Community structure of arthropods on the sea of sand at Bromo Tengger Semeru National Park

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Abstract. Bromo Tengger Semeru National Park (TNBTS) is the only conservation area in Indonesia that is unique with 5.25 ha of sea sand. A unique area usually presents specific organism within it. Such as Imperata cylindrica, it is one of the reeds that well-growth in the sea sand of TNBTS. Meanwhile, research on arthropods in a particular sea of sand habitats has never been done specifically in Indonesia. Thus, encouraging the authors to determine the differences of arthropods community structure between densely vegetated (I. cylindrica) area and non-vegetated area in the Sea of Sand at TNBTS. Pitfall-trap and funnel berlese were performed with 20 repetitions, respectively. Community structure analyses were identified using Diversity Index (H'), Importance Value Index (IVI), and Bray-Curtis Index. Results showed that the IVI score in the vegetated area is 129 and dominated by Formicidae, while non-vegetated areas present 144 scores and dominated by Aphididae. The diversity index (H') at the location with vegetation is higher than the location without vegetation. However, both locations showed a low diversity level. Bray-Curtis index shows an unsimilarity between two locations, indicated by 0.1 scores. This finding reveals that the arthropods community structure in the sea of sand between the vegetated area and non-vegetated area is different.

1. Introduction
Bromo Tengger Semeru National Park is the only conservation area in Indonesia that is unique in the form of a 5.25 ha sand sea [1]. Vegetation that grows at the base of the caldera is generally heat-resistant plants (sulfuric fumes emanating from the crater of Mount Bromo) such as: Casuarina sp., Acacia decurrens, Albizia lophanta, Anaphalis javanica, sand orchids, dan Imperata cylindrica. I. cylindrica is one of the most widely grown plants in the sand sea of Mount Bromo [2].

Land predominantly with reeds, can reduce the productivity and the auality of the soil. Reeds is a very strong weeds that compete to get the nutrients, light and water with other plants [3]. Soil organic matter is reduced by the water that carries over with the erosion process. This can be a warning to groups of animals that live terrestrial in the sand sea of Mount Bromo such as the Arthropods. Arthropods, especially in the Aceloterate Sub-phyllum; Insecta Class, Entognatha Class etc. it has a high level of survival rate and can live in extreme environmental conditions [4]. In desert regions with very high temperatures and cold snowy areas, several groups of insects can still exist [5].

One of the efforts to conserve natural resources is to carry out an inventory of soil animals in the sand sea of TNBTS. Research on Arthropods in particular sand sea habitats has never been done specifically in Indonesia, thus encouraging authors to conduct research on the community structure of
Arthropod in the sand seas of Bromo Tengger Semeru National Park, in the areas with *I. cylindrica* and areas without *I. cylindrica*. This research was done to uncover the diversity of Arthropods and as a conservative step for the inventory of Arthropods in the study of taxonomy and ecology.

2. Material and Method

2.1 Research Location

This research was conducted in the sand sea of Bromo Tengger Semeru National Park (TNBTS) East Java. The sampling point was shown in detail at Figure 1, with the sampling location in the sand sea with vegetation of the *I. cylindrica* and no vegetation. Sample identification and data analysis were carried out at the Ecology and Animal Diversity Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang.

![Figure 1. Sampling point at the sand sea of Mount Bromo](image)

2.2 Pitfall Trap and Funnel Berlese

The main method used are Pitfall traps and sand sampling (funnel berlese) [6]. Plots installed at each location (with vegetation and no vegetation) were 20 Pitfall traps and 19 sand sampling. Abiotic factors measured include air temperature, light intensity, air humidity, sand moisture, conductivity, sand pH, and water content in sand [7]. Measurement of water content is following the formula below:

\[
\text{% Dry Content} = \frac{\text{Cup weight and soil} - \text{final soil weight}}{\text{initial soil weight}} \times 100 \%
\]

\[
\text{% humidity} = 100 - \text{Dry content}
\]

Collected data then analyze to know the community structure of arthropods by three indexes, including diversity index (H’), important value index (IVI), and bray-curtis index.

3. Results and Discussion

3.1 Arthropods in the Sea of Sand with Imperata cylindrica Vegetation

Using pitfall trap on the vegetated area showed that (Figure 2a) the most dominant group is Formicidae Family with totally 234 individuals with an IVI value of 129.17%. Formicidae is the most dominant terrestrial animal group in the tropical area, ants play an important role in terrestrial ecosystems as predators, scavenger, herbivore, detrivor and granivore, and also have a role in their interactions with plants or other insects [8].

The Formicidae family is found in sandy seas with *I. cylindrica* vegetation because it has the ability
to explore various food sources, carcass eaters, some eat plants, so ants have a high survival rate [9]. Other Arthropod families found are the Oecophoridae, Delphacidae, Aphididae, Carabidae, Culicidae, Acarina and Lycosidae families (Figure 4).

