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The Community Structure of Parasitoid Associated with the Cassava Mealybugs on Cassava Crop in Bali Province

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Keywords

anagyrus lopezi;
cassava crop;
mealybug;
parasitoid;
phenacoccus manihoti;

Abstract

A parasitoid is a biological agent that can be used to control the mealybug of cassava crops. Detailed information on the community structure of parasitoid associated with the mealybug of cassava crop in Bali has not been reported. The research community structure of parasitoid associated with cassava mealybug in Bali has to be done to complete this data. This study began from April to August 2019. Samples were taken from 9 districts in Bali, namely Jembrana, Tabanan, Buleleng, Badung, Denpasar, Gianyar, Bangli, Klungkung and Karangasem Regencies. In each district, 5 sample units were selected with the diagonal method and 5 crops that were infected by mealybug were selected purposely in each sample unit. Furthermore, from 5 crops, 20-35 mealybug were taken per species so that the total number of mealybug taken per species per district were 100-175 adults. The results showed that there were 3 species of parasitoids associated with mealybug *Phenacoccus manihoti* namely *Anagyrus lopezi*, *Acerophagus papayae*, and *Blepirus insularis* with the average parasitization rates of 8.7%, 1.6% and 0.5% respectively, and 2 parasitoid species associated with mealybug *Paracoccus marginatus* were *A. lopezi* and *A. papayae* with the average parasitization rates of 2.1% and 4.1%, respectively. The structure of *P. manihoti* and *P. marginatus* mealybug parasitoid communities in Bali showed an unstable community structure. *A. lopezi* and *A. papayae* parasitoids were found spread in all regencies in Bali, while *B. insul*aris parasitoid was only found to spread in several regencies such as Jembrana, Tabanan, Badung, Denpasar and Bangli.

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Contents

1 Introduction

Mealybug is a pest that threatens cassava production in Indonesia. Mealybug attacks cause crop loss of about 30-50% (Dwianri, 2013; Wardani, 2015). In 2014, the attack of mealybug in Indonesia when converted accounts for around Rp 900 billion (Rauf in Kompas. Com, 2014). Mealybug attack on cassava crop is characterized by the appearance of white material on the surface of the leaves (Nurmasari, 2015). Severe attacks cause symptoms of the bunchy top at the shoot and shortening of the stem segment so that the quality and quantity of cassava tubers decrease (Abdulchalek *et al*., 2017).

Up to now, efforts to control mealybug pests on cassava crops by farmers are still based on the use of insecticides. Intensive use of insecticides with excessive concentrations causes adverse side effects to the environment and causes high production costs (Nurmasari, 2015). Besides, the application of insecticides also causes pest resistance and loss of natural enemies such as parasitoids which can later affect the community structure of parasitoids (Georghious & Saito, 2012). Community structure is a concept that studies the structure or composition of species and the abundance and dominance of species in a community. To reduce the damage caused by the use of insecticides, an alternative is needed to control the mealybug attack that does not cause side effects on the environment and farmers. One alternative control that has been reviewed and is environmentally friendly for a long term period is biological control. Biological control is part of a control system that can be used to control mealybug. In biological control, we can use organisms that are natural enemies of the mealybug such as parasitoids. A parasitoid is an insect in the pre-adult phase which becomes a parasite in the body of another insect (host) that can kill or weaken its host, causing death to its host (Purnomo, 2010). Control by using parasitoids provides many advantages because besides being safe for the environment it is also effective in suppressing the development of certain pest populations (Hidrayani *et al.,* 2011). *Anagyrus lopezi* and *Acerophagus papayae* are one of the parasitoids reported to be the natural enemies of mealybug (Abduchalek *et al*., 2017; Robert *et al*., 2015).

To date, detailed information on community structure and the distribution of parasitoids associated with cassava mealybug in Bali Province has not been reported, so studies of community structure and the distribution of parasitoids associated with cassava mealybug in Bali Province need to be conducted.

2 Materials and Methods

This research was conducted through two stages of research. The first stage of the research was conducted in the field and the second stage was carried out in the laboratory. The field research was carried out in the cassava farms owned by farmers in Bali Province. The second stage of the research was conducted at the Integrated Pest Management Laboratory of the Faculty of Agriculture, Udayana University. This research began from April to August 2019.

