The Population Structure and Presence of Helopeltis bradyi on the Tea Plant Parts at Various Times During the Day

F X Wagiman1*, N M Sari2, A Wijonarko1
1 Department of Plant Protection, Faculty of Agriculture, Universitas Gadjah Mada
2 PT. Pagilaran, Batang Regency, Central Java Province

* E-mail: wagimanfx@ugm.ac.id

Abstract. Behavioural characteristics of the tea mosquito bug, Helopeltis bradyi, are important to be understood to support the control efforts of the pest. The study was aimed to describe population structure and behaviour of H. bradyi on the tea plant parts. The field study was conducted at Pagilaran tea plantation located in Batang Regency, Central Java Province, at 870 m asl, in early dry season of March – April, 2018. All developmental stages of H. bradyi on tea plant parts of 20 sample plants were observed and recorded in situ in the morning, at noon, and in the afternoon. Results showed that nymphs dominated the H. bradyi population structure. Population density in the morning (06.00-08.00 a.m.) was 45.1 individuals/20 plants (5.54% eggs, 80.71% nymphs, 13.75% adults), at noon (11.00 a.m.-13.00 p.m.) was 41.7 individuals/20 plants (3.40% eggs, 84.00% nymphs, 12.60% adults), and in the afternoon was 37.0 individuals/20 plants (0% eggs, 88.38% nymphs, 11.62% adults). The H. bradyi was mostly present on tea shoots at upper leaf surface namely 97.08% in the morning, 79.27% at noon, and 88.14% in the afternoon, the rest was on lower leaf surface, shoot internodes, and other plant parts. The eggs were only found on tender internodes of shoots.

Key words: Helopeltis bradyi, plant parts, population structure, tea mosquito bug, Pagilaran

1. Introduction
The economic importance of the tea mosquito bugs (Helopeltis spp. (Hemiptera: Miridae)) as a noxious pest is reported in several countries of tea producers, namely Indonesia [1-3], Bangladesh [4], India [5], China [6], and Malaysia [7]. The damage and potential loss caused by the tea mosquito bug in tea had been reviewed [8]; losses up to 55% in Africa, 11-100% in Asia, 10-50% in India, and 10-15% with some cases up to 100% in Bangladesh. The economic threshold level (ETL) of the pest is very low. In south Indian tea plantation, the ETL is a 5% infestation. It was reported that in North Bengal Dooars plantation, the presence of one pair of the tea mosquito bugs per group of 10 bushes might cause economic damage within 14 days. Meanwhile, at tea plantation in Assam, the ETL and economic injury level (EIL) were estimated to be 2.81 and 3.75% shoot infestation [8]. Amongst species of the tea mosquito bugs, the Helopeltis bradyi Waterhouse is one of the worst pest insects of tea [3], [8].

Nature of damage of the tea mosquito bugs including H. bradyi is such as follow. This insect attacks directly on harvested tea plant parts. A typical damage symptom is resulted from the attack of the sucking pest insects. The nymphs and adults of the tea mosquito bugs suck cell sap from tender stems, petiole, young leaves and buds, which result in the formation of reddish brown circular feeding punctures. The 5th instar nymph, male, and female H. bradyi are able to make 57-83, 63-85, and 67-97
punctures within 24h, respectively [5]. The tea buds, shoots and tender leaves, become curled, dried and black with many sucking stains and provide no yield. The damaged shoots cannot be harvested and it inhibits growth of the next flush of shoots. The most seriously affected tea plants have a darker green in color and are stunted. The serious damage to tea plantations reduces both in the quantity and quality of the tea. Oviposition of the females causes the cracking stem and stunting plant growth. The two types of damage, sucking cell sap and oviposition, cause direct loss of the harvestable shoots, inhibiting plant growth and eventually resulting poor yields [8]. To develop proper management and control techniques, basic knowledge on biology and ecology of the pest insect is necessarily to be understood.