![Figure 2. IVI Values (%) of Families found in the sea of sand with *I. cylindrica* using: (a). Pitfall trap method, (b). Funnel berlese method](image)

The Delphacidae family was found in 11 individuals with an IVI of 25.03%. Aphididae families were found as many as 10 individuals with IVI 17.68%, Family Oecophoridae (moth) found as many as 7 individuals with IVI score of 11.91%. Carabidae and Culicidae families were found in 2 individuals with IVI 5.39%, respectively. Acarina and Lycosidae Family were found only 1 individual with IVI 2.69%, respectively.

The value of Shanon-Wiener index ($H'$) in the sand of sea with *I. cylindrica* vegetation using pitfall trap method is 0.58 which means that in vegetated sea of sand has a low level of Arthropod diversity (Table 1).

Using funnel berlese methods, totally we found three families, and each families composed of 1 individual (Figure 2b). Curculionidae Family usually found in sand because it certainly lives in the soil, plant tissue, and seeds. Before laying their eggs, the mother will dig the soil or plant tissue with their snout. Furthermore, it’s larvae can damage the roots, plant tissue, shoots, and seeds [10].

Shanon-Wiener ($H'$) in the vegetated sea of sand using Funnel berlese method has the score of 1.09, which means that it has a low level of diversity (Table 1). The abundance of soil arthropods is affected by the vegetation above. Vegetation produces litter which is a food source for soil arthropods, then the availability of food in the form of plants which is also used as a protector is an important factor in supporting the life, abundance and reproduction of Arthropods [11].

### Table 1. Diversity Index ($H'$)

|                | Pitfall Trap | Funnel berlese |
|----------------|--------------|----------------|
| Vegetated      | 0.58         | 1.09           |
| Non-Vegetated  | 0.65         | 1.38           |

3.2 *Arthropods in the Sea of Sand without Imperata cylindrica Vegetation*

Arthropods community in the non-vegetated sea of sand by the Pitfall trap method was carried out. The most dominant family was Aphididae, totally found as many as 62 individuals, with IVI value 144.19% (Figure 3a). Subsequent families found were Oecophoridae, Simuliidae, Delphacidae, Lycosidae and Braconidae. The Delphacidae and Simuliidae families were found in 3 individuals with an IVI value of 15.22%, respectively. Lycosidae and Oecophoridae (moth) families were found 2 individuals with an IVI value of 10.15%, respectively; and then 2 individuals from the Braconidae Family with an IVI value of 5.07%.
The value of $H'$ index in the sea of sand without vegetation by pitfall trap method showed 0.65 score which means it has a low level of diversity (Table 1). The Braconidae family is usually found to be active at around 3-5 pm. Braconidae shows a preference for a minimum value of 53% relative humidity, with an optimum temperature of 25°C. Light shows a high and significant correlation with the abundance of Braconidae with an optimum value of 2000 Lux [12].

As the most dominant family, Aphididae has a high abundance because there is no predator from aphids, causing apids well-developed and uncontrolled. These insects have a high ability of surviveness because they are able to reproduce parthenogenesis or without mating, for five days the newly hatched aphids have been able to produce offspring in large numbers [13].

According to Lo (2000), that the quality and relationship of a habitat in a landscape can affect the biodiversity of insects and species abundance. Habitat around plantations consisting of grasses and bushes in the polyculture agroecosystem also influences the presence of predatory insects [14]. This means that agroecosystem diversity can serve as a protector for the conservation of natural enemies. Alcohol can attract insects to enter the pitfall trap, the bait is placed in a trap bottle, the bait is made to attract insects to come. Bait can be served from alcohol, detergent and others [15].

Individuals obtained in the sand sea without vegetation by Funnel berlese method found 4 types of families. Individuals found with the same number and IVI from the Family Syrphidae, Culicidae, Simuliidae and Carabidae with IVI of 50% each (Figure 3b). The Carabidae family is found in sand sea by funnel berlese method because this insect lives under leaves or burrows in the soil. During the day, take shelter and hide underground and leaves, only active at night, most of his life is in the ground. The Carabidae family has one generation per year, in winter, eggs are laid singly in the soil. Larvae are found in soil, grass or under rocks and debris [16].

Syrphidae Family is found in locations without vegetation and According to Vockeroth, J.R, (1992) Syrphidae Family plays an important role in the biological control process of aphids, these insects as predators that eat aphids or aphids while in locations without vegetation Aphididae found quite a lot. This can attract Syrphidae to hunt for prey [17]. According to Bankowska, (1980) Species found in open areas such as mountain grasslands, some of the Diptera Order such as species from the Dolichoredinae Subfamily prefer xerothermic habitats such as sand, wet places in the mountains [18].

