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THE IMPORTANCE OF STEM BORER, *Apomecyna saltator* Fabricius (COLEOPTERA: CERAMBYCIDAE) IN HONEY PUMPKIN PLANTS (*Cucurbita moschata* Dusch)

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Abstract. *Currently, honey pumpkin plants are widely looked at and are in great demand for cultivation. Honey pumpkin production is in great demand with a relatively high price and can be stored for a relatively long time. Apomecyna saltator Fabricius (Coleoptera: Cerambycidae) as a pest of honey pumpkin in Indonesia is something that has been just known. The study about A. saltator on honey pumpkin is limited. This research was conducted to determine: the relationship between honey pumpkin plant phenology and investment of A. saltator; the effect of A. saltator infested to plant age, the length of productive period and production of honey pumpkin plants; and the importance of A. saltator on honey pumpkin plants. The study was designed with 2 treatments, namely A (honey pumpkin plants that were left exposed to A. saltator obtained by planting honey pumpkins in areas endemic to A. saltator) and B (honey pumpkin plants that were not attacked by A. saltator obtained by wrapping the honey pumpkin plant stems using plastic wrap from the base of the stem which was applied from 7 days after planting and continued every day in line with plant growth until the wrapped stems were 1.5 m long). The treatments were in five replications. Observation variables include; plant phenology, symptoms of A. saltator attack, age, length of productive period, and production of honey pumpkin plants. The research shows that A. saltator investment in honey pumpkin plants occurs from the vegetative phase when the plant is 2-3 weeks old until the final generative phase (fruit ripening). The attack of A. saltator had a significant effect on reducing age, length of productive period and production of honey pumpkin plants. Based on the pest economic meaning, A. saltator is classified as an important pest of honey pumpkin plants.*
Keywords: *A. saltator*; pest; importance

1. Introduction

Apomecyna saltator Fabricius (Coleoptera: Cerambycidae) as a pest of honey pumpkin in Indonesia has recently been identified. This pest was first reported in1896 in the state of Oahu and has been reported in Hawaii, Kauai, and Maui (Khan, 2012). In Indonesia, *A. saltator* was first reported in 2019 attacking honey pumpkin plants (*Cucurbita moschata* Dusch) in Jambi with plant infested up to 56.56% (Wilyus & Novalina 2019).

Honey pumpkin is a horticultural crop that is less commonly cultivated by farmers. Currently, this plant is widely looked at and is in great demand for cultivation because it has several advantages over the products of several other horticultural crops. Honey pumpkin is interesting to develop because it can be an alternative to food sources as it has good nutritional content. Therefore, it can be used as a solution in tackling the food crisis. Honey pumpkin fruit has several

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important nutritional components, including polysaccharides, proteins, essential amino acids, carotenoids, and minerals (Achu *et al*., 2005; El-Aziz & El-Kalek, 2011).

Honey pumpkin is an annual plant, belonging to the plant division of Spermatophyta class *Dicotyledoneae*, order of *Cucurbitales*, family of *Cucurbitaceae*, genus of *cucurbita*, species of *Cucurbita moschata*. This plant has been widely cultivated in North and South America before the arrival of Europeans. Archaeologists have found evidence of *C. moschata* in Peru from 4,000 - 3,000 BC and in Mexico from 1,440 - 400 BC (Ayuningtyas, 2019).

Honey pumpkin plants are widely cultivated during the dry season in areas with abundant rainfall, such as South and Southeast Asia. Honey pumpkin easily adapts to hot and humid climates. Honey pumpkin plants require a warm season with temperatures between 18 – 30^{o}C and for fruit enlargement with temperatures from 25 – 27^{o}C. Honey pumpkin cultivation can be carried out in areas with an altitude about 0 - 1200 m above sea level with rainfall around 700 - 1000 mm / year and has a humidity about 65% (Lolliani, 2017).

Honey pumpkin plant is a creeping plant that has tendrils with stems up to 5-10 m long. Male flowers first appear when the plant is 1 - 1.5 months old. Fruit reaches full size after 2 to 3 weeks after pollination and begins to ripen after 60 – 62 days after planting (Sudarto, 2000). The characteristics of the honey pumpkin reaching maturity are the color of the skin of the fruit is yellow (Asfandi, 2019) and the color of the fruit stalk changes to brownish green (Lestari, 2020). Zufahmi *et al*. (2015) reported that the morphological characters of honey pumpkin plants from various regions showed differences in the morphology of stems, leaves, flowers, fruits, and seeds. Furqan *et al*. (2018) also reported that the morphological characters of honey pumpkin plants from various regions showed differences in fruit and seed morphology.

