OCCURANCE AND SEASONALITY OF *STREPSICRATES SEMICANELLA* AND *HELOPELTIS THEIVORA* ON *EUCALYPTUS* AND EFECT OF TEMPERATURE ON THEIR INCIDENCE

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Leafroller, *Strepsicrates semicanella* and the sap sucking bug, *Helopeltis theivora* caused severe damage on early growth in *Eucalyptus* (Myrtaceae) trees in Indonesia. However, information on the occurrence, seasonality and effect of weather parameters on these serious pests of *Eucalyptus* were insufficient. In this study, incidence progression of *S. semicanella* and *H. theivora* on *Eucalyptus* plants after planting was investigated and the damage caused on *Eucalyptus* plantations was monitored for the period of two years (2018–2020). The ideal phase for *S. semicanella* to cause considerable damage to young *Eucalyptus* plantations was one to three months after planting whereas for *H. theivora* it was three to six months. Incidence of *S. semicanella* was at peak in May to July and *H. theivora* was at peak in December to March. There was marginally significant correlation between the incidence of *H. theivora* and total rainfall ($R^2 = 0.12$, $P = 0.019$) in the same month. The results from the study provided precise estimates in the period of incidence of *S. semicanella* and *H. theivora* on *Eucalyptus* trees and will enhance the strategies to manage both of these pests.

Keywords: leafroller, sap sucking bug, tree age, damage, population dynamics, weather

INTRODUCTION

Eucalyptus (Myrtales: Myrtaceae) is largely planted in Riau, Sumatra, Indonesia, where it is utilised to produce paper, pulp and viscose materials (Paine et al. 2011, Tavares et al. 2020). In Indonesia, the young commercial plantation of *Eucalyptus* faced serious pest attacks (Raimon et al. 2020, Tavares et al. 2020, Tachi et al. 2020). Leafroller, *Strepsicrates semicanella* (Lepidoptera: Tortricidae) and the sap sucking bug, *Helopeltis theivora* (Hemiptera: Miridae) are important pests as they caused considerable damage to young *Eucalyptus* trees (Hardi & Intari 1990, Paine et al. 2011, Srikumar et al. 2020a). In New Zealand, *S. macropetana* was recorded to attack at least 15 *Eucalyptus* species on juvenile foliage, forming the damaging stage by feeding on the shoot tips, buds and developing flowers which were attached together in webs (Nuttall 1983, Mauchline et al. 1999). Leafroller caterpillars fed on the leaves and shoot tips of young *Eucalyptus* trees severely affecting its development and growth (Mauchline et al. 1999). Severe infestation of *S. semicanella* on *Eucalyptus* trees caused height loss of 30–40 cm in first three months after planting in Riau, Indonesia. Sap sucking mirid, *Helopeltis bradyi* was reported as a serious pest on *Eucalyptus* trees in North Sumatra, Indonesia infesting 57% of trees (Hardi & Intari 1990, Srikumar et al. 2020c). Damage by these mirids caused severe dieback of young shoots and retarded plant growth in *Eucalyptus* trees (Stonedahl 1991, Nair 2000). Height loss caused by severe infestation of *H. theivora* could be up to 1 m in first six months of planting of *Eucalyptus* trees. There was also observed that the damage caused by *H. theivora* declined after *Eucalyptus* trees reached 3 m in height, normally in six months after planting. At this stage the *Eucalyptus* trees were dominated by *Arthriticus eugeniae* and *Ragwelellus* sp. (Srikumar et al. 2020c).

Equatorial climate with hot, humid and rain throughout the year is prominent in Indonesia. Rain occurred in the form of downpours or thunderstorms, which sometimes caused flood. Southern part of Sumatra receives around 4000 mm of rainfall per year. The peak period from October to December, when rainfall amounts up to more than 400 mm per month (World Climate Guide 2021).

Currently, *S. semicanella* and *H. theivora* infestations on commercial *Eucalyptus* plantations in Sumatra were managed by insecticide application (Srikumar et al. 2020b). Pest surveillance was crucial for the design and implementation of successful Integrated Pest Management programmes (Prasad & Prabhakar 2012). Both *S. semicanella* and *H. theivora* were serious threats to *Eucalyptus* trees but information on their population dynamics was totally lacking in Indonesia. The objective of the current study was to comprehend the incidence progression of *S. semicanella* and *H. theivora* on *Eucalyptus* trees, their seasonality in occurrence, and effect of rainfall on their incidence.

