctures is hard brownish and black spots. These punctures affect the fruits' edible quality and decrease its market value. Young fruit growth is retarded and the fruit often withers and drops. Inflorescence will fall or shed and necrosis of stems due to feeding of the bug (CABI, 2020).

Figure 2: Damage of *T. papillosa* in litchi (Source: ICAR, India)

3.3 Economic threshold level for T. papillosa

Economic threshold level for the control of *T.Papillosa* depends upon various factors such as location, genotype of the host plant, crop stage and other environmental conditions. A group researcher computed the correlation between the density of nymph of *T.Papillosa* Drury and the fruit drop rate of Euphoria longan and reported the economic threshold for its control during young fruit period which were 1.6 and 1.2 heads for panicle respectively for 2nd nymphal instar for young plants and adult plants, correspondently 33% and 26% of the panicles were found to have the bug in young and adult plants (Xu et al., 2006).

3.4 Integrated management practices

3.4.1 Mechanical methods

This pest is reported to be combated by shaking the trees in winter and collecting and dropping them in kerosene. Since the adult female bugs lays egg in egg masses, the eggs are visible, so the eggs can be removed and destroyed manually. Also, insect infested plants parts should be destroyed. Handpicking and destroying of older larvae during early stages of the crop also helps to minimize its infestation. Catching the adults in the cold months (Jan-Feb) since during the winter rest period of the bugs, they are very weak and do not move (Kiem, 1995).

3.4.2 Cultural control

It includes strengthening the management of fertilizer, to increase plant resistance to diseases and pests. Fallen fruits should be removed timely and shoots controlling, and pruning should be appropriate (Dahal et al., 2024). Garden should be cleaned in winter and infested shoots should be cut off to reduced pest source after fruit harvest (Plant Protection Research Institute).

3.4.3 Physical control

Installation of electric moth-trapping light on every 10-15 acres to kill the stinkbug, scarabs, suck fruits leaves moth and other pests, and other artificial hunting for longicorn has been reported (Plant Protection Research Institute).

3.4.4 Biological methods

Biological control is one of the most widely adopted environmentally friendly techniques for the management of pests (Ren and Chen, 2012). Various field research has identified many natural enemies of *T. papillosa* which are *Tenodera sinensis*, *Hierodula patellifera, Gampsocleis spp.,* spiders, south China tree toad, and various birds (Meng et al., 2017). Use of solitary egg endo-parasitoids *Anastatus japonicas (*Hymenoptera: Eulophidae) and *Ooencyrtus corbetti (Hymenoptera: Encyrtidae)* are successful classical biological controls in China since late 1960s (Song-li et al., 2014). The adult longevity, long oviposition period, short life cycle, high fecundity, easy access, mass rearing and resistance to adverse environmental conditions make *Anastatus spp.* ideal for biological control.

Since the occurrence of parasitoids *Anastaus* species was not synchronous with the seasonal occurrence of the litchi stink bug, augmentation of the population of the parasitoids was studied and released. The release of parasitoids on February and March resulted in the suppression of the pest population and 100% parasitism of host eggs by the end of March (Nanta, 1988). Similarly, a group researchers reported that the parasitism of *A.*

japonicus could reduce the population of *T. papillosa* in next generation by 91.6% (Ji-Dong et al., 2004; Ji-Dong et al., 2008). Releasing *Anastatus* at the appropriate period gave 90% control of *T.papillosa* which was 1.25 folds higher than when spraying with insecticide 3 times (insecticide Trichlorfon and Resmethrin sprayed at 1:800 dilutions) (Chen et al., 1990).

The praying mantis (*Hierodula patellifera)* co-exists in the orchard with *T. papillosa*. In the assessment of the predatory nature of *H.patellifera*, it was found that its consumption rates increased with the increase in pest density offered but there was a decline in its search efficiency (Wang et al., 2020). This concludes that praying mantis (*H.patellifera)* can be an effective bio-control agent for the control of *T. papillosa.* Entomo-pathogenic fungus like *Paecilomyces lilacinus*, *Beauveria bassiana, Metarhyzium anisopliae* are found to control *T.papillosa* particularly during the wet seasons. These fungi enter the insect's body through cuticle and can also produce toxins to aid invasion thereby infecting different developmental stages of the pest. A strain of *M.anisopliae* was found to be highly pathogenic on *T.papillosa* when used at a concentration of 1.0*10^7 conidia/ml with good insecticidal activity in the field as reported (Jia, 2005). A group researcher also obtained similar results with *M.anisopliae, B. bassiana and P. lilacinus* (Fan et al., 2007). The advantages of entomo-pathogenic fungus are broad spectrum of diffusion effects, less chance of pest developing a resistance, ease of production and greater specificity against target species.

Nematode *Mermis sp.* was found to parasitize *T.papillosa,* the ratio of parasitism reaching 60-70% as reported by the workers of Plant Protection in China and abroad. The systematic investigation and study of *Mermis spp.* have been made for 10 years and is expected to be used in the agricultural production (Lijun, 1999). Researches in China in botanical insecticides have been concentrated in species including *Azadirachta indica, Melia spp., Trypterygium spp.* and *Tephrosia bhogelii* which contain insect growth regulating properties which are active against *Tessaratoma papillosa* (Cheu, 1989). Due to problems of rapidly increasing costs of modern synthetic organic insecticides, pest resurgence and detrimental effects on non-target organisms and environmental quality, all researchers dictate the need for effective, economical and safe insecticide.