Honey pumpkin cultivation is inseparable from the problem of plant pests, but there is still very limited information about honey pumpkin pests. *A. saltator* is one of the pests of honey pumpkin plants and considered as an important pest (Wilyus & Novalina, 2019). It was further explained that *A. saltator* always attacked honey pumpkins planted in Teaching and Research Farm, Faculty of Agriculture, Jambi University. *A. saltator* is also known as Cucurbit vine borer (Wang, 2017) and cucurbit longicorn. The insect belongs to: phylum of Arthropoda, Class of Hexapoda, Ordo of Coleoptera, Family of Cerambycidae (ITIS, 2022). Cerambycidae is popularly known as longhorn beetles, distributed from sea level to mountains wherever their host exist (Kariyanna *et all*., 2017b; Dwari & Mondal, 2018). *A. saltator* found in Hawaii, Kauai, Maui (Khan, 2012), Laos, India, Vietnam, Sri Lanka (Kariyanna *et al*., 2017a; Rapuzzi *et al*., 2019). *A. saltator* has been reported to attack various plants from the Cucurbitaceae family but rarely attacks cucumber, watermelon, pumpkin plants and guards (Khan, 2012). Kariyanna *et al*., (2017b) reported that *Coccinia indica, Lagenaria vulgaris, Cucurbita moschata, Luffa aegyptiaca* and *Luffa acutangular* are host plants of *A. Saltator*.

A. saltator grows and develops through complete metamorphosis. The lifespan of an adult insect is 35-44 days. Imago of *A. saltator* lays eggs on plant stems (Shah &Vora, 1974). Sontakke (2002) explained that the egg period was 6-8 days, larval period was 34 to 42 days and pupal period was 8 to 10 days with 2-3 days of prepupal period. *A. saltator* produces 3-4 generations in a year (Kariyanna *et al*., 2017c). Imago of *A. saltator* is gray with white spots arranged in three V-shaped markings along the elytra. *A. saltator* imago is 10.75 mm long and 3.45 mm wide, (Duffy, 1980; Khan, 2012), antenna 11 segmented, extended beyond the middle of elytra, segments apically darker, segment- I small, robust, almost globular, segment-III largest, bow like (Mitra *et al*., 2016)

A. saltator larvae develop through 6 instar stages with a long larval period of 31 – 37 days (Kessing & Ronald, 2007). Each instar 1 – 5 period is completed within 3 – 5 days and for instar 6, it will be completed within 14 – 15 days. The larvae of *A. saltator* are cream in color with an average length of 13.90 mm. Larvae will turn into pupae that form inside the stem. The average pupa length was 11.74 mm (Khan, 2012).

There is still very limited information explaining the importance of *A. saltator* in honey pumpkin cultivation. *A. saltator* caused severe damage to Cucurbitaceae plants in most parts of India (Kariyanna *et al*., 2017b). The attack of *A. saltator* begins with the oviposition of eggs on the stems of the plant by the female imago, then the eggs hatch into larvae and *A. saltator* larvae will eat and drill holes in plant stems (Khan, 2012). The attack of *A. saltator* on honey pumpkin plants reached 56.66%. It was further explained that *A. saltator* attacks more in the generative phase, but this pest can also attack strongly in the vegetative phase if honey pumpkin plants are cultivated continuously, and honey pumpkin plant death can occur if pests invest early (on young plants) (Wilyus & Novalina, 2019). This study describes in more detail the association between *A. saltator* and plants.

2. Methods

The research was carried out at the Teaching and Research Farm, Faculty of Agriculture, Jambi University in October 2020 – January 2021. The study was designed with 2 treatments, namely A (honey pumpkin plants left exposed to *A. saltator* pests) obtained by planting honey pumpkins in areas endemic to *A. saltator* and B (Honey pumpkin plants that were free from attack by *A. saltator* which were obtained by wrapping the honey pumpkin plant stems using plastic wrap from the base of the stem which was applied from 7 days after planting and continued every day in line with plant growth until the wrapped stems were 1.5 m long. Each treatment was repeated five times which were randomly assigned to groups. Each replication consisted of 6 plants.

Observation variables include; Honey pumpkin plant phenology, symptoms of *A. saltator* attack, plant age, plant productive period and production.