Samples were taken from 9 districts in Bali, namely Jembrana, Tabanan, Buleleng, Badung, Denpasar, Gianyar, Bangli, Klungkung, and Karangasem Regencies. In each district, 5 sample units were determined by the diagonal method and in each sample unit with an area of 250,000 m2, 5 plants that were attacked by mealybug were selected purposively. Furthermore, from those 5 plants, 20-35 mealybug were taken per species so that the total number of mealybug taken per species per district were 100-175 adults.

The mealybug obtained were then put into a transparent plastic cup with a height of 15 cm and a diameter of 10 cm. Mealybug in plastic cups was maintained until the parasitoids appeared. Emerging parasitoids were identified based on morphological and color characteristics (Noyes & Hayat, 1994).

Data Analysis

1) The diversity of the Mealybug parasitoid species was calculated using the Shannon-Wienner iversity index (Magurran, 2005):

$$H' = - \Sigma Pi \ln Pi \longrightarrow pi = ni/N$$

Note: H ' : diversity index
Pi : ni / N (number of individuals of type I divided by the total number of individuals).
Ni : number of individual types i
N : total number of individuals
Index value: <1.5 = Low diversity index
1.5-3.5 = Medium diversity index
> 3.5 = High diversity index

2) The abundance index is calculated using the Margalef index formula (Magurran, 2005).

$$R1 = \frac{S - 1}{\ln N}$$

Note: R1 = Index of abundance
S = Number of species found
Ln = Logarithm nature
N = Total number of individuals

Index value:
<2.5 = Low species abundance
2.5-4.0 = Moderate species abundance
> 4.0 = High species abundance

3) The dominance index is calculated using the Menhinick index (Magurran, 2005).

$$D = \Sigma \frac{ni\ (ni-1)}{N\ (N-1)}$$

Note : D = Indeks of dominance
N = Total number of individuals
Ni = Number of individual types i

Index value: 0.00 <D <0.30 = Low dominance index
0.30 <D <0.60 = medium dominance index
0.60 <D <1.00 = High dominance index

4) The percentage of parasitoids using the formula of Sasmita and Baehaki (Magurran, 2005).

$$\text{Percentage of parasitoid} = \frac{\text{Number of parasitoid}}{\text{Number of mealybug}}$$

3 Results and Discussions

The type and parasitization rate of mealybug parasitoid

Based on morphological characteristics such as color and embellishment, 4 species of mealybug that were found attacking cassava crop in Bali Province had been identified, namely *Phenacoccus manihoti*, *Paracoccus marginatus*, *Ferrisia virgata*, and *Pseudococcus jackbeardsleyi*. From the four mealybug species, 3 parasitoids were found, namely *Anagyruz lopezi, Acerophagus papayae*, and *Blepirus insular* which were associated with the cassava mealybug *P. manihoti* and only 2 parasitoid species namely *A. lopezi* and *A. papayae* were associated with the cassava mealybug *P. marginatus*. No parasitoid was found to be associated with *F. virgata* and *P. jackbeardsleyi*. The parasitization rates of the parasitoid for mealybug *P. manihoti* and *P. marginatus* are presented in Figure 1 and Figure 2.

