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Effect of certain insecticides on egg batch of *Sycanus collaris* (Insecta: Hemiptera: Reduviidae)

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Abstract
The impact of agrochemicals on the reduviid bug egg batch is covered for the first opportunity in this study. One of the prevalent predators in the agroecosystem is *Sycanus collaris*. Post development of hatching rate and survival of *Sycanus collaris* egg batch were studied for six commonly used insecticides in the tea agroecosystem namely Flubendiamide + Thiacloprid, Thiamethoxam + L-cyhalothrin, Bifenthrin, Pungamia Soap, Neem Soap and Emamectin benzoate. Maximum effect was observed in 2× recommended dosages of Bifenthrin and Thiamethoxam+ L- cyhalothrin treated egg batches followed by Emamectin benzoate and Flubendiamide + Thiacloprid and least effects were recorded in the neem soap and pungamia soap applied egg batches. This study paves an idea on the survivability of nymphs where the egg batch is exposed with the insecticide. This experiment reveals Bifenthrin has the lowest survival rate in all the dosages followed by the Thiamethoxam+ L- cyhalothrin and Flubendiamide + Thiacloprid in the double recommended dose of field recommendation. The study hence concluded that the application of pesticide will also have impact on the egg hatchability and fecundity of the natural enemies under the field condition.

Keywords: *Sycanus collaris*, naturual enemies, insecticides and ovicidal activities

Introduction
Tea is a monoculture perennial plantation crop in which its spread over a large cultivated area hence worth it creates its own micro climatic zone. Spiders made up 43% of the population in tea plantations, followed by Coleoptera (31%). Other predators made up 26% of the total, including Hemiptera (8%), Neuroptera (5%), Mantodea (7%), Odonata (4%), and others (2%) (Das *et al*. 2010) [17]. Reduviid bugs belongs to the family Reduviidae, is a large cosmopolitan family of the Suborder Heteroptera under the order Hemiptera. They are one of the highly successful predators, and plays a key role in the biological control of insect pests. The development of sustainable crop production has become more dependent on an in-depth grasp of the biological and environmental interactions occurring inside agriculture (Kathiresan, 2007) [11]. This approach strengthens the health of the soil, enhancing plant resistance to environmental challenges and permitting several insects in the fields to be naturally controlled. However, a variety of chemical fertilizers and pesticides, including fungicides, herbicides and insecticides as well as biological control agents and microorganisms that promote the plant growth are applied to crops in modern agriculture (Paredes and Lebeis, 2016) [13]. The south Indian tea habitat is primarily covered in extremely dense forest cover and it also has an abundance of assassin bugs belongs to the family Reduviidae. One of the such species is *Sycanus collaris*, also reported as the predator of tea mosquito bug. According to earlier research findings, tea mosquito bugs were formerly only during wet season. Currently tea mosquito bugs constitute the most destructive pest to the tea ecosystem and are observed all year round. Conventional management practices are followed for the management of the pest hence there is no judicious use of synthetic pesticide to bring the tea mosquito bug population below Economic Threshold Level (ETL). In addition to mortality caused these chemicals may also have sublethal effects on the biological-control agents' immature-stage development, fecundity, fertility, longevity, and sex ratio, as well as their behavioural parameters, which include feeding activity, mobility, orientation, and rate of predation (Desneux *et al*., 2007; Guedes *et al*., 2016) [15, 5]. They might also reduce the biocontrol benefits provided by these natural enemies (Biondi *et al*., 2015) [3]. In the tea ecosystem along with the pest population

natural enemies also co-existence. The reduviid act as biocontrol agents inhabited in forest ecosystem, semi-arid zones and agro ecosystems and they have a wide range of prey which is characterised as insect pests hence it can act as an integral part of integrated pest management. Bhat *et al*. (2013) [2] reported that the reduviids *Panthous bimaculatus, Sycanus collaris* and *Rihirbus trochantericus* were excellent predators of TMB nymphs and adults on cashew. Reduviid bug is a naturally existing predator of the tea mosquito bug (Barbora and Singh, 1994; Soma *et al*., 2010). The present study was carried out to study the impact of commonly used agrochemicals on the egg batches of reduviid bugs, *Sycanus collaris.*

Fig 1: *Sycanus collaris* egg batch

Fig 2: Reduviid nymphal mortality with impact of agrochemicals

Materials and Methods

Rearing of *Sycanus collaris* and collection of Egg batch

The *Sycanus collaris* adults are cultured and maintained in the predator factory of UPASI Tea Research Institute, Valparai (Coimbatore, Tamil Nadu, India). The temperature and relative humidity were maintained at 26±2 °C and 85±5%. The bugs were kept in plastic containers along with dried jack fruit leaves and provided rice moth larvae *C. cephalonica* as regular prey. *S. collaris* which lay egg batches on dried leaves were kept separately and the egg batches which were have almost similar count were chosen for the experiment.

