THE PRESENCE OF MEALYBUGS (HEMIPTERA: PSEUDOCOCCIDAE) ON *Chrysanthemum morifolium* RAMAT

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ABSTRACT

Chrysanthemum morifolium is the most exported ornamental cut flower in Indonesia. Its cultivation cannot be separated from pests attacks, especially mealybugs which affect its sale value. This study aimed to identify mealybugs species on *C. morifolium*, to determine population density, the intensity attack level and damage symptom of *Phenacoccus solenopsis*. Mealybug identification was carried out by collecting mealybugs and preparing the slides mount. The population density and attack intensity of *Ph. solenopsis* were observed on three varieties of chrysanthemum. The damage symptom caused by mealybugs, a certain number of *Ph. solenopsis* were infested to the plants and observed. The result shows that there are four mealybugs species, i.e *Ferrisia virgata*, *Ph. solenopsis*, *Planacoccus minor,* and *Pseudococcus jackbeardsleyi.* From this study, *F. virgata and Pl. minor* are newly recorded mealybugs pests found on chrysanthemum. The highest population of *Ph. solenopsis* is recorded in White Reagent variety as many as 73.5 mealybugs per plot or 8.72% of intensity attack level. Malformation of vegetative phase of chrysanthemum reported as reduction of leaf size, wavy leaves, thickened, shriveled, curled, and twisted leaves. Further damage on generative phase caused up to 30 mealybug infestation showed the incurvation of bud and flower stalk, and reduction of overall plant size.

Keywords: Species identification, population, daisy, *Ph. solenopsis*, malformation.

ABSTRAK

Chrysanthemum morifolium merupakan pokok hiasan untuk bunga potong yang paling banyak dieksport di Indonesia. Serangan serangga perosak ke atas tanaman pokok hiasan tidak dapat dielakkan terutamanya koya yang dapat memberi kesan terhadap nilai penjualan. Kajian ini bertujuan untuk mengenal pasti spesies koya pada *C. morifolium*, untuk mengenali kepadatan populasi, intensiti fasa serangan dan simptom kerosakan *Phenacoccus solenopsis.* Pengenalpastian koya dilakukan dengan mengumpulkan koya dan menyiapkan slaid. Kepadatan populasi dan intensiti fasa serangan *Ph. solenopsis* diperhatikan pada tiga jenis pokok bunga kekwa. Simptom kerosakan yang disebabkan oleh koya diperhatikan pada pokok bunga kekwa yang diserang oleh *Ph. solenopsis*. Hasilnya menunjukkan bahawa terdapat empat spesies koya, iaitu *Ferrisia virgata*, *Ph. solenopsis, Planacoccus minor,* dan *Pseudococcus jackbeardsleyi*. Daripada kajian ini, *F. virgata* dan *Pl. minor* ialah serangga

perosak baharu yang ditemui pada pokok bunga kekwa. Populasi tertinggi *Ph. solenopsis* dicatatkan dalam variasi Reagen Putih sebanyak 73.5 koya per plot atau 8.72% intensiti fasa serangan. Kerosakan fasa vegetatif pokok bunga kekwa boleh dilihat pada pengurangan saiz daun, daun yang berombak, ketebalan daun, kedrutan, kerinting, dan daun bengkok. Kerosakan lebih lanjut pada fasa generatif adalah disebabkan oleh serangan 30 koya iaitu pada tangkai tunas dan bunga, serta pengurangan keseluruhan ukuran tanaman.

Kata kunci: Pengecaman species, populasi, bunga kekwa, *Ph. solenopsis*, kerosakan.

INTRODUCTION

Chrysanthemum morifolium is an ornamental plant favored by many people because of its beautiful shape and various colours (Purnobasuki et al. 2014; Ramadhani et al. 2018). *Chrysanthemum* spp. can be used as a cut flower, potted flower, herb, and has the potential to produce biopesticide. According to Kardinan and Karnawati (2012), *Chrysanthemum cinerarifolium* flower extract acts as a bioinsecticide that contains an active compound, pyrethrin, which is poisonous to insects. As one of the cut flower ornamental plants, chrysanthemum has high economic value and are the most exported among other ornamental plants. It is reflected in the increase of export volume in Indonesia from 49.52 tons in 2017 to 59.11 tons in 2018 with top destination countries are Japan and Kuwait (BPS-Statistics Indonesia 2018).