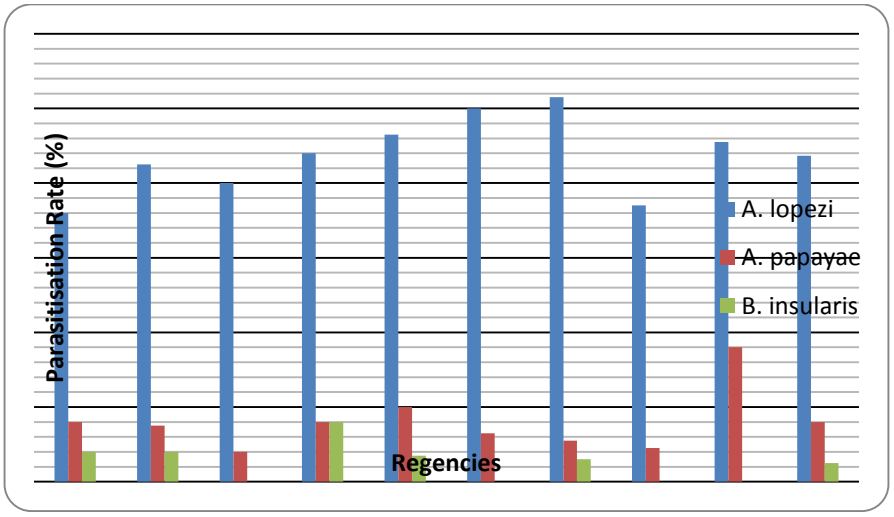

Figure 1. Parasitization rate of parasitoid on *Phenacoccus manihoti*

Figure 1 can be seen that the three parasitoid species had different parasitization rates in each district. *A. lopezi* had the highest parasitization rate in Bangli Regency at 10.3% and the lowest in Jembrana Regency at 7.2%. *A papayae* had the highest parasitization rate in Jembrana Regency at 3.6% and the lowest in Buleleng Regency at 0.8%. *B. insularis* had the highest parasitization rate in Badung Regency at 1.6% and lowest in Buleleng, Gianyar, Klungkung and Karangasem Regencies at 0%. From these three parasitoids, *A. lopezi* was the parasitoid with the highest parasitization rate for *P. manihoti* in Bali Province compared to *A. papayae* and *B. insularius* (Figure 1). The high parasitization rate of *A. lopezi* in the mealybug *P. manihoti* is due to *P. manihoti* is the main host of *A. lopezi* (Karyani *et al*., 2016; Lindayani *et al.,* 2018).

The parasitization rate of *A. papayae* on *Paracoccus marginatus* in each district ranged from 2.9% to 5.6%, while the parasitization rate of *A. lopezi* ranged from 1.3% to 3.2%. The average parasitization rate of *A. papayae* in the mealybug *P. marginatus* in Bali province was higher than *A. lopezi* (Figure 2). According to Amarasekare (2008), *A. papayae* is a natural enemy of *P. marginatus* which is from American continent. Amarasekare *et al.* (2009), found that *A. papayae* is more effective in controlling *P. marginatus* in the field than *Anagyrus loecki*, and *Pseudleptomastix Mexicanai*.

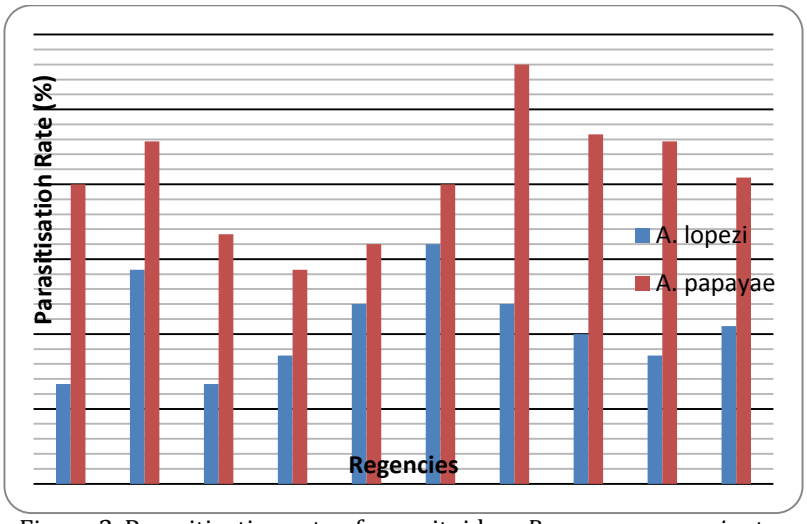

Figure 2. Parasitization rate of parasitoid on *Paracoccus marginatus*

The parasitization rate is greatly influenced by the population of mealybug parasitoids. High and low parasitoid population is influenced by several factors such as suitability of the host, the availability of host crops, the use of insecticides and others. Host suitability is able to support the rapid growth and development of insects so as to increase its population (Wulandari *et al*., 2018). According to Baggen & Gurr (1998), the availability of host crops that are used as a source of nutrition for parasitoids can increase the ability of parasitoids as biological agents. The use of unwise insecticides on agricultural land can cause a decrease in parasitoid populations both directly because it can poison the parasitoids and indirectly because of the death of the parasitoid host so that parasitoids cannot multiply its population (Miwada *et al.,* 2019).