The Simuliidae Family can survive at low temperatures to maintain normal activities. Simuliidae shows various variations of adaptation by reducing the time needed for adult stages of climatic conditions in mountainous regions. The *Austrosimulium pestilens* species of the Simuliidae Family survives in an indefinite dry season by laying their eggs in moist sandy soil by the river. Winter larvae produce larger adult flies than summer larvae [19]. The value of Shanon-Wienner diversity ($H'$) based
on the results found in sea sand without vegetation by Funnel berlese method is 1.38 which means that in the sea of sand the absence of vegetation has a low level of diversity (Table 1).

A month before conducting this study, we conducted a preliminary study and found Collembola individuals, but in small numbers from the Sminthuridae and Hypogastruridae families. Collembola is found in sea sand, Collembola is supported by environmental conditions. According Suhardjono et al., 2012 rainfall can affect indirectly on the existence of Collembola. Soil moisture plays a major role in the distribution of Collembola. Collembola can be an indicator of biological water content in the soil, some species are sensitive to changes in soil moisture [20]. The water content can affect the composition of Collembola species in the soil. As a result, density and abundance can change from year to year [20].

Environmental factors play an important role to influence the composition and structure of the Arthropoda community. Abiotic and biotic factors work together in an ecosystem to determine the diversity, abundance and composition of Arthropods [11]. The Bray Curtis similarity index value is used to determine the level of similarity of several places where the biota or environment forms similarity. Curtay's Bray Index interval ranges from 0-1, the closer to 1, the higher the level of similarity produced [21]. Based on IBC (Bray Curtis Index) inter-sea sand vegetation and without vegetation has a value of 0.103. This value indicates the absence of similarity between the two locations.

3.3 Abiotic Factors in the Sea of Sand

Abiotic factors measured were soil temperature, air temperature and humidity, conductivity, pH and water content at the observation site. The soil temperature and air temperature in the non-vegetated area is higher than the vegetated area (Table 2). The conductivity value in the vegetated sand sea is lower than in the non-vegetated sand sea. The pH vegetated area and non-vegetated area are less than 7 (acidic). That is because the location of vegetation in the presence of reeds affects temperature and humidity.

| Location     | Soil Temp. (ºC) | Air Temp. (ºC) | Humidity (%) | Soil Conductivity | Soil pH | Water Content of Soil (%) |
|--------------|-----------------|----------------|--------------|-------------------|---------|--------------------------|
| Vegetated    | 30.35           | 21.8           | 55.5         | 33.82             | 3.987   | 0.132                    |
| Non-Vegetated| 32.8            | 23             | 50           | 61.64             | 3.799   | 0.0108                   |

Temperature greatly affects everything correlate to insects, insects are considered poikilotherm meaning animals whose body temperature is approximately equal to the temperature of the surrounding environment, the temperature of the surrounding environment can affect the metabolic processes in the insect's body, the faster the temperature the metabolic reactions that occur in the insect's body [22].This shows that every process that occurs in the insect's body such as the growth, development or activity of the insect depends on the temperature of the environment. Temperature affects the time of development, for example what has been done on the larvae and pupa beetles of the Coleoptera Order, the time interval between the instar stage and the pupa or cocoon stage decreases sharply. Wasps are able to move faster at higher temperatures and the chance to lay eggs; if humidity is increased it can decrease the parasitism. Humid conditions at more than 85%, could make small parasitoids have difficulty to move in wet conditions [22].
Figure 4. Several Families of Arthropod have been found; A. Formicidae, B. Oecophoridae, C. Carabidae, D. Delphacidae, E. Aphididae, F. Culicidae, G. Simuliidae, H. Curculionidae, I. Lycosidae, J. Braconidae, and K. Syrphidae.

Sunlight has a fundamental influence on the development and ecology of insects that live in certain climates or seasonally. Summer is used by adult insects such as the Coleoptera Order of the plant-eating Chrysomelidae family to become sexually mature before the reproduction process ends in summer. Abiotic factors can cause large fluctuations in the abundance of insects in the surrounding environment. In addition, insects can interact significantly with abiotic factors such as competition and predation [22].

4. Conclusion
Arthropods community structure in the sea of sand with vegetation Imperata cylindrica and without vegetation shows the differences. Formicidae family is dominant in vegetated sand sea with IVI of 129.17%. Meanwhile, Aphididae Family is dominant in non-vegetated sand sea with IVI of 144.19%.
Index of Diversity (H’) using pitfall trap and funnel berlese method in the area without vegetation is higher than vegetated sea of sand. However, at both location indicated a low diversity index. Bray-Curtis Index value showed 0.103% of similarity, that means the similarity between two areas are very low and shows different community structure. The Arthropods found to act as herbivores are the Family Aphididae, Delphacidae and Oecophoridae; Arthropods as predators of the Family Formicidae, Lycosidae, Carabidae and Curculionidae; Arthropods as parasitoids is the Braconidae Family; and Arthropods as predator and pollinator is Syrphidae Family.

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