Currently, Chrysanthemum production is limited by pests and diseases, one of which is mealybugs (Hemiptera: Pseudococcidae). A number of mealybugs species have been recorded on several species of chrysanthemum throughout the world (Garcia et al. 2016). The mealybugs are small sap-sucking insects by penetrating their stylets to the phloem tissue (Ouvrard et al. 2013; Williams & Granara 1992). Mealybugs infestation on plants can cause defoliation, stop the linear growth of stem and flower stalk, and increase leaf thickness and as medium of sooty mold (Mani & Shivaju 2016). Some species of mealybugs have also been reported to act as virus vectors in flowering plants and fruit trees (Kondo & Munoz 2016; Mani & Shivaraju 2016). Species mealybugs reported to attack chrysanthemum i.e: *Eliococcus manifectus*, *Rhizoecs faliever*, *Rhizoecus kondonis*, *Phenacoccus parvus*, *Phenacoccus madeirensis*, *Pseudococcus jackbeardsleyi*, *Phenacoccus solenopsis*, and *Paracoccus marginatus* (Sridhar et al. 2016; Sylesha 2013).

West Java Province is one of the top *C. morifolium* production centres in Indonesia. One of the companies engaged in this field is PT. Natalia Nursery, which produces chrysanthemum cut flowers in Bogor Regency. As of now, species of mealybugs that attack chrysanthemums are yet to be identified, especially in Indonesia. Therefore, this research was conducted to identify mealybugs species that attacked chrysanthemum plants at PT. Natalia Nursery, calculating population density and intensity attack level of *Phenacoccus solenopsis* and observing malformation caused by mealybugs.

MATERIALS AND METHODS

Sampling Sites and Duration

The research was started from February to July 2020. Mealybug samples were collected and the population as well attack intensity was observed in the chrysanthemum plantation at PT. Natalia Nursery, Tenjolaya District, Bogor Regency, West Java, Indonesia. Mealybugs

identification and damage symptom examine were carried out at the Insect Biosytematics Laboratory, Plant Protection Department, Faculty of Agriculture, IPB University, Bogor.

Mealybugs Samples Collection, Slide Mounting and Identification

Mealybugs on the chrysanthemum plantation at PT. Natalia Nursery, Bogor, Indonesia were collected. Mealybugs on the plant was documented before taken using a small brush and proceeded put into an eppendorf tube containing 70% alcohol. In addition, live mealybugs were also collected to be observed morphologically. The specimens prepared on slides using method given by Sirisena et al. (2013). The mounting process involved maceration using KOH 10%, staining on Acid Fuchsin, dehydration, dewaxing, clearing and mounting on Canada Balsam.

Identification of *Phenacoccus solenopsis* were carried out by observing the morphological characteristics of a live female adult and the dry collection using the identification key of Thomas and Ramamurthy (2008) and Sartiami et al. (2016). Identification of *Ferrisia virgata, Pl. minor* and *Ps. jackbeardsleyi* was carried out by observing the morphological characteristics of living specimens and the mounted specimens referring to several sources, namely Cox (1987), Williams (2004), Kaydan and Gullan (2012), Roda et al. (2012), Mani and Shivaraju (2016), Sartiami et al. (2016), CABI (2020) and Sartiami et al. (2020).

Calculation of Population and Attack Intensity

Among four species, *Ph. solenopsis* was the most common mealybugs found on chrysanthemum as a colony or singly. The species of *Ps. jackbeardsleyi*, *Pl. minor*, and *F. virgata* were found as individually. Infestation of *Ph. solenopsis* colonies cause stunted chrysanthemum and damage the quality produced. In this study, the observation of population and attack intensity focuses on the dominant mealybug species that caused damage to the chrysanthemum.

