Arthropoda diversity in organic cocoa farming in Bantaeng District

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Abstract. Cocoa is an important commodity boosting national economy especially as a provider of employment, a source of income and foreign exchange. Organic cocoa cultivation can reduce production costs and benefit farmers. Farmers do not need to use inorganic fertilizers and pesticides. One of the problems faced in cocoa cultivation includes pest attacks that play a role in causing a decrease in productivity of cocoa plantations. Types of natural enemies such as insects can also play a role as biological control (a predator for other insects) that is able to suppress plant insect pest populations. The study aims to determine the type and number of arthropods found in cocoa plants that are managed organically and inorganically.

The study was conducted in cocoa plantation area of Gantarang Keke Sub-district, Bantaeng District. Area of organic and inorganic cocoa plantations is ± 1 Ha. Determination of sample plants was carried out randomly using diagonal method, which was 5 replications and in each replication were 5 cocoa plants. Sampling technique is done by net method for plants that are around the plant and Pitfall traps for soil arthropods. Arthropods that were caught were then identified. Data analysis uses statistical t-test. The results showed that in organic cocoa plants, total arthropods population was 50% higher compared to inorganic cocoa farms. Arthropods that are active at soil surface are more commonly found in organic farms, namely order Hymenoptera, Formicidae family which acts as a predator.

1. Introduction
Cocoa is one of the mainstay commodity plantations that is quite important for the national economy, especially as a provider of employment, a source of income and foreign exchange. In 2009, cocoa plantations provided employment and a source of income for ± 1.29 million family heads of farmers, mostly in Eastern Indonesia, and contributed the third largest foreign exchange contribution to the plantation sub-sector after rubber and palm oil with a value of 624 million dollars US [1]. Organic cocoa cultivation can reduce expenditure costs and benefit farmers [2]. Farmers do not need to use inorganic fertilizers and pesticides. The use of organic fertilizers and pesticides is likely to harm farmers. number of the problems faced in cocoa cultivation is poorer nutrients, especially micro-nutrients and natural hormones, pest and disease infestation [3], as well as other maintenance factors that are not optimal will affect the level of production and quality of low cocoa pods [4].

The role of insects is important to cause an increase or decrease in the productivity of cocoa [5]. Types of natural enemies such as insects can also play a role as biological control (a predator for other...
insects) that is able to suppress plant insect pest populations. A common predatory insect is the praying mantis (*Hierodula* sp.; *Mantodea; Mantidae*), ant (Hymenoptera; *Formicidae*), wolf spider (Arachnida; *Lycosidae*), which preys on other insects. In a plantation ecosystem there are also parasitic insects in other insects (*Cleptoparasitisme*), for example from the Order Diptera and Hymenoptera which can be as endoparasites or ectoparasites. The presence of parasitic insects on plantations can help suppress insect pest populations [6]. The continuous use of pesticides will certainly cause more serious problems, namely the killing of natural enemies, occurrence of resurgence, secondary pest outbreaks, and environmental pollution [7,8]. To anticipate this problem, the concept of integrated pest control is an appropriate alternative, because IPM aims to limit the use of pesticides as little as possible but the target quality and quantity of production can still be achieved [5]. In integrated pest control strategies, exploiting the potential of natural enemies has an important role in suppressing the abundance of pest populations. Cocoa plants are generally cultivated under shade trees so that the relative humidity in the plant canopy is quite high but the light intensity is quite low.

2. **Materials and methods**

2.1. **Determination of location**
Determine the location of organic and inorganic cocoa farms of ± 1 Ha size to be observed, then determine the cocoa plants that will be sampled with a diagonal shape of 5 replications at random, in each test there are 5 cocoa plants. Organic cocoa farms use vegetable pesticides such as maja fruit, lemongrass, soursop leaves, sugar apple seeds, tuba roots, which are used as pesticides for pests, while vegetable pesticides for diseases such as galangal, lemongrass, clove leaves, cashew seeds, and soursop leaves. Whereas in inorganic cocoa farms use synthetic pesticides such as Za, NPK, and Urea.

2.2. **Sampling**
Sampling was carried out by the Pitfall Traps method, namely by using aqua glass with a length of ± 5cm. Placed under a tree that has been made a hole using a small crowbar to plant a trap pitfall traps that have been filled with water and soap. Pitfall traps were placed in 9 units in 1 repetition with different cocoa trees.

2.3. **Data analysis**
Data analysis was used with T-test statistical test, namely:

$$t_{hit} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s^2_1}{n_1} + \frac{s^2_2}{n_2}}}$$

Information:
- $\bar{X}_1$: Average number of insects in organic treatment
- $\bar{X}_2$: Average number of insects in inorganic treatment
- $s^2_1$: Variety of organic treatments
- $s^2_2$: Variety of inorganic treatment
- $n_1$: The number of insects in organic treatment
- $n_2$: Number of insects in inorganic treatment