The community structure of the mealybug parasitoid

Community structure is a concept that studies the structure or composition of species and their abundance in a community (Schowalter, 2016). In general, there are three approaches that can be used to describe community structure, namely diversity, abundance, and species domination. The study of the diversity, abundance and dominance of mealybug parasitoid species in Bali Province is aimed to obtain the community structure description of the parasitoid associated with mealybug that attacks cassava crops.

In this study, 2 parasitoid community structures were obtained, namely parasitoid community structure associated with mealybug *P. manihoti* (Table 1) and parasitoid community structure associated with mealybug *P. marginatus* (Table 2)

Table 1
Community structure of parasitoid associated with *Phenacoccus manihoti* mealybug

Mealybug parasitoid	Number of parasitoid on each regency in Bali*)								
	1	2	3	4	5	6	7	8	9
A. lopezi	9	8	11	13	16	17	17	7	12
A. papayae	2	2	1	1	3	2	2	1	4
B. insularis	1	1	0	2	1	0	1	0	0
N Parasitoid	12	11	12	16	20	19	20	8	16
N mealybug	125	130	125	125	150	150	175	110	110
Diversity (H')	0.72	0.76	0.29	0.60	0.61	0.34	0.52	0.38	0.56
Abundance (R1)	0.80	0.83	0.80	0.72	0.67	0.68	0.67	0.96	0.72
Domination (D)	0.56	0.53	0.83	0.66	0.65	0.80	0.72	0.75	0.60

Information: regency*) 1: Jembrana, 2: Tabanan, 3: Buleleng, 4: Badung, 5: Denpasar, 6: Gianyar, 7: Bangli, 8: Klungkung, 9: Karangasem

Based on the results of community structure analysis in Table 1 shows the value (H') in each district ranged from 0.29 to 0.76 with an average of 0.53. According to Shannon-Wiener (Magurran, 2005), the parasitoid diversity index associated with mealybug *P. manihoti* is belong to the low category because it has a diversity index value of <1.5. Parasitoid abundance index values associated with mealybug in all locations ranged from 0.67 to 0.96 with an average of 0.76. According to Margalef (Magurran, 2005), the abundance index of mealybug parasitoid belongs to the low category because it has a value of <2.5. The dominance index value of mealybug *P. manihoti* parasitoids in each regency is belonged to the moderate and high dominance categories, because it has the dominance index value ranging from 0.53 to 0.83 with an average of 0.68. According to Kent & Paddy (1992), the community structure of the parasitoid associated with mealybug *P. manihoti* in each regency in Bali has a less stable structure. This is because it has a diversity index value smaller than 1.

Table 2
Community structure of parasitoid associated with *Paracoccus marginatus* mealybug

Mealybug parasitoid	Number of parasitoid on each regency in Bali*)								
	1	2	3	4	5	6	7	8	9
A. lopezi	2	5	2	3	3	4	3	3	3
A. papayae	6	8	5	5	4	6	6	7	8
N Parasitoid	8	13	7	8	7	10	9	10	11
N mealybyg	150	175	150	175	125	125	125	150	175
Diversity (H')	0.56	0.67	0.60	0.66	0.68	0.67	0.64	0.61	0.59
Abundance (R1)	0.48	0.39	0.51	0.48	0.51	0.43	0.46	0.43	0.42

Information: Regency*) 1: Jembrana, 2: Tabanan, 3: Buleleng, 4: Badung, 5:Denpasar, 6: Gianyar, 7: Bangli, 8: Klungkung, 9: Karangasem