Evaluation of insecticides against *S. collaris* egg batch

The agrochemicals which are regularly used in the tea ecosystem were selected for these experiments. A total of six agrochemicals were dissolved separately in water at their field recommended dose, half the field recommendation and along with the double the recommended dose was selected to obtain individual insecticide solutions. Each individual egg batches with five replication of *S. collaris* were selected from the stock culture having similar number of eggs. The egg batches were brought to the treatment immediately after the eggs laid by the adults. The egg batches were sprayed with individual solution prepared and immediately transferred to the containers which were covered with muslin cloth. The ratio of the number of larvae that hatched from the insecticide-treated eggs to the control eggs was used for determining the viability of the eggs. The freshly hatched larvae from each experiment were counted to ascertain the survival of the embryonic stage and then separately placed into the plastic containers to evaluate the survival rate. The comparison of larval survival were carried out between the second instar nymphs of the experimental and the control.

Results

To our knowledge, no reference has evaluated the effect of insecticides on the eggs of *S. collaris.* The present experiment was carried out to study the impact of the agrochemicals on the hatching of *S. collaris* egg batch. All insecticides except botanicals such as Pungam soap and Neem soap (ICAR-IIHR) reduced the larval hatching rate upto 25% while compared to the control in the double dosage of field recommendation. Among the field recommended dosage, the Bifenthrin, Emamectin benzoate and Thiamethoxam + L-cyhalothrin shows 50% reduction. While in the treatments with the egg batch sprayed with half the recommended dosages shows control, Pungam soap, Neem soap and Emamectin benzoate shows similar rates but Bifenthrin has mild impact on the egg hatching followed by Thiamethoxam + L- cyhalothrin and Flubendiamide + Thiacloprid (figure 1). Among insecticides with different concentration, Bifenthrin, Emamectin benzoate and Thiamethoxam + L- cyhalothrin caused higher reductions in the nymphal hatching rate compared to Flubendiamide + Thiacloprid, Pungam soap and Neem soap. However, no significant effect was observed on egg incubation, hence concluded that these compounds did not affect the embryonic development period.

Immediately after hatching the Bifenthrin exhibited knockdown effects at double the advised dosage and recommended dosage, with only extremely low survival rates being detected in half recommended (figure 2). Survival of 20.0, 60.0 and 80.0 were recorded in the Thiamethoxam + L-cyhalothrin sprayed egg batches on the 2 ×field recommended (FR), FR and 0.5 FR respectively. Flubendiamide + Thiacloprid shows 75% of nymphal survival compared to the control in the half recommended while 22% and 38% in the 2 ×FR and FR dosages respectively. However, Pungam soap and neem soap did not affect the nymph development. Based on survivability Bifenthrin were highly harmful to *S. collaris* nymph, while Thiamethoxam + L- cyhalothrin and Flubendiamide + Thiacloprid were slightly harmful.

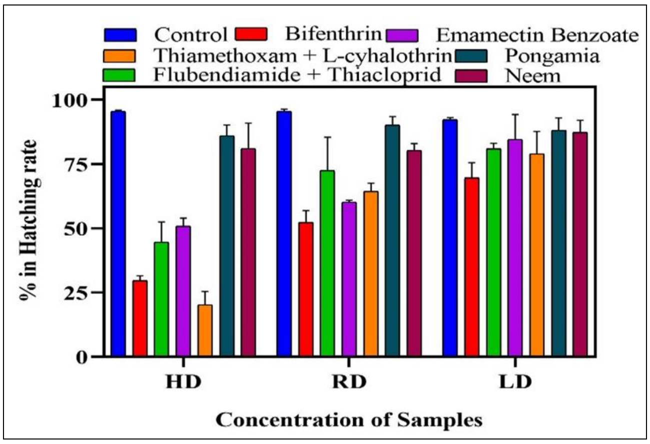

Fig 3: Bar diagram showing the hatchability of reduviid eggs when treated with agrochemicals.