Spraying insecticides or bioinsecticides is frequently applied in a tea plantation to control the general pests of tea including the tea mosquito bugs. Hand sprayer or power sprayer is an application tool to spray insecticide droplets correctly and directly contact with the target pest. The applicator must recognize the presence of the target pest, where the pests exist on the plant parts. Thus, the applicators can adjust the spraying method to ensure the target pest is exposed to the insecticide droplets.

Some aspects of biology and ecology of the tea mosquito bug including *H. bradyi* have been studied namely feeding behavior [5], vertical distribution pattern [3], natural enemies [3],[4],[8], host range [4], fecundity and life cycle [4], population dynamic[4], response to environmental factors [4], climatic factors related to the pest infestation [4]. Information on aspects of population density and behavioral characteristics of the target pest that related to the spraying efficiency is still limited. Therefore, objective of the study was to describe the population structure and presence position of *H. bradyi* on the tea plant parts at different times during the day.

2. **Materials and Methods**

Field observation was conducted at Pagilaran tea plantation which located in Keteleng Village, Blado District, Batang Regency, Central Java Province, during the early dry season of March to April, 2018.

2.1. **Study site**

An orientation of tea plantation was done to determine the proper study site, to ensure there was infestation of the tea mosquito bug and to easy observation. The selected tea plantation plot for study site was the plot of 10 years old tea plantation which the plucking status is called as *Jendang* meaning the first-year pruning stage. Each of the tea plants has a dozen cut branches and a dozen of shoots, approximately 10 leaves per shoot. The selected tea plantation plot indicated being infested by the tea mosquito bug, *H. bradyi*. In this study, we selected an area of 4 ha plot at an altitude of 870 m above sea level (Figure 1).

![Map of the tea plantation at afdeling Pagilaran showing the study site took place, yellow marking at the altitude of 870 m above sea level](image-url)
2.2. Sampling and observation
The sampling unit was a plant that infested by *H. bradyi* such as indicated by symptom of infestation and the presence of the pest insect. The symptom of infestation is indicated with the attacked shoots may present dieback symptoms and/or damages to the tender tissues due to process of egg laying [4]. Sampling size (n) was 20 plants, the samples were taken at random by purposive sampling method namely the infested plants.

Observation *in situ* and recording individual number of all stages of *H. bradyi* that present on tea plant parts were done three times a day namely in the morning (06.00 – 08.00 a.m.), at noon (11.00 a.m. – 13.00 p.m.) and in the afternoon (16.00 – 18.00 p.m.). The tea plants parts were *peko* leaf, 1st young leaf, 2nd young leaf petiole, 1st internode, 2nd young leaf, 2nd young leaf petiole, 2nd internode, 3rd young leaf, 3rd internode, 4th young leaf, 4th young leaf petiole, 4th internode, 1st *kepel* leaf, 1st *kepel* petiole, 5th internode, 1st old leaf, 1st old leaf petiole, 6th internode, 2nd old leaf, 2nd old leaf petiole, 7th internode, 3rd old leaf, 3rd old leaf petiole, 8th internode, 2nd *kepel* leaf, 2nd *kepel* petiole, 9th internode, twig, branch, and stem. The presence of *H. bradyi* individuals on upper leaf surface and lower leaf surface was also observed and recorded.

3. Results and Discussion
The species of Helopeltis in Java are only one species namely *H. bradyi* [2], therefore, the tea mosquito bug that infest the tea plantations at Pagilaran is *H. bradyi*. Initially, this pest infestation in the Pagilaran tea plantation was reported in 2014 and the pest did not cause significant losses. However, the pest infestation developed rapidly in the following years until February 2018 and severely threatened tea production.

3.1. Population structure of *H. bradyi*
Population structure means the composition of a population. In this study, the population structure of the tea mosquito bug, *H. bradyi*, shows how the population is divided up between developmental stages of egg, nymph, and adult. The population structure of *H. bradyi* at the Pagilaran tea plantation in the morning, at noon, and in the afternoon was consistently dominated (more than 80%) by nymphs (Figure 2), then followed by adults and eggs.