Observations of plant phenology were carried out every day on 5 sample plants that were not attacked by *A. saltator* which were determined purposively. Observations were made to find out when the first cotyledons appeared, cotyledons opened, leaves appeared, male flowers appeared, female flowers appeared, the first harvest, the last harvest.

Attacks of *A. saltator* were observed on plants of treatment A every day, starting 7 days after planting (dap). Observations were made by examining stems, leaves and fruit. Signs and symptoms of *A. saltator* attacks were recorded during observations.

Observations of plant age, plant productive period and production were carried out on all plants attacked by *A. Saltator* in treatment A and all plants that were not attacked by *A. saltator* in treatment B. Plant age was determined based on the age of the plant until the last harvest. The productive period of the plant (the days) was calculated by subtracting the age of the last harvested plant with the age of the first female flower plant, then by calculating the average length of the productive period per plant. Fruit weight and production were calculated by weighing the weight of each fruit per plant in each experimental unit.

Data on plant phenology and symptoms of *A. saltator* attack were presented descriptively to explain the relationship between phenology, plant age and investment/attack of *A. saltator* in the field. The effect of *A. saltator* attack on plant age, plant productive period, and honey pumpkin production was analyzed by t test at a significance level of 0.05 with SPSS software.

Figure 1. Imago of *A. saltator*

3. Results and Discussion

3.1. Plant Phenology, Investment and Symptoms of *A. saltator* attack

Honey pumpkin seed cotyledons appeared on the surface of the nursery media (soil and manure) 2-3 days after sowing (DAS). Cotyledons opened (split) 4-6 DAS. The first and second leaves appeared 4-6 DAS. The first male flowers appeared 18 -29 days after planting (DAP) and the first female flowers appeared 20-34 DAP. The first fruit formed 30-42 DAP. The first harvest (the first physiological maturity) was 66 – 68 DAP and the last harvest (the last physiological maturity) was 79 – 84 DAP (Table 1).

The presence (the first investment) of imago *A. saltator* on honey pumpkin was detected in the vegetative phase at the age of 14 DAP (Figure 1).

Table 1. Honey Pumpkin Plant Phenology

No.	Phenology		Plant age
	Description	Code	
1	Cotyledons appeared	V1	2 – 3 DAS
2	Cotyledons opened (split)	V2	4 – 6 DAS
3	The 1st and 2nd leaves appeared	V3	6 – 8 DAS
4	Male flowers appeared	G1	18 – 29 DAP
5	Female flowers appeared	G2	20 – 34 DAP
6	The first fruit appeared	G3	30 – 42 DAP
7	The first physiological ripe fruit (The first harvest)	G4	66 – 68 DAP
8	The last physiological ripe fruit (last harvest)	G5	79 – 84 DAP

Note: seedlings were transferred (planted) to the field at the age of 8 days old;
DAS = day after sowing;
DAP = day after planting

A week after *A. saltator* imago was found, the honey pumpkin stem showed symptoms of yellowish- white spots growing lengthwise, and several other spots of the same color along with several other spots of the same color. Symptoms of further attacks were the color of the stem changes to brownish orange and the spots began to dry up and looked like scratches or cuts on the stems. Then, the attack of *A. saltator* developed into brown spots that expanded and dried up causing the stem to break and reveal the inside of the stem. Further attacks caused the entire stem of the pumpkin to turn blackish- brown and began to shrivel. The leaves turned yellow to dry and eventually dried up, causing the plant to dieBesides attacking the stem, this pest also bored fruit stalks, which could cause fruit to fall before harvest time. In the stalks was found dirt (feces) in the form of wet powder. In bore holes, *A. saltator* larvae were generally found. In one infected stem, more than one larva of *A. saltator* with various stadia were usually found. *A. saltator* larvae can be found in all parts of the stem and even on fruit stalks. Larvae can continue their life cycle on dead (dry) plant stems until they form pupae (Figure 2).

Figure 2. Symptoms of *A. saltator* attack on honey pumpkin plants; early symptoms in the form of yellowish white patches growing lengthwise (a); brown spots are getting bigger and clearer and plant stems are cracked (b and c); Brown spots on cracked stems get bigger and stem color changes to brown (d and e); The color of the stem changes to dark brown-black (f); The fruit stalk dries up and there is larval droppings and there is a powder in the form of larvae droppings (g); larvae of *A. saltator* in the stem of the honey pumpkin plant (h) and larvae of *A. saltator* in the fruit stalk (i).