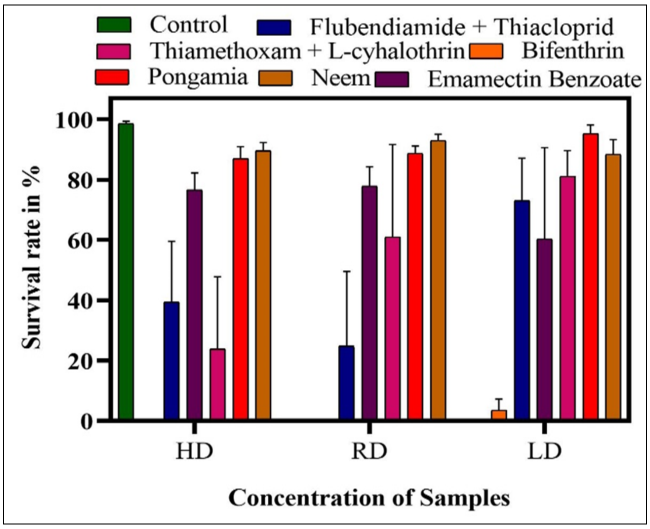

Fig 4: Bar diagram showing the Survival of reduviid nymphs when treated the eggs are with agrochemicals.

Discussion

In the present study we are addressing the research gap in the impact of the egg batches of the natural enemies when it is exposed to the regular pesticides applied to the agro ecosystem. The outcomes of this study suggest that *S. collaris* eggs exposed to the tested insecticides may inhibit the expansion of this species since in several cases they dropped the rate of eggs hatching and finally killed practically all emerging larvae. Our findings showed that the most harmful insecticides were Bifenthrin and Emamectin benzoate. According to Hassan *et al*. (2010), contact with residual deposits is a major exposure route for pesticides to predatory insects. Our results support this hypothesis by showing that while Bifenthrin did not exhibit a knockdown effect on the hatching of S. collaris eggs, it was still able to kill all of the emerging nymphs. Predatory beetle populations are decreased by several insecticides (Tran *et al*., 2016) [21]. Lacewings (*Chrysoperla carnea*) may have reduced fertility due to insecticidal residue (Garzón *et al*., 2015) [8]. Pyrethroids are one of the most common classes of pesticide used in agro ecosystems (Davies *et al*., 2012; Liao *et al*., 2018) [4, 12] and includes allethrin, bifenthrin, cyhalothrin, cypermethrin, permethrin and deltamethrin. Considering heteropterans, especially reduviids, may adapt to ecological conditions and the secondary effects of phytosanitary sprays, they have the potential to be effective biological control agents. Insecticides have distinct impacts on predators based on the species, treatment behaviour, and growth stage. Many insect species are harmed by insecticides, most notably Hemiptera, Coleoptera, and Hymenoptera. For instance, large doses of sulfoxaflor are toxic to helpful insects like wasps (Riaza *et al*., 2022) [16]. The study concluded by Rabeesh *et al*., 2024 [15] that synthetic pyrethroids sprayed in the tea ecosystem is having adverse effect on natural enemies. The previous studies on reduviid bug species such as *S. collaris*, *Rhynocoris marginatus*, *Rhynocoris kumarii* and *Sycanus dichotomus* shows they are having toxic impact while they were in contact with the pesticides (Sriraksha *et al*., 2021; Patel 2020; George and Ambrose 2004; Farehan *et al*., 2013) [20, 14, 6, 7]. The previous studies on reduviid species against the botanicals and bioformulation such as neem-based products and *M. anisopliae* were not having any impact (Sahayaraj *et al*., 2003; Ullah *et al*., 2019; Sahayaraj *et al*., 2018) [18, 22, 19]. The synthetic pesticides have severe impact on the survivability of nymphal stages of the predator.

Conclusion

The evidence presented above points out that insecticidal exposures have a direct effect on the nymphal development and hatching of beneficial insects like reduviids. Then, the possible effect of the insecticides on the egg batches and nymphal development of beneficial insects. IPM initiatives that support the reduction of pesticide use that threatens agriculture and predators ought to be promoted as an environmentally responsible strategy for a successful decrease in pesticide use. Farmers ought to be incentivized to employ Integrated Pest Management (IPM) as a pest management approach to save the biodiversity of beneficial insects and fortify the agro-ecosystem functions, so ensuring a secure global food supply in the future.

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