This tea mosquito bug was more abundant to observe in the morning, the population density was about 45.1 individuals/20 plants, then it slightly reduced approximately 7.54 and 17.96% at noon and in the afternoon, respectively. It implies that for practical purpose in insecticide spraying the proper working time is forenoon from 06.00 – 11.00 a.m. At present, the control of insect pests of tea tends to depend on insecticide spraying [9]. It is more advantage to spray in the forenoon period because besides target pests appear more abundant, fine weather, and less wind, as a result spraying will be more efficient due to the drop lets optimally hit on targets. On the other hand, local weather in the afternoon at high altitude like in the tea plantation is typically cloudy and rainy.

3.2. Presence of *H. bradyi* on tea canopy
3.2.1. Presence of *H. bradyi* on tea plant parts. It is interesting to note that eggs of *H. bradyi* were found in the morning and at noon, not found in the afternoon. We believed that the eggs must remain in the tea plants. As we know that in the afternoon (16.00-18.00 p.m.) at tea plantation with high altitude of 870 m asl, it was not fine weather, it tended to cloudy, dark, cool, and very moist. Visual observation without magnifier, it is very difficult to see sign of egg existence, namely very small two unequal chorionic processes. The eggs are laid in the shoot, and the chorionic processes project outside with the longer process above the shorter one [10]. The eggs (Figure 2, yellow circle) were observed mostly to present on internodes of shoot, which is in line to what reported by Gope & Handique (1991) [10].

The mosquito bugs, nymphs (Figure 2, green circle) and adults (Figure 2, red circle), tend to prefer the leaves mainly on young leaves for feeding. Several nymphs and adults of the mosquito bugs were found to present on tender internodes probably for feeding as well. Some nymphs were found to present on stem to avoid light at noon and afternoon or for other purposes. Almost of tea shoot parts were
infested by the tea mosquito bugs. Most infestations occurred on the tenderest shoot and towards the base of the shoot, the infestation was on the wane.

The plant parts: (1) peko leaf, (2) 1st young leaf, (3) 1st young leaf petiole, (4) 1st internode, (5) 2nd young leaf, (6) 2nd young leaf petiole, (7) 2nd internode, (8) 3rd young leaf, (9) 3rd young leaf petiole, (10) 3rd internode, (11) 4th young leaf, (12) 4th young leaf petiole, (13) 4th internode, (14) 1st kepel leaf, (15) 1st kepel petiole, (16) 5th internode, (17) 1st old leaf, (18) 1st old leaf petiole, (19) 6th internode, (20) 2nd old leaf, (21) 2nd old leaf petiole, (22) 7th internode, (23) 3rd old leaf, (24) 3rd old leaf petiole, (25) 8th internode, (26) 2nd kepel leaf, (27) 2nd kepel leaf petiole, (28) 9th internode, (29) twig, (30) branch, and (31) stem.

**Figure 2.** The population structure and presence of developmental stages of *H. bradyi* on tea plant parts at different times during the day

The desired type of tea plucking is generally the type of medium plucking with a composition of 70% medium plucking, a maximum 10% fine plucking, and 20% rough plucking. A fine plucking is peko leaf or *burung* leaf with one young leaf. A medium plucking is peko leaf or *burung* leaf with two or three young leaves. A rough plucking is peko leaf or *burung* leaf with more than four leaves [11]. In the tea plucking process, 1 – 4 leaves will be cut. These parts of shoot are the most preferable to the tea mosquito bugs. The tea plucking is meaning less to the pest control because the females of tea mosquito bug lay their eggs on uncut tender internodes, nymphs and adults are still feeding on the tender-old leaves. Therefore, the tea mosquito bugs always threat the tea production.