3.2. Effect of *A. saltator* attack on the Age of Honey Pumpkin Plants

The attack of *A. saltator* significantly affected the age of the honey pumpkin plants. The average age of honey pumpkin plants infected wth *A. saltator* was 68.8 days. This is shorter than the average age of honey pumpkin plants that were not attacked by *A. saltator*, which was 76 days with a significance value of 0.027 (Table 2).

Table 2. Effect of *A. Saltator* attack on honey pumpkin plant age

Treatment	Average age of plants (days)
A	68.8 a
B	76.0 b
Significance	0.027

Numbers in the same column followed by different lowercase letters indicate that they are significantly different according to the t-test at a significance level of 5%.

3.3. Effect of *A. saltator* Attack on the Productive Period of Honey Pumpkin Plants

The attack of *A. saltator* significantly affected the length of the productive period of honey pumpkins. The average of productive period of honey pumpkins that were attacked by *A. saltator* was 41.80 days. This is shorter than the average of productive period of honey pumpkins that were not attacked by *A. saltator*, which was 47.63 with a significance value of 0.002 (Table 3).

Table 3. Effect of *A. saltator* attack on productive period of honey pumpkin plants

Treatment	Average of produktive period (days)
A	41.80 a
B	47.63 b
Significance	0.002

Numbers in the same column followed by different lowercase letters indicate that they are significantly different according to the t-test at a significance level of 5%

3.4. Effect of *A. saltator* Attack on Honey Pumpkin Production

The attack of *A. saltator* significantly affected the honey pumpkins production. The production of honey pumpkins that were attacked by *A. saltator* was an average of 1.568 kg/stems. This is lower than the production of honey pumpkins that were not attacked by *A. saltator* which was an average of 2.004 with a significance value of 0.048 (Table 4).

Table 4. Effect of *A. saltator* attack on honey pumpkin production

Treatment	Average of production	
	Kg/plant	Number of fruits/plants
A	1.568 a	1.40
B	2.004 b	1.52
Significance	0.048	

Numbers in the same column followed by different lowercase letters indicate that they are significantly different according to the t-test at a significance level of 5%

3.5. Relationship between Investment, Attack of *A. saltator* and Plant Phenology of Honey Pumpkin plants

In this study, it was found that the investment and initial laying of *A. saltator* eggs on honey pumpkin plants occurred during the late vegetative phase, namely when the plants were 2-3 weeks after planting (WAP). This was indicated by the early attack symptoms of *A. saltator* detected 21 DAP or one week after imago of *A. saltator* was found in honey pumpkin plantations, namely 14 DAP. Honey pumpkin plants entered the generative phase at the age of 18-29 DAP (Table 1). Eggs of *Apomecyna* hatch in 5-7 days (Shah &Vora, 1974), and the symptoms of *A. saltator* attack occurred several days after the eggs hatching into larvae and drilling the stems of the pumpkin plants. *A. saltator* larvae have 6 instars with a larval period of 31 – 37 days, each larval stage 1 – 5 is completed in 3-5 days and for stage 6, it is completed in 14 – 15 days (Kessing & Ronald, 2007).

The attack of *A. saltator* on honey pumpkin plants begins with imago which lays eggs on the inside of the base of the stem. Then, it will develop into larvae which enter by grinding the bottom of the stem, extending upwards to form a tunnel along the tendrils and stem tissue followed by yellowing of the attacked stem. The death of leaves starts from old leaves to young leaves with a long process of death. Symptoms of hoisting can be seen from the remnants of powder around the affected stem (Khan, 2012).

The attack of *A. saltator* on honey pumpkin plants was detected after entering the generative phase with visible symptoms of cracked stems and necrosis (Wilyus & Novalina, 2019). Symptoms like this often occur starting from the bottom of the stem, extending upwards. If we open the stem, we will see a hole, and if we continue to trace it, we will find *A. saltator* larvae inside. Such symptoms are followed by yellowing and death of the leaves from old leaves to young leaves. The process of death of honey pumpkin plants by *A. saltator* attack is quite long. Thus, the plants can still produce. It is estimated that the production of honey pumpkins affected by *A. saltator* will decrease in quantity and quality.