The observation of population and attack intensity of *Ph. solenopsis* was carried out on three plots and on each plot contained two flowerbeds. Observations were conducted once a week starting from 1 WAP (weeks after planting) to 8 WAP. Population was observed by counting the number of mealybugs on the stems and leaves. The intensity of mealybug attack was calculated using the Townsend and Heuberger (1943), while the scoring of plant damage was referring to Kranthi et al. (2009) in Table 1, as follows:

$$I = \frac{\sum_{i=1}^{k} v_i \times n_i}{N \times V} \times 100\%$$

I = Attack intensity,
n_i = Number of plant with attack category i,
v_i = Score with category i,
N = Number of observed plant,
V = Highest score

Table 1. Scoring of mealybug's attack

Score	Attack Category
0	None
1	1 to 10 of mealybugs spread all over the plant
2	The top part of the stem or an entire branch is infested with mealybug
3	The top part of the stem is infested with mealybug followed with several curled and twisted leaves
4	The main stem and branch are infested, stunted growth, dry, and sooty mould is present.

(Source: Kranthi et al. 2009)

Statistical differences of *Phenacoccus solenopsis* population data on three chrysanthemum varieties were validated using Analysis of Variance and Tukey's test at 5% level. These analysis carried out using IBM SPSS Statistics 23 software.

Observation of Attack Symptoms with Different Population Number

Preparation of test plants

The chrysanthemum varieties used in the study were Fiji Kuning for damage symptoms observations with a total of 30 plants. Plant cuttings were planted in 15 cm × 15 cm polybags containing soil mixed with 20 kg manure and 3 kg TSP fertilizers. NPK fertilizers was given when the plants reached 2 WAP (weeks after planting). Chrysanthemums used in the study were 5 WAP old.

Phenacoccus solenopsis rearing and infestation to plant test

Adult of *Ph. solenopsis* was taken from chrysanthemum plantation at PT Natalia Nursery. Mealybugs were transferred and reared on chrysanthemums that have not yet flowering, then the plants were put into a plastic confinement with a diameter of 20 cm and height of 70 cm. The mealybugs on chrysanthemums were let to reproduce until a sufficient number was obtained for testing.

Four group number of instar-1 nymph were infested into each plant, namely 6, 15, 24, and 33 individuals. And six repeated for each group were done for this test. Mealybugs were normally infested chrysanthemums on the upper stems and leaves shoots. Plants that had been infested were covered with plastic confinement.

Symptoms observation

Damage symptoms due to *Ph. solenopsis* were observed every day starting from 1 DAI (day after infestation) until entering the initial generative stage of plants. The parameters observed included the presence or absence of damage symptoms on plants, the condition of stems, leaves, buds and flower buds. Observation data were presented descriptively.

RESULTS AND DISCUSSION

There were four species of mealybugs found, namely *Phenacoccus solenopsis, Planacoccus minor, Ferrisia virgata* and *Pseudococcus jackbeardsleyi* on chrysanthemum plantation at PT. Natalia Nursery, which *Ph. solenopsis* dominated the plants. Of the four species, two have already been reported by Garcia et al. (2016) and Sridhar et al. (2016) namely, *Ph. solenopsis* and *Ps. jackbeardsleyi*. Another two mealybug species, namely, *F. virgata* and *Pl. minor* have

been firstly recorded in *Chrysanthemum* spp. from this study. Species identification on the genus Ferrisia resulted *F. virgata* only. Although, in Indonesia other Ferrisia species was newly recorded namely *F. dasylirii* but chrysanthemum was not mentioned as its host plants (Zarkani et al. 2020).

***Phenacoccus solenopsis* Tinsley**

The body of an adult female is oval about 5 mm in length, the integument is white to yellowish and covered with a wax coating. This species has 18 lateral wax filaments with the posterior pairs are the longest and has three pairs of black spots on the abdomen and one pair on the thorax (Figure 1a & 1b). Hosts of *Ph. solenopsis* was reported by Garcia et al. (2016), which has 205 plant genera and 64 families. Kedar and Saini (2015) also reported that 13 ornamental plants were the host of *Ph. solenopsis* with two common plants, namely, *Tagetus erecta* and *Chrysanthemum indicum*. Previous research has recorded that *Ph. solenopsis* infested chrysanthemums from low infestation level (Sahu et al. 2019) to high infestation (Vijay & Suresh 2013).