MATERIALS AND METHODS

Study site

The studies were conducted on a *Eucalyptus* commercial plantations in Riau, Sumatra, Indonesia at 0° 30’ N and 101° 26’ E with 33 m altitude from year 2018 to 2020.

Incidence progression

Data were sampled from five plots placed in six different fields at PT. Riau Andalan Pulp and Paper plantation. The plots were established systematically in the field. Each plot size consisted of 7 × 7 plants (gross plot) and 5 × 5 plants (net plot). Gross plot represented the total plot used for experiment and data were recorded only from net plot to minimize the borer effect. Spacing between trees was 3 m × 2 m with initial total stocking plants of 1667 trees per ha. The fresh lesion of light brown discoloured area caused by *H. theivora* feeding on the leaves and presence of living *S. semicanella* larva in leaf shelters on each tree was recorded and classified according to the following scale: 0 for no fresh lesion or larva (healthy) and 1 for fresh lesion or larva (unhealthy). *S. semicanella* incidence was observed by opening the damaged leaf roll and confirming the living larva. For *H. theivora*, the fresh lesion was considered for scoring. This pest incidence scoring technique was experimented on *Eucalyptus* trees from starting date of planting to six-months-old trees with a height of 3 m. Pest incidence was recorded weekly during this observation period. Incidence (%) for *S. semicanella* and *H. theivora* was calculated according to the following formula; Incidence = [(number of infested trees) ÷ (total trees in the net plot)] × 100.

Seasonality

The climate in Riau is tropical with average temperature of 28.0 °C with maximum and minimum temperature reaching 34.4 °C and 20.1 °C, respectively. Monthly average also showed that the maximum temperature varied from 29 °C to 32 °C whereas minimum temperature from 26 °C to 27 °C (Figure 1).

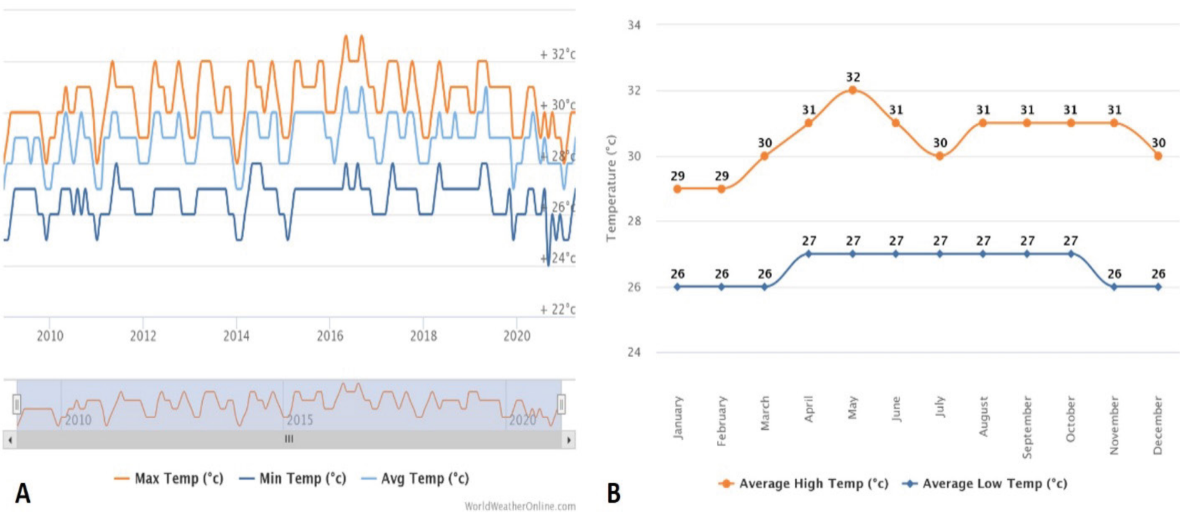

Figure 1 (A) Temperature of Riau, Indonesia for 2010–2020 and (B) Monthly temperature average (WorldWeatherOnline.com)

Seasonality and incidence of *S. semicanella* and *H. theivora* on *Eucalyptus* trees, monitoring was conducted in the young *Eucalyptus* plantations. Monitoring was carried out at plantation age of one, three and five months covering a total of 118,800 ha. In each 25 ha, a sample of 1.5% trees were monitored.