The results of the community structure analysis in Table 2 show that the value (H') in each district ranged from 0.56 to 0.68 with an average of 0.63. According to the Shannon-Wiener provisions (Margurran, 2005), the parasitoid diversity index associated with mealybug *P. manihoti* is belong to the low category because it has a diversity index value of <1.5. The parasitoid abundance index values associated with mealybug in all locations ranged from 0.39 to 0.51 with an average of 0.46 included in the low category. According to Margalef (Magurran, 2005), if the abundance index value is <2.5 then it is categorized as low. The dominance of mealybug *P. manihoti* parasitoids in each district is included in the moderate dominance category because it has the index value ranging from 0.43 to 0.57 with an average of 0.50. According to Kent & Paddy (1992), the community structure of the parasitoid associated with mealybug *P. manihoti* in each district in Bali has a less stable structure. This is because the diversity index value obtained is smaller than 1.

The stability of a community indicates the survival of each species that constructs the community. A stable community structure indicates that the preservation of species in the community can be maintained. An unstable community structure indicates that the preservation of one type of community is threatened (Mawazin, 2013).

The distribution of the mealybug parasitoid

The results showed that the parasitoid *A. lopezi* and *A. papayae* spread throughout the regencies in Bali Province, whereas the parasitoid *B. insularis* was only found in Jembrana, Tabanan, Badung, Denpasar and Bangli (Figure 3). According to Burrel & Baudry (1995), the distribution of parasitoid species depends on the biological characteristics of the species and the availability of its host.

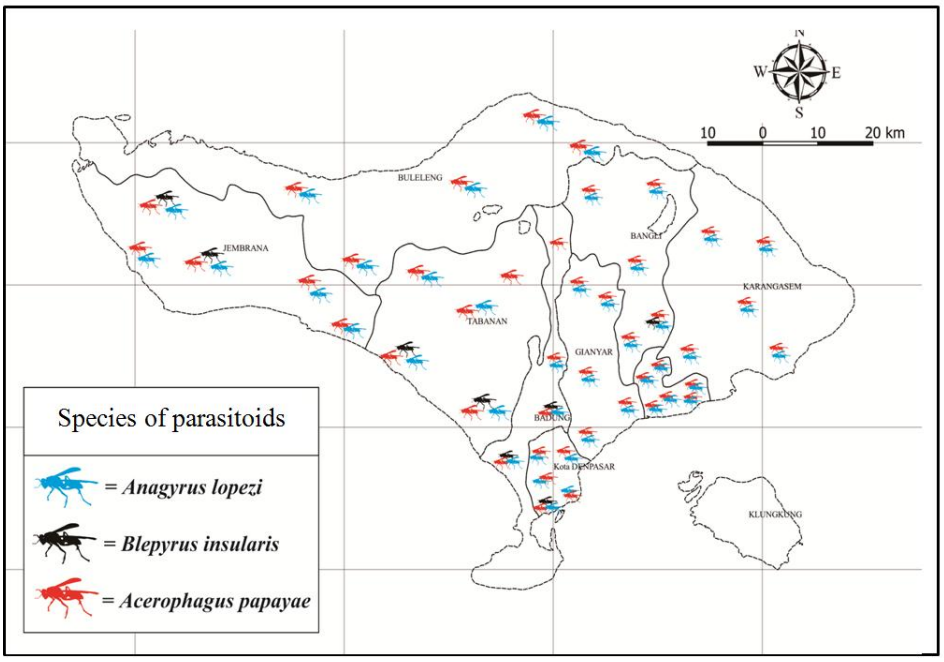

Figure. 3. Map of the distribution of mealybug parasitoid in Bali

4 Conclusion

The results showed that there were 3 species of parasitoids associated with mealybug *P. manihoti*, namely *A. lopezi, A. papayae*, and *B. insularis* with the average parasitization rates of 9.1%, 1.6% and 0.5%, respectively. This study only found two species of parasitoids in mealybug *P. marginatus,* namely *A. lopezi* and *A. papayae* with the average parasitization rates of 2.1% and 4.1%, respectively. The community structure of the parasitoid in mealybug *P. manihoti* and *P. marginatus* in Bali are unstable. The parasitoid A*. lopezi* and *A. papayae* had been found to spread in all regencies in Bali, while the parasitoid *B. insularis* had been found to spread in several districts such as Jembrana, Tabanan, Badung, Denpasar, and Bangli.

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