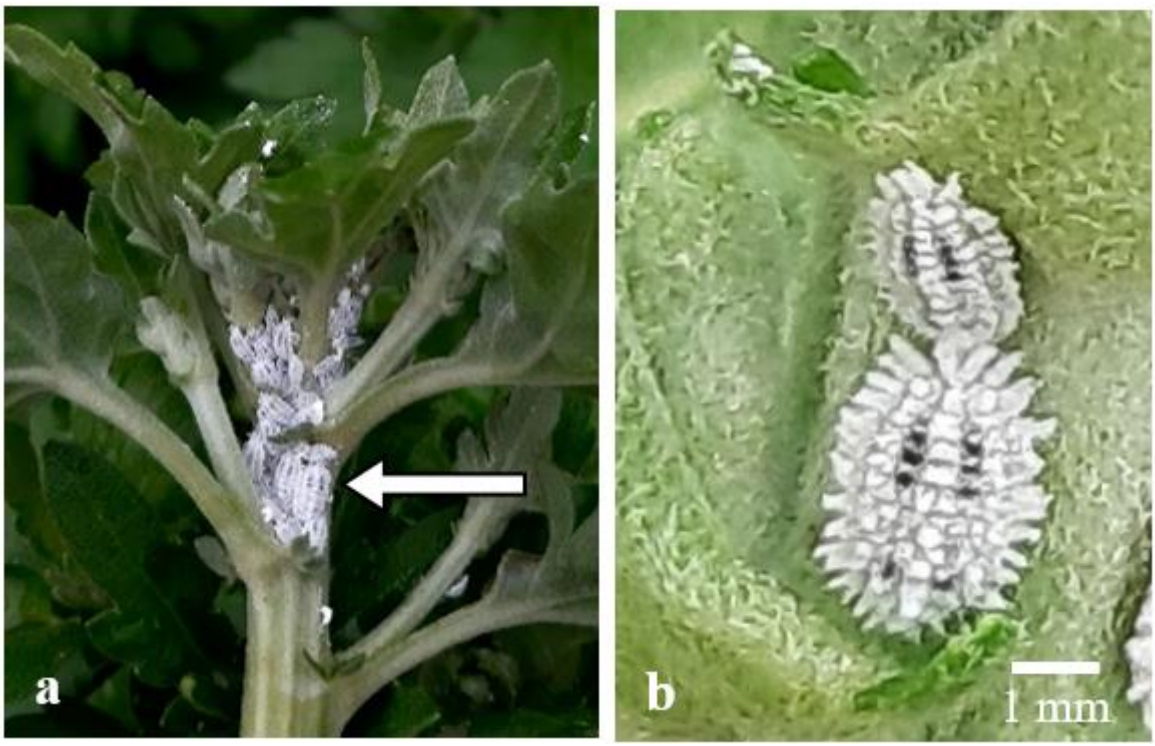

Figure 1. *Phenacccus solenopsis*: (a) colony in stem, (b) adult female

***Planacoccus minor* (Maskell)**

In this study, *Pl. minor* found to invest in the shoots of the leaves (Figure 2a). Adult female mealybug is pinkish, covered with white wax, oval-shaped, wingless, and has a dark line running down the dorsal (Figure 2b). The body can measure up to 4 mm in length, and produce 18 pairs of short lateral filaments with the posteriors pair being longer than the other. *Pl. minor* has a host range of more than 250 species in nearly 80 families, some of which include important crops such as banana, citrus, cacao, coffee, maize, grape, mango and soybean (Roda et al. 2012).