Effect of rainfall

Rainfall data for all fields were obtained from weather station records managed by PT. Riau Andalan Pulp and Paper plantation. The monitoring and rainfall data were combined into one data structure. Modified variables of rainfall data for analysis consisted of monthly rainfall and 1 to 2 months before rainfall. Monitoring incidence of pests and rainfall variables were correlated using simple parametric correlation. Further correlation was observed and compared between complete monitoring incidence data (0–100% incidence) and monitoring incidence data (25–100% incidence) in order to obtain higher correlation value as possible. The significances of correlation were measured using linear regression indicated with R^2 and P (Bhamare et al. 2018).

RESULTS

Incidence of *S. semicanella* on *Eucalyptus* plants started from two weeks after planting. Infestation promptly increased during 3 weeks after planting. At this stage, the early larval instars typically occurred within buds, on shoot tips or between the apical junctions of two leaves. Incidence of *S. semicanella* reached highest in 5 to 11 weeks after planting with 90% and 84% incidence, respectively. *S. semicanella* incidence started declining from 15 weeks after planting and further reduced in 21 weeks after planting (Figure 2). Mean height of trees during 15 weeks after planting was 2 m. The incidence of *H. theivora* on *Eucalyptus* trees was 2% in nine weeks after planting. Infestation promptly increased in 13 weeks after planting and reached

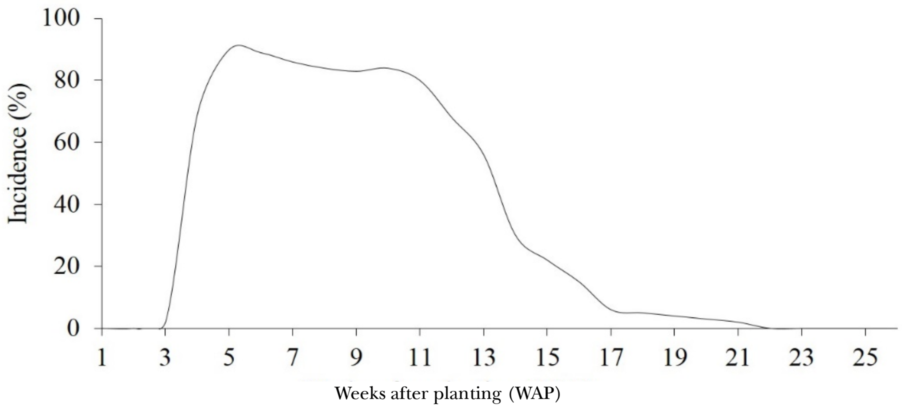

Figure 2 Incidence of *Strepsicrates semicanella* on *Eucalyptus* trees

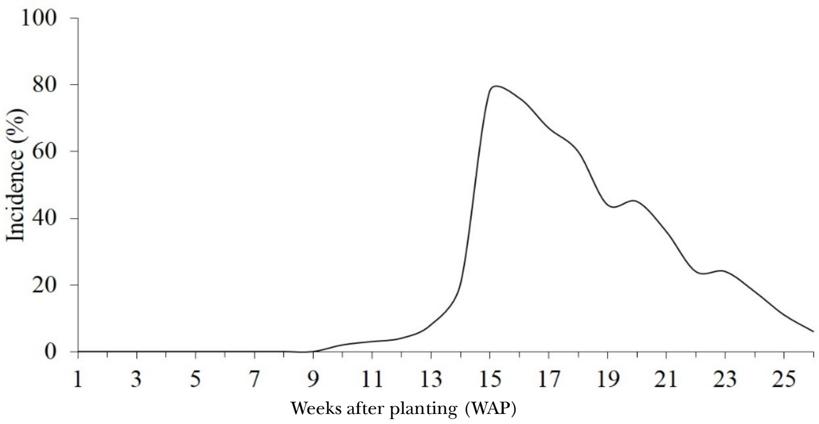

Figure 3 Incidence of *Helopeltis theivora* on *Eucalyptus* trees

highest in 15 weeks after planting with 78%. *H. theivora* incidence started its steep decline from 23 weeks after planting and further reduced in 25 weeks after planting (Figure 3). Mean height of trees during 25 weeks after planting was 3 m.

Seasonality of *S. semicanella* on *Eucalyptus* plantations revealed that the pest was present throughout the year. Incidence was seen high in April, May, June and July with 11.1%, 13.9%, 13.1% and 12.9%, respectively. Incidence was lowest in September with 4.9% (Figure 4). The incidence of *H. theivora* was also present throughout the year. Incidence was seen high in January and February with 4.7% and 5.2%, respectively. There was also a slight peak in May with 3.8% incidence. Infestation was lowest in September and October months with 1.7% and 1.2%, respectively.

