Association of Herbaceous Species on the Sand Dunes of Parangtritis Yogyakarta as Biology Learning Resource

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***Abstract*— Sand dunes as an ecosystem have exceptional characteristics, such as those of the sand dunes of the Kretek Sub-District of Bantul Regency in the Special Region of Yogyakarta. The uniqueness of sand dunes is not only reflected by the conditions of the habitat but also by their unusual vegetation species, particularly the herbs. This research seeks to: 1) identify the herbaceous stratum vegetation on the sand dunes of Parangtritis, 2) discern herbaceous species with positive association, 3) distinguish negatively associated herbaceous species, and 4) gauge the potential of herbaceous species association on the Parangtritis sand dunes as a resource in learning biology. The sample was collected by means of quadrats and then analyzed with a 2x2 contingency table and Ochiai's index. Results indicate both positive and negative associations in three different areas from the shoreline to the mainland. Combinations of herbaceous species tend to decline the further they are from the shore. The strongest positive association of herbaceous species was found in the combination between Tridax procumbens and Spinifex littoreus. These research findings potentially serve as biology learning material for grade X of high school in the topic of ecosystem structure and function.**

Keywords: association, herb, sand dune, biology learning resource

I. Introduction

The exceptional ecosystem of sand dunes in the Kretek Sub-District of Bantul Regency in the Special Region of Yogyakarta is shaped by sand deposits from Mount Merapi volcanic materials that enter the nearby river which empties into the Indian Ocean. Sea waves and winds then take the sand back from the ocean to the shore and its environs, creating mounds of sand dunes. The key ecological role of sand dunes is to avert abrasion, block seawater from infiltrating groundwater layers, and serve as barricade against tsunami [1].

The Parangtritis Sand Dunes are divided into the core zone, the buffer zone, and zones for particular uses, sustainable fishery, natural and cultural attractions, and culinary tourism. The core zone covers an area of 141.15 ha, the restricted zone 95.3 ha, and the buffer zone 176.6 ha, constituting an overall area of 413 ha [2]. The dunes boast a variety of herbs, the interactions or associations among which had been unknown, thus implicating the need to study herbaceous species associations within this sand dune ecosystem. Determain species of herbaceus have positif and negative asosiation in sandunes parangtritis.

Learning resources encompass everything used to support and facilitate the learning process [3]. The 2013 Curriculum denotes that one of the basic competencies which grade X high school students have to master is the ability to observe an ecosystem, identify its components, and depict interaction between components and how they link to energy flow. It is thus expected that this study helps students achieve this basic competency by providing a learning resource for high school biology. The potential use of the research outcomes as learning resource for biology in high school is assessed through Djohar's criteria [3], comprising: 1) clear potential availability of the object and issue of study, 2) relevance to learning objectives, 3) clear targets of the material and its application, 4) clear information to disseminate, 5) clear exploration guidelines, and 6) clear benefits to attain. gauge the potential of herbaceous species association on the Parangtritis sand dunes as a resource in learning biology.

II. Methods

Pilot observations were carried out by means of a 1:4,000 scaled map from the Geomaritime Science Park to delineate the overall situation of the Parangtritis Sand Dunes, the herbaceous vegetation, and the area of study.

The study area covers 14.1 ha of the 141 ha core zone area determined by the observations. Quadrats were used to collect the sample. The study area was divided into three zones: the closest to the coast (200m from the shoreline), the middle zone (540m from the coastline), and the farthest away from the coast (1,040m from the shoreline), each with an area of 5 ha. A hundred 1x1m quadrats were installed in each zone, and the frequency of individuals from every species was calculated and sorted into six groups, namely no individual, one, two, three, four, and five or more individuals. The abiotic factors of each zone, including soil pH, air temperature, soil temperature, soil moisture, humidity, illuminance, and soil salinity, are also measured, along with the analysis of N, P, and K soil nutrients. Each vegetation species was identified at the Plant Taxonomy Laboratory of Universitas Gadjah Mada.

Associating herbaceous species were determined by analysis with a 2x2 contingency table [4]. If the counted (is less than in the table (, there is no association between both species, but if count is greater than table then an association exists. An association is deemed negative when the number of observed quadrats containing species A or B only is greater than expected while there are fewer observed quadrats with both species than expected. A positive association occurs when there are fewer observed quadrats with species A or B only than expected while the observed quadrats that include both species are more numerous than expected. The frequencies of all pairs of species are presented in a matrix, and the strength of the association is measured with the Ochiai index [4]; [5].

III. RESULTS AND DISCUSSION

Within all the observed areas were 19 species of herbaceous plants. The presence of fewer than 20 plant species typifies an extreme habitat, where only particular species are able to survive well in limited conditions. Herbs are commonly found on slopes in close proximity to each other but spread within a reasonable range of elevation and inclination. Association results from the physiological and morphological match of one plant with another, and can take place due to the physical factors of the habitat, such as shade and the microclimate generated by light and temperature.