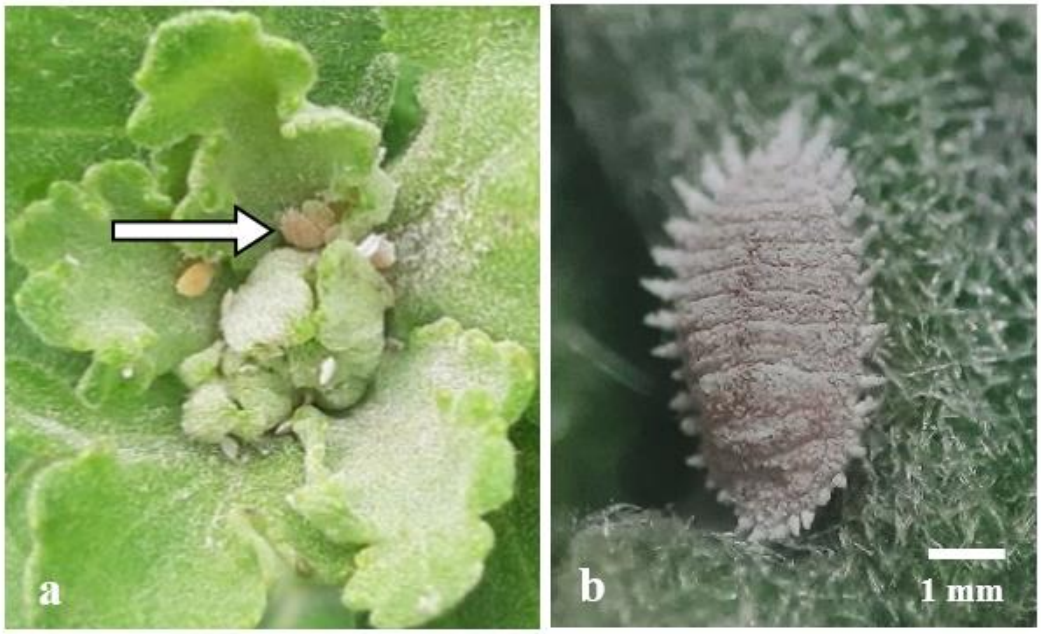

Figure 2. *Planacoccus minor*: (a) nymph 1st instar in shoots, (b) adult female

***Pseudococcus jackbeardsleyi* Gimpel and Miller**

Psedococcus. jackbeardsleyi was found to be infested in the leaf buds and in the axilla (Figure 3a). The body of an adult female is an elongated oval-shaped, greyish with several parallel lines very clearly on the dorsal. It has 17 pairs of waxy filaments lateral and longer posteriorly to equal or surpasses its body length (Figure 3b). Garcia et al. (2016) reported that this species has host plants of 112 genera and 52 families. In Tamil Nadu and Karnataka, India, this species was reported along with *Paracoccus marginatus* that are attacking chrysanthemum (Sylesha 2013).

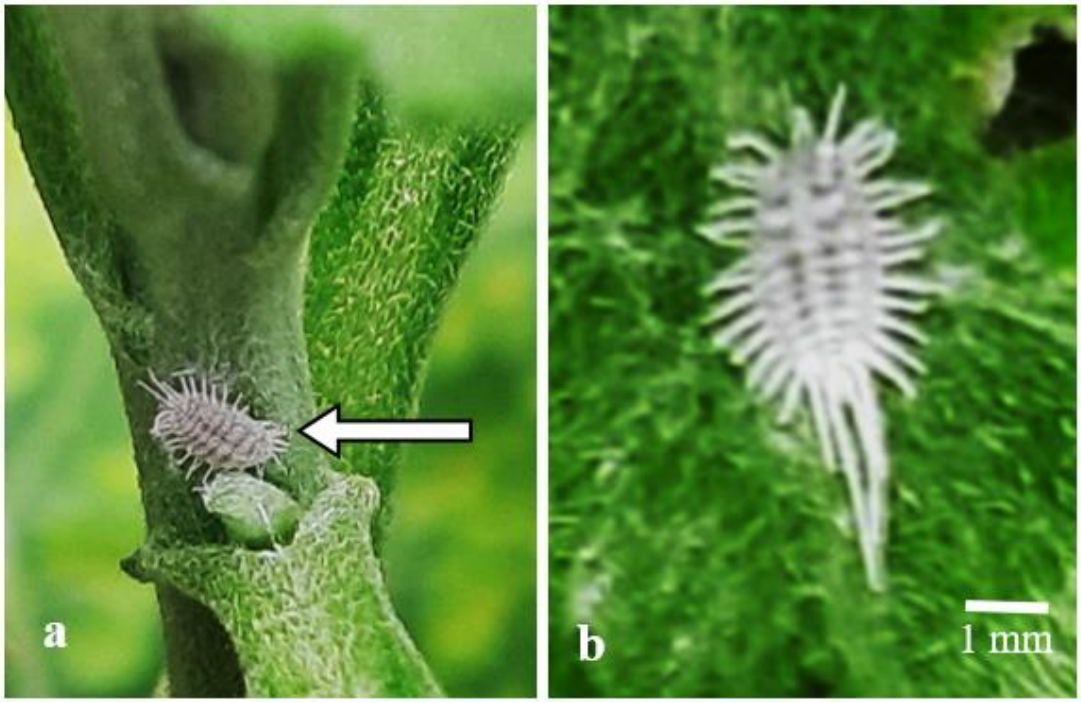

Figure 3. *Pseudococcus jackbeardsleyi:* (a) on the axil of a leaf, (b) adult female