Application of neem seed oil to the prothorax of the nymphs of the litchi stink bug showed that the oil is a strong ecdysis and growth inhibitor where treated nymphs reduced growth, darkened wrinkled cuticle, microscopic examination of the cuticle showed malformed structure and death occurred during succeeding instars (Cheu, 1989). Dr. H. Schmutterer found that spraying of the neem seed extract 0.3% (w/v) was effective for 21 days under field conditions. The mortality rate of *T.papillosa* was higher in the *Azadirachtin* injected trunk as compared to check treatments and its content in ripe fruit was also reported to be less and this suggests that *Azadirachtin* injection method may also be employed as a bio-control method for the control of *T.papillosa* (Shulte et al., 2006). In an experiment conducted by Mo Shengqiong, Lao Heng, Li Zhishan, they reported that the plant source fruit insecticide comprising of 20-30 parts of bulbs of garlic, 20-30 parts of pyrethrums, 20-30 parts of red-knees herb, 5-10 parts of soap nuts, 10-15 parts of rotenone and 2-5 parts of levo alphla-terpilenol by weight when diluted by 300-500 times prior to spray *T.papillosa* could be effectively prevented.

3.4.5 Chemical method

The timing of spray is of utmost important because the bugs vary in their susceptibility to insecticides at different times of the year depending on their body fat content and its nature (Srivastava et al., 2009). These bugs may be controlled with any systemic insecticide. A spray of 1:800 Dipterex (Trichlorfon) after harvest gave promising control of newly emerged adults and nymphs (Liu, 1965). It was earlier reported that Dipterex was found to be one of the most effective compound for the control of *T.papillosa* when applied at concentration of 0.067% was able to kill adults and young nymphs when applied in the middle of march and at the beginning of May (Shih-foon et al., 1964).

In an experiment conducted, showed that *T.papillosa* was insensitive to Trichlorfon (due to resistance) and Delta-methrin and Beta-cypermethrin both had better control effect but they were not the optimal choices due to risk of residue and pollution (Yao-Chang, 2005; Khanal et al., 2024). Instead *B.bassiana* was preferred over them due no risk of pollution and residue, although it worked a little slowly, the effect was more than 90%. Similarly, for finding alternatives to long used trichlorfon, a mixture of chloropyrifos and cypermethrin (10:1) was found to be highly effective against the overwintered adults even at low concentration (138 ppm) causing 100% mortality rate within 7 days compared to 1125ppm trichlorfon and similar results was obtained in early instar nymphs (Zeng et al., 2001).

In a study conducted in Bihar, India in 2015 to assess the dose mortality response of 17 insecticides for the management of litchi stink bug, it was found that Dichlorovous 76EC showed maximum mortality (100%), followed by 86.67% mortality to 1st instar nymphs by Acephate 75SP, Quinalphos 25EC and thidocarb 75WP within 24 hours at field doses and chlorantraniliprole was found to be most toxic based on LD_{50} value and concluded that field mortality of younger stages nymphs of litchi stink bug could be enhanced by increasing concentration of Chlorantraniliprole, Thiacloprid, Thiodocarb and Spinosad (Choudhary et al., 2015). Similarly, spraying of Chlorophos 50EC @ 0.2% before flowering and after fruit set to kill the larvae was also reported (Kiem, 1995). In laboratory and field experiments carried out in China, it was found that when normal females mated with males that had been dipped in aqueous solution containing 0.6% of Thiotepa in mid-February resulted in 99.5% of the eggs un-hatched (Lin and Chiu, 1983).

4. Conclusion

The *Tessaratoma papillosa* Drury, often known as the Litchi Stink Bug, poses a considerable danger to the productivity and market value of litchi and other fruit crops in Asia. The biology of this pest displays a complicated life cycle with several nymphal instars and adult stages, all of which feed on sap and cause serious harm to host plants. The insect is especially difficult for producers to control because of its adaptability to a variety of climatic conditions and resistance. Integrated pest management (IPM) techniques provide a long-term approach to controlling *T. papillosa* populations by integrating mechanical, chemical, biological, and cultural control strategies. It is possible to minimize breeding sites by cultural measures like canopy management and sanitation, and to avoid harm through mechanical restrictions like bagging fruit clusters. Biological controls show potential as environmentally benign substitutes, especially when using natural predators and parasitoids such as *Anastatus japonicus*.

In cases of severe infestations, chemical controls are still an essential tool, but their usage must be carefully considered to prevent resistance building and environmental harm. An integrated strategy that incorporates various techniques and is customized to certain local conditions is crucial for long-term management. It will be essential to carry out further study on host-pest interactions, pest biology, and creative management techniques in order to lessen *Tessaratoma papillosa's* detrimental effects on the production of litchis. The sustainability and efficacy of management initiatives will be further improved by increasing the possibilities for biological control, enhancing farmer education on IPM approaches, and strengthening monitoring methods.

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