There was marginally significant correlation between the incidence of *H. theivora* and total rainfall (R^2 = 0.12, P = 0.019) in the same month (Figure 5). The mean correlation was 0.55 (Table 1). The correlation between incidence and total rainfall in one month before incidence was not significant (R^2 = 0.06, P = 0.104). The mean correlation was 0.29. The relationship between incidence and total rainfall in two months before incidence was not significant by statistics (R^2 = 0.06, P = 0.111). However, the mean correlation was 0.62 in this case. The relationship between *S. semicanella* incidence and total rainfall in the present month (R^2 = 0.022, P = 0.027), one month before incidence (R^2 = 0.001, P = 0.707) and two months (R^2 = 0.001, P = 0.750) before incidence were tested, but no significant correlations were found (Figure 6 and Table 2).

DISCUSSION

The incidence of *S. semicanella* on *Eucalyptus* trees showed peak phase between one to three months after planting. When the trees reached 21 weeks after planting, the *S. semicanella* infestation became negligible and concentrating mainly in lower part of tree leaves having no impact on tree growth. Change in physiochemical characteristics of *Eucalyptus* tree leaves might be the reason for less preference for *S. semicanella* as the *Eucalyptus* tree grows older. Exceedingly significant (P = 0.001) correlation of trichomes on sunflower, *Helianthus annuus* leaves with whitefly, *Bemisia tabaci* population was noticed suggesting that the increase in trichomes resulted in suppression of whitefly population (Lanjar et al. 2014). The physiochemical characteristics of leaves changed in accordance with development of plant age and physical height might have impact on insect damage. Incidence of *H. theivora* on *Eucalyptus* trees was in peak phase between three to six months after planting. There were reports of *H. theivora* attacking young *Acacia* and *Eucalyptus* plantations in Sumatra, Indonesia (Nair 2000, Srikumar et al. 2020c).

The study on seasonal occurrence of *S. semicanella* on *Eucalyptus* plantations showed the pest was present throughout the year. The sprcies *S. macropetana* went through many more generations, perhaps between six and eight depending on climate (Miller 1925, Mauchline et al. 1999). There were at least four generations of *S. macropetana* in the study at Bay of Plenty, New Zealand (Mauchline 2000).

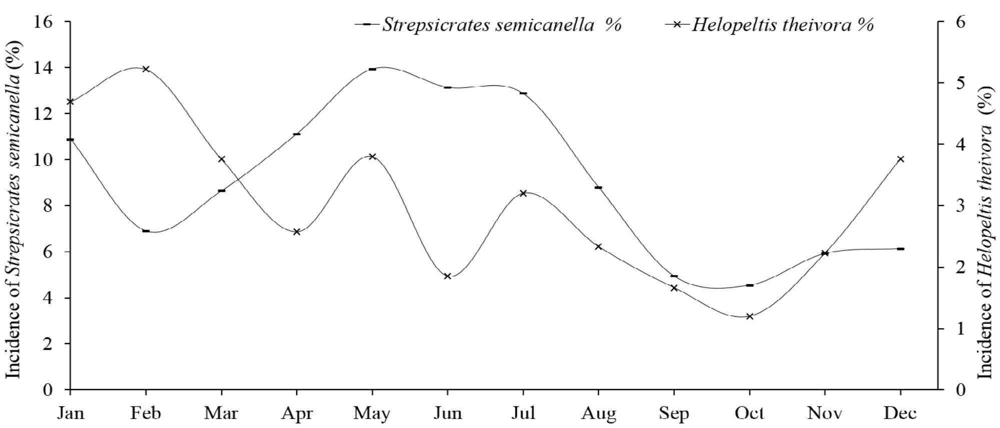

Figure 4 Seasonality of *Strepsicrates semicanella* and *Helopeltis theivora* for the period of 2018 to 2020