***Ferrisia virgata* (Cockerell)**

Ferrisia virgata is a species that has long cotton-like filaments in all directions with a pair of dark dorsal longitudinal stripes. Adult female covered with white wax, body length of 4 - 5 mm, greenish-yellow, posteriorly has two long, tail-like filaments half the length of its body. *Ferrisia virgata* was found on the back of the leaves (Figure 4a), stems (Figure 4b), and shoots leaf. This species causes damage to various plants such as fruit and flowers. Garcia et al. (2016) noted that the *F. virgata* is one of the most polyphagous mealybugs that has one of the most polyphagous mealybugs with plants in about 210 genera in 79 families.

Figure 4. *Ferrisia virgata*: (a) under the leaves, (b) on the stem

Population of *Phenacoccus solenopsis*

Mealybug of *Ph. solenopsis* was found in chrysanthemum when the third observation occurred or when the plants were 3 WAP (Table 2). In the same week, *Ph. solenopsis* average population in Purple Daisy variety was higher than the other two varieties, whereas the least population was found in the Diamond Standard Pink variety with an average of 1 individual per plot with significantly different results. Significantly different results were also appeared in the Diamond Standard Pink variety against the White Reagent variety at the plant age of 8 WAP with an average population of 46 individuals per plot. The population of *Ph. solenopsis* did not have significant differences in all varieties when the plants were at 4, 5, 6, and 7 WAP. At 7 to 8 WAP the population of *Ph. solenopsis* increased quite largely.

Table 2. The average population of *Phenacoccus solenopsis* on three chrysanthemum varieties

Plant age (WAP)[a]	Average population (mealybugs/plot)		
	White Reagent	Purple Daisy	Diamond Pink
1	0.0a[b]	0.0a	0.0a
2	0.0a	0.0a	0.0a
3	5.5ab	7.0a	1.0b
4	8.5a	6.5a	3.0a
5	7.5a	8.5a	3.5a
6	32.5a	12.5a	21.0a
7	61.5a	35.0a	49.5a
8	73.5a	57.0ab	46.0b

[a]WAP: Week After Planting
[b]Numbers on the same row followed with the same letter shows an insignificant difference for the same plant age based on Tukey's test on the 5% level.

Intensity of *Phenacoccus solenopsis* Attack

The intensity of *Ph. solenopsis* attack on three chrysanthemum varieties is shown in Figure 5. The highest attack intensity occurred at week 8 on the White Reagent variety at 8.72%. White Reagent variety was more susceptible to *Ph. solenopsis* and the attack were continued to increase, although at week 5 is decreased. The decrease has also occurred in the other two varieties at different plant ages. Based on observation, the Diamond Standard Pink variety was the variety that had the lowest attack intensity against *Ph. solenopsis* compared to the other two varieties.

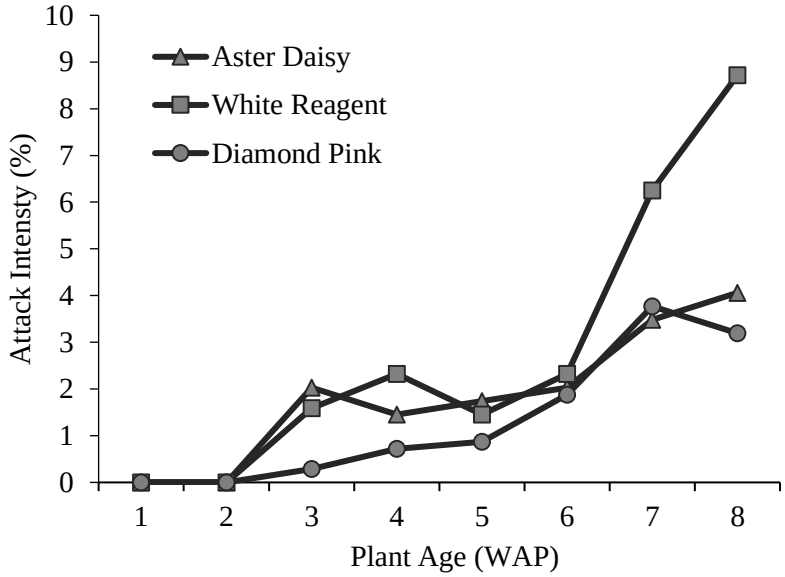

Figure 5. The intensity of *Phenacoccus solenopsis* attack on three chrysanthemum varieties