3.2.2. Presence of *H. bradyi* on the tea leaf surface. Upper leaf surface of tea was the most preferred by the tea mosquito bugs to present on (Table 1). As shown in Figure 2 and Table 1 it seems that at noon and in the afternoon the nymphs and adults of the tea mosquito bug exhibited to avoid the sunlight. They were found to present on upper leaf surface 97.08% in the morning, then it reduced to 79.27% at noon,
and increased again to 88.14% in the afternoon. However, when it is a cloudy day, the tea mosquito bugs are found to be present during all day [8].

The \textit{H. bradyi} had been reported to exhibit a weak clumped of vertical distribution pattern on a tea plant [3]. This tea mosquito bug preferred to present on tea shoot parts for feeding namely young and old leaves and tender internodes. This finding is in line with report of Bhuyan & Bhattacharya (2006) that \textit{H. theivora} adults preferred to eat the second leaf than the first and the third leaf [12].

Table 1. Presence of \textit{H. bradyi} on leaf surface and other plant parts of tea at different times during the day

| Tea plant parts: | Numbers and proportion of \textit{H. bradyi} during the day |  |
|------------------|-----------------------------|------|
|                  | In the morning (06.00-08.00 a.m.) | At noon (11.00 a.m. - 13.00 p.m.) | In the afternoon (16.00 - 18.00 p.m.) |
|                  | Mean ± SD | % | Mean ± SD | % | Mean ± SD | % |
| Upper surface of the leaf | 1.66 ± 1.24 | 97.08 | 1.53 ± 1.60 | 79.27 | 1.56 ± 1.26 | 88.14 |
| Lower surface of the leaf | 0.04 ± 0.25 | 2.34 | 0.39 ± 0.68 | 20.21 | 0.16 ± 0.25 | 9.04 |
| Petiole, internode, others | 0.01 ± 0.11 | 0.58 | 0.01 ± 0.11 | 0.52 | 0.05 ± 0.11 | 2.82 |

Finding on some biological and ecological characteristics of the \textit{H. bradyi} on tea plantation has an implication on efficiency of insecticide spraying to the target pest. Hard plucking should then be carried out to remove all the affected shoots, followed by spraying in the infested area with the recommended insecticide. Spraying should commence from the outside, towards the central infested area. Spraying should be undertaken in early morning and late afternoon hours with proper spraying machine, recommended nozzle, and recommended insecticide [12]. The nymphs and adults of the tea mosquito bugs may effectively be controlled with insecticide spraying, but the eggs may avoid from insecticide spraying or from predators because the eggs are inserted in the tissue of tender internodes of tea shoot [8]. Even though, the eggs are probably attacked by parasitoids namely \textit{Telenomus} sp., \textit{Chaetostricha} sp. and \textit{Erythmelus helopeltidis} Gahan [13]. Meanwhile, the potential predatory spider namely \textit{Oxyopes javanus} coexisted with \textit{H. bradyi} in the same parts of the plant to occur in the morning, at noon, and in the afternoon was 50.0, 58.3, and 66.7%, respectively, whereas the rest existed separately [3]. The predator:prey ratio of \textit{O. javanus} and \textit{H. bradyi} was approximately 1:10 [14].

4. Conclusion

Population density of \textit{H. bradyi} found in Pagilaran tea plantation was high in the morning (45.1 individuals/20 plants: 5.54% eggs, 80.71% nymphs, 13.75% adults), then be on the wane at noon (41.7 individuals/20 plants: 3.40% eggs, 84.00% nymphs, 12.60% adults), and in the afternoon (37.0 individual/20 plants: 0% eggs, 88.38% nymphs, 11.62% adults). The \textit{H. bradyi} nymphs and adults were mostly found to present on tea shoots at upper leaf surface (88.16%), the rest were on lower leaf surface, petioles, and internodes of shoots. While eggs were only found on the tender internodes of shoot.