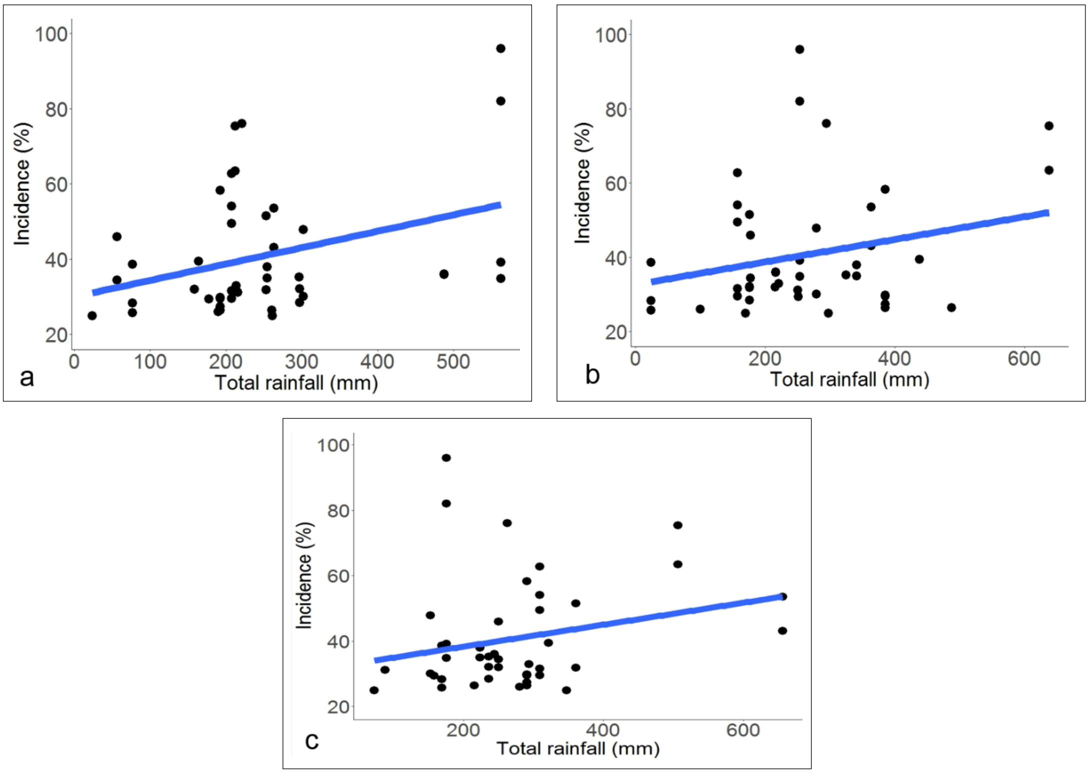

Figure 5 Relationship of *Helopeltis theivora* incidence and rainfall (a) rainfall in present month of *H. theivora* incidence ($R^2 = 0.12$, $P = 0.019$), (b) one month before *H. theivora* incidence ($R^2 = 0.06$, $P = 0.104$) and (c) two months before *H. theivora* incidence ($R^2 = 0.06$, $P = 0.104$) (incidence of *H. theivora* was considered above 25% for the analysis)

Table 1 Relationship with rainfall and *Helopeltis theivora* incidence

Area of 955 ha with > 25% *H. theivora* incidence	Rainfall		
	Present month	1 month before	2 months before
Pearson's correlation (R^2)	0.55	0.29	0.62

The incidence of *H. theivora* increased from December onwards and reached peak in January and February. The observation supported the findings which showed the activity of *Helopeltis* spp. initiated in October and damage found gradually to increase and reached maximum during December to February in cashew, *Anacardium occidentale* plantations in India (Srikumar & Bhat 2013, Srikumar & Bhat 2016, Saroj et al. 2016). Cashew plants started flushing, flowering and fruiting during December to February and was related to high *Helopeltis* spp. attack during these months (Sundararaju & Sundarababu 1999).

In *Eucalyptus* plantations of Indonesia, the incidence increase of *H. theivora* during December–March might be attributed to the weather factors. There was good relationship between the incidence of *H. theivora* and total rainfall in the same month. Rainfall could adversely affect the chemical control of *H. theivora* and led to swift spread of incidence in plantation. The wet season might favour more pest egg hatching by preventing desiccation of eggs in the dry season. The population of *H. theivora* coincided with months of heaviest rainfall, although a one-month gap was observed in the June–July peak (Muhamad & Fee 1993). There was also evidence indicating that *Helopeltis* populations fluctuated in response to more localised and less regular climatic events, tending not to do well under conditions of heavy rain, high winds or low relative humidity (Miller 1941, Betrem 1950, Pillai et al. 1985).