The results of this study provide interesting information about the relationship between investment, symptoms of *A. saltator* attack and honey pumpkin plant phenology, namely; 1) in honey pumpkin plants, larvae of *A. saltator* with various stadia can be found at the same time. This shows that one or several female of *A. saltator* imagos can lay eggs on one honey pumpkin plants stem at different periods. This is understandable because female *A. saltator* imago can live for 35-50 days (Kariyanna *et al*., 2017b); 2) on the stems of plants that have been rejected (already harvested) there were also found many *A. saltator* larvae from various instars. *A. saltator* larvae can grow and develop on the rest of the plant, thus accelerating the weathering of plant stems. This shows that *A. saltator* is also a detrifor. Therefore, *A. saltator* can survive and thrive on the remains of honey pumpkin stems that are not eradicated; 3) Besides being able to attack all parts of the plant stem, *A. saltator* larvae can also attack the fruit, especially the fruit stalk so that it can cause the fruit to fall.

3.6. Relationship between Attacks of *A. saltator* and Honey Pumpkin Production

Plant production is closely related to plant health. The growth and development of the honey pumpkin plant fruit will be good and perfect if the plant is in a healthy and vigor condition. This study showed that the vigor and health of honey pumpkin plants that were attacked by *A. saltator* had serious problems. As explained above, the attack of *A. saltator* can cause serious damage to the stem. Besides, it can also cause damage to the fruit stalk.

The eating activity of *A. saltator* larvae on the stems of the honey pumpkin plant resulted in disruption of nutrient transport to the leaves and the transport of photosynthetic products to the fruit as well as damage to the leaves so that the photosynthesis process decreased. The results of this study indicate that *A. saltator* attack caused a decrease in age (Table 2.), productive period (Table 3) and production (Table 4) of honey pumpkin plants.

Table 4. shows that honey pumpkin production that was left exposed (uncontrolled) from *A. saltator* was 1.568 kg/plant. It is significantly different from the average production of honey pumpkin plant that was not attacked by *A. saltator* which was 2.004 kg/plant. It means that the attack of *A. saltator* has reduced the quantity of honey pumpkin production by 21.74%.

The attack of *A. saltator* in addition to reducing production quantitatively also reduces production quality. *A. saltator* attack causes plants to die more quickly and have a shorter productive period so that the fruit is harvested before it is physiologically fully ripe. The colour of harvested fruit before ripening is physiologically paler and less sweet in terms of taste than the perfectly physiologically ripe fruit. It is also estimated that the nutritional quality of fruit harvested before physiologically fully ripened is lower than that of fully physiologically ripened fruit.

3.7. The Economic Significance of *A. saltaor* in Honey Pumpkin plants

A. Saltator can be classified as an important pest on honey pumpkin plants because at least in the last two years, it has been proven to attack honey pumpkin plants and cause economic damage. The results of this study indicate that *A. saltator* has caused economic losses, namely reducing honey pumpkin production by 21.74%. Previous research showed that in the same research location, the percentage of honey pumpkin plants in the field that was attacked by *A. saltator* reached 56.66% (Wilyus & Novalina, 2019). It was further explained that *A. saltator* attacks more in the generative phase, but this pest can also attack strongly in the vegetative phase if honey pumpkin plants are cultivated continuously. Honey pumpkin plant death can occur if the pest is invested early (on young plants).

4. Conclusions

Infestation of imago *A. saltator* on honey pumpkin was detected in the vegetative phase at the age of 14 DAP until the final generative phase (fruit ripening). The damage to honey pumpkin plants by *A. saltator* was caused by larval feeding activity that could occur in all parts of the stem and fruit stalk. Symptoms of *A. saltator* attack on honey pumpkin plants are in the form of necrotic stems, cracks like incisions and the presence of hoist holes displaying in the stems from bottom to top, as well as occur on fruit stalks. *A. saltator* attack on honey pumpkin stems also causes plants to die slowly.

Infestation of *A. saltator* on honey pumpkin has caused economic losses significantly, namely reducing honey pumpkin production by 21.74%. This pest is always found in the honey pumpkin agroecosystem at the Teaching and Research Farm, Faculty of Agriculture, Jambi University and it can significantly reduce honey pumpkin production. Therefore, based on the economic meaning, *A. saltator* is classified as an important pest of honey pumpkin plants.

Due to the economic effect caused by this pest, efforts should be made to control this pest to support the development of a sustainable honey pumpkin cultivation business. Researches supporting integrated pest management needs to be carried out towards the management of *A. saltator* effectively and sustainably.

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