Symptoms of *Phenacoccus solenopsis* Damage on Chrysanthemum

Damage symptoms on vegetative phase

Based on our observation, the plants started to show the first symptoms after 7 days of infestation in the 24 and 33 individuals treatments. Whereas in plants infested with 6 and 15 individuals, symptoms occurred in 9 DAI. The population of 6 *Ph. solenopsis* individuals shows that the symptoms only occur on the leaves, precisely the surface of the leaves is wavy or uneven (Figure 6a). *Ph. solenopsis*, which was infested into several main stems, did not show any symptoms of damage. It could be seen from the main stem that grew straight without any signs of incurvation. Plants infected by this population could still grow and get taller. On the infestation of 15 individuals, chrysanthemums showed signs of damage on the leaves and stems. This symptom is a malformation of almost an entire leaf shoot, reduced leaf size (Figure 6b), then followed by a curve stem near the shoots.

Similar symptoms also occurred in the infestation of 24 individuals which caused the leaves to shrivel, edges curled, surface thickened, size reduced (Figure 6c) and incurvation of the stems. In the population of 33 individuals, a lot of mealybugs infested the plant's growing point and attacked the shoots, causing disrupted shoot growth and abnormal shape (Figure 7d). Damages on these parts could inhibit the generative growth of plants because the bud would not grow. This statement is supported by Jagadish et al. (2016) which states that when mealybugs infest the vegetative phase and attack the growing point, that will cause stunted plant growth and the plant cannot produce flowers. Apart from the leaves, the stems infested with mealybugs cause incurvation. According to Nagrare et al. (2016), plants affected by mealybugs during the vegetative phase show symptoms of abnormal shoots, shrivelled leaves, stunted plants and leaf fall. Curved stem due to *Ph. solenopsis* is shown in Figure 8a. Meanwhile, plants that were not infested with *Ph. solenopsis* shows no symptoms of damage to both the leaves and the stem which grew straight (Figure 8b).

Figure 7. Damage symptoms on shoots (arrow signs): (a) 6 mealybugs, wavy or uneven leaves surfaces, (b) 15 mealybugs, reduced leaves sizes, malformed leaves edges, (c) 24 mealybugs, shrivelled, curled, and partly thickened leaves, (d-e) 33 mealybugs, damages on shoots, (f) no infestation

Figure 8. Damage symptoms on stems (arrow signs): (a) curved upper stem (b) straight stem, no infestation

Damage symptoms on generative phase

In the generative phase, infested mealybugs entered the second generation and start to reproduce crawlers, causing damage to the bud and flower stalk. Damage symptoms to the bud occurred in the scales leaves. In this part, the size reduced, the leaf surface thickened (Figure 9a) and the leaf bud appears as if twisted (Figure 9b). Subsequent damage occurs to the flower stalks with symptoms of incurvation (Figure 9d-e). Curved flower stalk appeared in 4 of 30 plants with a population of mealybugs above 30 individuals. These symptoms were absent in plants that were not infested with *Ph. solenopsis*. There is no abnormal shape in the leaf and flower bud (Figure 9c) and the flower stalk is straight (9f). Jagadish et al. (2016) also reported that the damage symptoms that occurred in sunflower due to *Ph. solenopsis* is leaf curl, malformation and stunted growth. Mealybugs that attack shoots will affect the buds and flowers of sunflower with a symptom of seedless flower malformation.