References
[1] Indriati, G. dan F. Soesanthy. 2014. \textit{Helopeltis} spp. and their control techniques in tea (\textit{Camellia sinensis}) plantation. \textit{SIRINOV}, 2(3): 189-198.
[2] Melina, S., E. Martono, Y. A. Trisyono, Suputa, Moechtar, and R. Radek. 2016. Morphology of adult \textit{Helopeltis bradyi} (Heteroptera: Miridae) of Java, resolving a longstanding species uncertainty. \textit{North-Western Journal of Zoology} 12 (1): 110-121.
[3] Sari, N. M., A. Wijonarko, and F. X. Wagiman. 2019. The Vertical Distribution of \textit{Helopeltis bradyi} and \textit{Oxyopes javanus} on Tea. \textit{Jurnal Perlindungan Tanaman Indonesia}, 23(1): 125–132. DOI: 10.22146/jpti.38118
[4] Ahmed, M. and M.S.A. Mamun. 2014. Tea mosquito bug, \textit{Helopeltis theivora} Waterhouse (Hemiptera: Miridae): A threat to tea cultivation in Bangladesh. Paper Presented in the Regional Seminar of Zoological Society of Bangladesh at BTRI.
[5] Srikumar, K. K., B. Radhakrishnan, B. Suresh Kumar and P. Prabhakaran. 2015. New record of *Helopeltis bradyi* Waterhouse and *Pachypeltis maesarum* Kirkaldy (Hemiptera: Miridae) on tea *Camellia sinensis* L.O. (Kuntze) in southern India. *Current Biotica* 9(3): 281-284.

[6] Saha, D. and A. Mukhopadhyay. 2013. Insecticide resistance mechanisms in three sucking insect pests of tea with reference to North-East India: an appraisal. *International Journal of Tropical Insect Science* 33(1): 46–70. doi:10.1017/S1742758412000380

[7] Saroj, P. L., P. S. Bhat, and K. K. Srikumar. 2016. Tea mosquito bug (*Helopeltis* spp.) – A devastating pest of cashew plantations in India: A review. *Indian Journal of Agricultural Sciences* 86(2): 151–62.

[8] Roy, S., N. Muraleedharan, A. Mukhapadhyay and G. Handiquea. 2015. The tea mosquito bug, *Helopeltis theivora* Waterhouse (Heteroptera: Miridae): its status, biology, ecology and management in tea plantations. *International Journal of Pest Management* 1-19. http://dx.doi.org/10.1080/09670874.2015.1030002

[9] Mamun, M.S.A., M. Ahmed, and S.K. Paul. 2014. Integrated approaches in tea pest management for sustainable tea production. Conference Paper.

[10] Gope B. and R. Handique. 1991. Bio-ecological studies on the tea mosquito bug, *Helopeltis theivora* Waterhouse in North East India. Two and a Bud. 38(1-2): 21-27.

[11] Effendi, D. S., M. Syakir, M. Yusron, dan Wiratno. 2010. Budidaya dan pasca panen teh. Pusat Penelitian dan Pengembangan Perkebunan, Bogor. 65 hal.

[12] Roy, S., A. Rahman, M. Sarma, A. Babu and B. Deka. 2018. Integrated management of tea pests of Northeast India. Special Bulletin. Tea Research Association. Tocklai.

[13] Srikumar, K. K. and P. S. Bhat. 2013. Biology of the tea mosquito bug (*Helopeltis theivora* Waterhouse) on *Chromolaena odorata* (L.) R.M. King & H. Rob. Scientific Note. *Chilean Journal of Agricultural Research* 73(3): 309-314. doi:10.4067/S0718-58392013000300015

[14] Sari, N. M. 2018. Spatial distribution of *Helopeltis bradyi* and *Oxyopes javanus* in PT Pagilaran tea plantations, Batang, Central Java. Master Thesis. Faculty of Agriculture, Universitas Gadjah Mada.

**Acknowledgement**

We are indebted to the PT Pagilaran which had facilitated us to conduct field study at the tea plantation and to Mr. Subito who had always accompanied us during field observation.