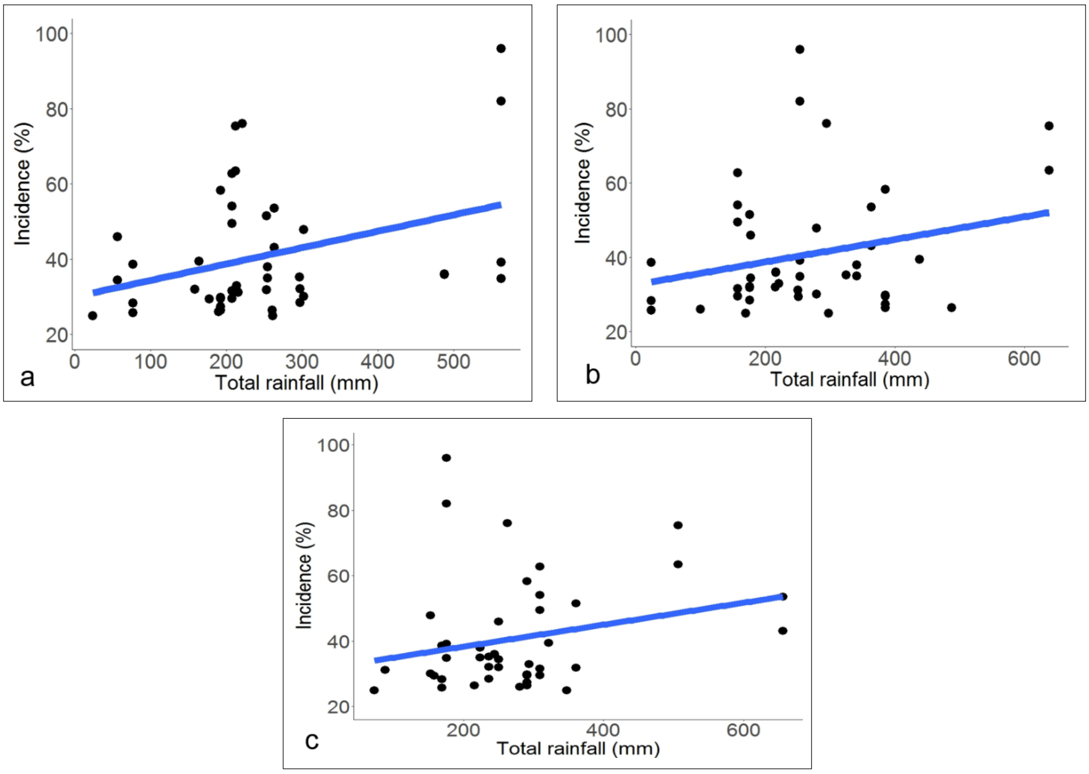

Figure 6 Relationship of *Strepsicrates semicanella* incidence and rainfall (a) rainfall in present month of *S. semicanella* incidence (R^2 = 0.022, P = 0.027) (b) one month before *S. semicanella* incidence (R^2 = 0.001, P = 0.707) and (c) two months before *S. semicanella* incidence (R^2 = 0.001, P = 0.750), (Incidence of *S. semicanella* was considered above 25% for the analysis)

Table 2 Relationship with rainfall and *Strepsicrates semicanella* incidence

Area of 5006 ha > 25% leafroller incidence	Rainfall		
	Present month	1 month before	2 months before
Pearson's correlation (R^2)	-0.19	-0.05	0.26

A cyclical population fluctuation of *Helopeltis* sp. was observed on cocoa in East Java, Indonesia and was related to the abundance of cocoa pods (Mujiono 1987). The reduction or absence of *Helopeltis antonii* population according to food source and climatic factors was also reported (Giesberger 1983, Mujiono 1987, Karmawati et al. 1999).

It was reported that the air temperature at maximum on-site (R^2 = 0.56, P = 9.40^{e-05}) and weather station (R^2 = 0.80, P = 0.002)] had significant relationship with the abundance of *S. macropetana* (Lin 2017, Mauchline 2000). The tropical climate in Riau with average air temperature 28.0 °C throughout the year might favour the abundance of *S. semicanella* in *Eucalyptus* plantations.

Present study suggested that the major pests of *Eucalyptus* trees, *S. semicanella* and *H. theivora* have differential preference in choosing plant age or development stage of the trees. Both *S. semicanella* and *H. theivora* exhibited seasonality in occurrence on *Eucalyptus* plantations. *Helopeltis theivora* incidence showed significant positive correlation with high rainfall occurrence in the month. Our results provided precise estimates in the period of incidence of *S. semicanella* and *H. theivora* on *Eucalyptus* trees and will enhance strategies to manage these pests.

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