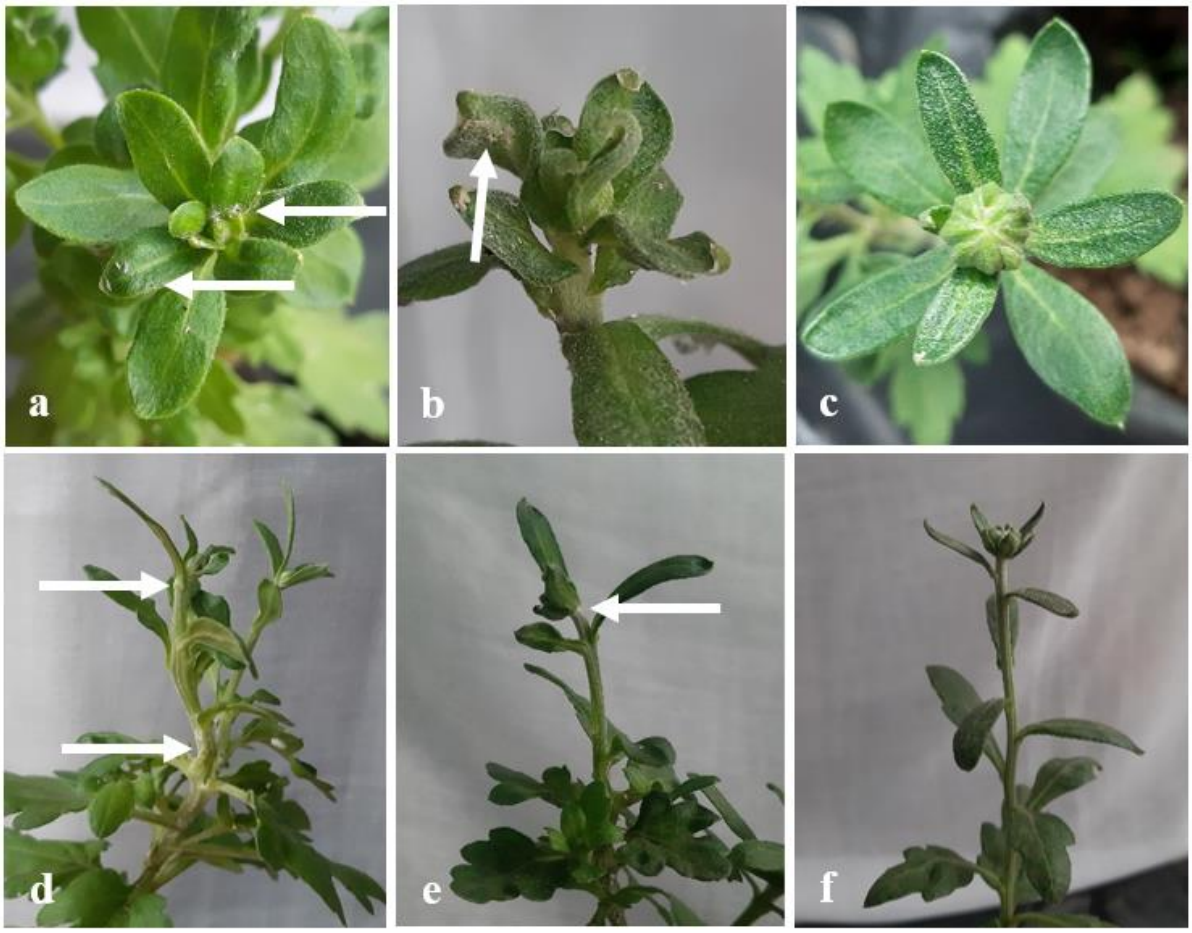

Figure 9. Damage symptoms on generative phase (arrow signs): (a) leaves surfaces thicken, undeveloped bud flower, (b) twisted leaf, (c) no infestation, bud flower normally developed, (d-e) flower stalk incurvation, (e) no infestation, straight stalk

CONCLUSION

There are four mealybugs species found on chrysanthemum, namely, *F. virgata*, *Pl. minor*, *Ph. solenopsis* and *Ps. jackbeardsleyi*, which *Ph. solenopsis* is the dominant species. Chrysanthemum is the new host record for mealybugs species of *F. virgata* and *Pl. minor.* The highest population and intensity of *Ph. solenopsis* attack occurred on *Chrysantemum morifolium* var. White reagent, with a population of 73.5 mealybugs per plot and intensity of 8.72%. Damage symptoms to chrysanthemum are varies: shrivelled, sunken and reduced size of leaves, curved upper stem, and twisted leaf bud. The population of six mealybugs does not inhibit the growth of chrysanthemum, only showed some wavy leaves. Populations of 15, 24, and 33 individuals cause stem incurvation, plant growth inhibition and stunting. A high population up to 30 mealybugs on flowering stage of chrysanthemum caused curved flower stalk.

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