3. **Results and discussion**
The number of arthropods caught using Pitfall Traps in the area of organic cocoa and inorganic cocoa is 9 orders, with an organic cocoa arthropod population of 554 trails, while the total population of inorganic cocoa arthropods was 265 trails (table 1).
Table 1. Arthropod population in organic and inorganic cocoa plantation using the pitfall traps method

| Order      | Family         | Farming system | Role   |
|------------|----------------|----------------|--------|
|            |                | organic        | inorganic |
| Coleoptera | Tenebrionidae  | 12             | 6      |
|            | Cicindelidae   | 7              | 5      |
|            | Carabidae      | 9              | 3      |
|            | Chrysomelidae  | 6              | 3      |
|            | Scarabaeidae   | 9              | 2      |
|            |                | Total          | 43     |
| Orthoptera | Acrididae      | 9              | 2      |
|            | Tettigoniidae  | 4              | 4      |
|            |                | Total          | 13     |
| Hymenoptera| Formicidae     | 338            | 130    |
|            | Scoliidae      | 11             | 5      |
|            |                | Total          | 349    |
| Hemiptera  | Alydidae       | 34             | 14     |
|            | Reduviidae     | 5              | 3      |
|            | Coreidae       | 13             | 6      |
|            |                | Total          | 52     |
| Diptera    | Sarchopagidae  | 5              | 5      |
|            | Asilidae       | 5              | 5      |
|            | Drosophilidae  | 8              | 8      |
|            | Culicidae      | 8              | 22     |
|            | Anthomyiidae   | 3              | 5      |
|            |                | Total          | 29     |
| Dermaptera | Forficulidae   | 14             | 11     |
|            |                | Total          | 14     |
| Lepidoptera| Lymantriidae   | 11             | 3      |
|            | Arctiidae      | 4              | 6      |
|            | Geometridae    | 7              | 3      |
|            |                | Total          | 22     |
| Arachnida  | Araneidae      | 11             | 5      |
|            | Lycosidae      | 9              | 5      |
|            |                | Total          | 20     |
| Neuroptera | Myrmeleonidae  | 12             | 4      |
|            |                | Total          | 12     |
|            |                | Number of insects | 554 | 265 |

Table 1 shows that 9 (nine) orders of insects by using the pitfall Traps both organic and inorganic cocoa farms. While the total number of insects found more in organic cocoa were 554 tails while the insect population of inorganic cocoa were 265.
Table 2. Statistical t test results per family in organic and inorganic cocoa farms

| Order       | Family          | Farming system | T-Test Results |
|-------------|-----------------|----------------|----------------|
|             |                 | Organic        | Inorganic      | t hit | t' |
| Coleoptera  | Tenebrionidae   | 2.4            | 1.2            | 0.85<sup>m</sup> | 1.9 |
|             | Cicindelidae    | 1.4            | 1              | 0.28<sup>m</sup> | 2.03|
|             | Carabidae       | 1.8            | 0.6            | 0.85<sup>m</sup> | 2.39|
|             | Chrysomelidae   | 1.2            | 0.6            | 0.42<sup>m</sup> | 2.46|
|             | Scabridae       | 1.8            | 0.4            | 0.99<sup>m</sup> | 4.08|
| Orthoptera  | Acrididae       | 1.8            | 0.4            | 0.99<sup>m</sup> | 4.08|
|             | Tettigoniidae   | 0.4            | 0.8            | 0<sup>m</sup>    | 2.35|
| Hymenoptera | Formicidae      | 67.6           | 26             | 29.5<sup>t</sup> | 1.64|
|             | Scoliidae       | 2.2            | 1              | 0.85<sup>m</sup> | 1.97|
| Hemiptera   | Alydidae        | 6.8            | 2.8            | 2.83<sup>+</sup> | 1.7 |
|             | Reduviiidae     | 1              | 0.6            | 0.28<sup>m</sup> | 2.52|
|             | Coreidae        | 2.6            | 1.2            | 0.99<sup>m</sup> | 1.89|
| Diptera     | Sarchopagidae   | 1              | 1              | 0<sup>m</sup>    | 2.13|
|             | Asilidae        | 1              | 1              | 0<sup>m</sup>    | 2.13|
|             | Drosophilidae   | 1.6            | 1.6            | 0<sup>m</sup>    | 1.89|
|             | Culicidae       | 1.6            | 4.4            | -1.4<sup>m</sup> | 1.80|
|             | Anthomyiidae    | 0.6            | 1              | 0.28<sup>m</sup> | 2.52|
| Dermaptera  | Forficulidae    | 2.8            | 2.2            | 0.42<sup>m</sup> | 1.79|
| Lepidoptera | Lymantridae     | 2.2            | 0.6            | 1.13<sup>m</sup> | 2.86|
|             | Arctidae        | 0.8            | 1.2            | 0.28<sup>m</sup> | 2.18|
|             | Geometridae     | 1.4            | 0.6            | 2.56*          | 2.43|
| Arachnida   | Araneidae       | 2.2            | 1              | 0.85<sup>m</sup> | 1.97|
|             | Lycosidae       | 1.8            | 1              | 0.56<sup>m</sup> | 1.99|
| Neuroptera  | Myrmeleonidae   | 2.4            | 0.8            | 1.3<sup>m</sup>  | 2.07|

For Hymenoptera, the population of *Formicidae* in organic cocoa farms was higher (67.6) than population in inorganic farms (26) based on T-test analysis ($T_{hit} 29.5$; $T_{tab} 1.64$) (table 2). For Hemiptera, the population of *Alydidae* in organic farms was significantly higher than population in inorganic gardens ($T_{hit} 2.83$; $T_{tab} 1.7$) and For Lepidoptera, the population of *Geometridae* family in organic cocoa farms was significantly higher than the population in inorganic cocoa farms ($T_{hit} 2.56$; $T_{tab} 2.43$). In contrast, among other populations no significant different population of *Tenebrionidae*, *Cicindelidae*, *Carabidae*, *Chrysomelidae*, *Scarabaeidae*, *Acrididae*, *Tettigoniidae*, *Scoliidae*, *Reduviidae*, *Coreidae*, *Sarchopagidae*, *Asilidae*, *Drosophilidae*, *Culicidae*, *Anthomyiidae*, *Forficulidae*, *Lymantridae*, *Arctiidae*, *Araneidae*, *Lycosidae*, and *Myrmeleonidae* occurred in both organic and inorganic farms.

The most active insects found in surface ground of both organic and inorganic farms were from Order *Hymenoptera*, family *Formicidae* (table 1). And, in both organic and inorganic farms the arthropods discovered were more diverse population identified as the role of plant pests and predators, parasitoids and pollinators. The role of insects in occupying agro-ecosystem varies. There are active insects in surface ground as pests and natural enemies, some decompose organic matter, and some are pollinator allowing plant breeding service [6].

Arthropods that are active at ground level based on table 1, which is found in organic cocoa farms without the application of chemical pesticides shows that predatory, phytophagy, and decomposing insects are higher in organic cocoa farms than in inorganic cocoa farm that use chemical pesticides. Organic farming performs a better processing plantation [10]. The number of insects inhabiting the soil surface particularly a group of predators in organic farm seemed to have a higher population than inorganic farm [11]. More diverse arthropod types in organic cocoa plants consisted of order of
Hymenoptera, Formicidae family than inorganic cocoa and population dynamics in each organism in the farms differed from time to time. One of six interrelated factors dictating population dynamic is the increase of diversity of the community by the time [12], the more heterogenous vegetation in farm, the more complex flora and fauna communities. In farm, competition in space or food always happens once number of organisms exploits the same sources, no matter whether source sufficiency, competition continues to occur.

4. Conclusion
There were more populated and diverse arthropods in organic farm than inorganic cocoa farms. One of the arthropods’ families found active in surface of the soil of organic farms was Formicidae family (Hemynophtera) with a predator role.

References
[1] Directorate General of Plantations 2018 Statistics of Indonesian plantations 2015-2018 (Jakarta: Agriculture Department)
[2] Kuswinanti T, Junaid M, Melina, Surapati U and Ratnawaty 2019 A promising microbial use on cocoa: decomposing cocoa waste and controlling Lasiodiplodia theobromae in-vitro IOP Conference Series: Earth and Environmental Science 343 102256
[3] Marelli J P, Guest D I, Bailey B A, Evans H C, Brown J K, Junaid M and Puig A S 2019 Chocolate under threat from old and new cocoa diseases Phytopathology 109 1331-1343
[4] Syarkawi, Husni and Sayuthi M 2015 Effect of the altitude on the level of cocoa pod borer (Conopomorpha cramerella Snellen) attack in Pidie District J. Floratek. 10 52-60
[5] Putra I G A P, Watiniasih N L and Suartini N M 2011 Inventarisasi serangga pada perkebunan kakao (theobroma cocoa) laboratorium unit perlindungan tanaman Desa Bedulu, Kecamatan Blahbatuh, Kabupaten Gianyar, Bali Biology Journal 14 19-24
[6] Gustianda, Sari R H and Zulaikha S 2015 The dominance of tree insects in the mountains of Sawang Ba’u, Sawang Sub district, South Aceh Regency Proceedings of Biotic National Seminar 138-141
[7] Rauf A, Shepord B M and Johnson M W 2000 Leafminers in vegetables, ornamental plants and weeds in Indonesia: Survey of host crops, species composition and parasitoid Int. J. Pest Manage. 46 257-266
[8] Wanguyun A P and Geraldi A 2019 Understanding Pesticide Degrading-microbe Community Using Molecular Approaches Pollut. Res. 38 118-22
[9] Untung K 1996 Introduction to Integrated Pest Management (Yogyakarta: Universitas Gadjah Mada Press)
[10] Widiarta I N, Kusdiaman and Suprihanto 2006 Arthropod diversity with integrated crop management JHPTT 6 61-69
[11] Suryadi D, Megawati A, Susilo B, Dalimartha L M, Wiguna E C, Isdiantoni, Koentjoro M P and Prasetyo E N 2017 Integrated management model of organic horticulture for narrow land plantation Proceeding Biology Education Conference 14 118-125
[12] Sianipar M S, Luciana D, Entun S and Hidayat R C S 2015 Pest insect diversity index on rice (Oryza sativa L.) in paddy rice fields in Sukawening Village, Ciwidey District, Bandung Regency Bioma 17 9-15