The herbaceous plant species located in all three study zones are Tridax procumbens, Fimbristylis barbata, Gomphrena celosioides, Digitaria sanguinalis, Hedyotis corymbosa, Ageratum conyzoides, Dactyloctenium aegyptium, Phylantus niruri, Vernonia cinerea, and Spinifex littoreus. Placed only within the first and third zones is Fimbristylis cymosa, whereas Physalis pubescens, Spermacoce pusilla, and Barchiaria mutica are solely present in the first and second zones. Meanwhile, several species such as Elephantopus scaber, Passiflora foetida, Ipomea pascaprae, Portulaca oleracea, and Emilia sonchifolia grow exclusively on the shoreline. According to analysis, a consistent negative association occurs between Spinifex littoreus and Phylantus niruri in the first and third study zone. A negative association is also detected between Digitaria sanguinalis and Fimbristylis barbata within the first and second zones, but they are positively associated in the third. Negative association is a condition where two species can live together without any competition [6].

The maximum Ochiai index (IO) value of 1 is evident in merely one combination of herbs (0.58%) in the first study zone only, whilst not sighted in the second and third. The minimum IO value of 0 (no association) emerges in 147 combinations (85.96%) in the first zone, 68 in the second (87.18%), and 59 in the third (89.39%). The combination of the species types resulted from Ochiai index analysis reveals a vegetation association [7]. This signifies that although associations do exist at the Parangtritis Sand Dunes, their connection is considerably weak. According to Kurniawan [8] the value of association is divided into four levels: extremely high (0.75-1.00), high tinggi (0,49-0,74), low (0.48-0,23), and extremely low (<0.22). [9] explains that plants in a community are interdependent, and they are hence not bound by chance. Disturbance on one plant will lead to consequences on all others. In general, vegetation species on sand dunes demonstrate tolerance to live together in the same area or mutualistic symbiosis in sharing a living space. However, this association analysis is restricted to statistical tests, whereas laboratory tests are required to determine positive association between at least two plant species.

The first study zone features positive association between Tridax procumbens and Fimbristylis barbata, but they are negatively associated in the third. One plausible explication is that such positive effect only happens under strong pressure, specifically high salinity. When salinity is experimentally decreased by adding freshwater, the hitherto positive interaction transforms into a negative competitive one. Such phenomenon is known as habitat amelioration [10]. It shows the mutual symbolism for the species living together in the same area [7].

A. *Ochiai's index*

Of the herbaceous stratum in the three study zones, a high value of Ochiai's index (0.75 – 1.00) solely takes place in the first zone in the positively associating combination of Tridax procumbens L. and Spinifex littoreus, in that for every Tridax procumbens L. there is also a Spinifex littoreus. The Ochiai index of this association is very high (0.79), representing firm interaction between both species to coexist in the first zone. On the other hand, edaphic or soil factors greatly influence the prevalence of those two plant species. Analysis shows that the first study zone has the highest concentration of potassium (K) at 45 ppm, compared to 20.33 ppm and 21.33 ppm in the second and third zone respectively. There is a specific correlation between both species' survival and potassium concentration, accounting for their coexistence and robust association.

[11] describe that Tridax procumbens L. bears a sprawling stalk that later rises. The stalk which forks from the base is equipped with long hair that is used to intercept the generative organ of Spinifex littoreus borne by the wind. This facilitates Spinifex littoreus to flourish alongside and give a more stable substrate for Tridax procumbens L. by keeping sand from being carried away by winds. Furthermore, both species thrive

in the same habitat conditions consisting of open space, sandy ground, and sand hills or dunes. Based on the association indices of all pairs of in the three zones, it can be observed that from the coastline inwards positive associations tend to decline from 14 combination pairs to six pairs and eventually four. Negative associations also diminish from 10 combination pairs near the shoreline to four pairs in the middle and merely three in the farthest zone from the coast. A similar pattern applies to combination pairs without association. None of the positive and negative combination pairs has a high Ochiai index value, except that of Tridax procumbens and Spinifex littoreus.

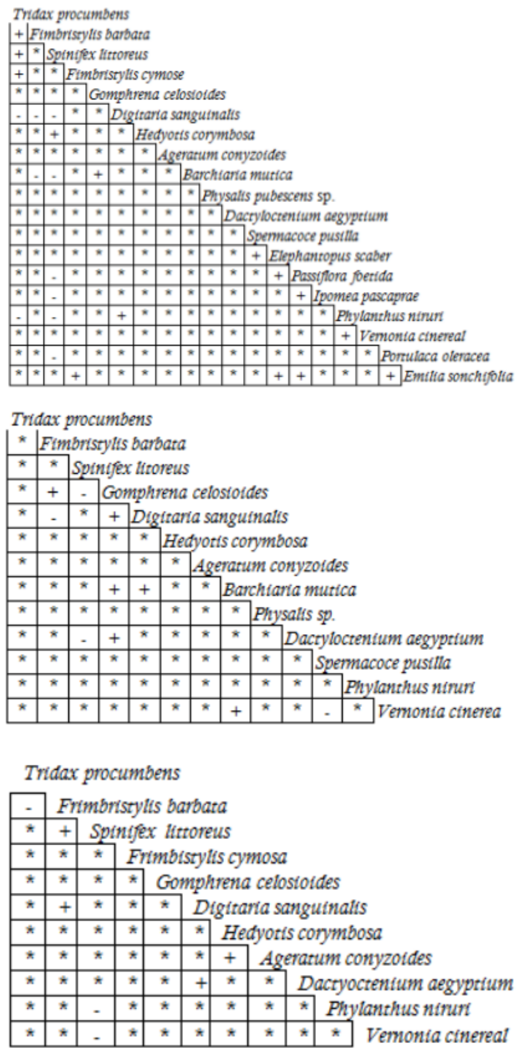

Fig. 1. Association matrix of herbaceous species components of sand dunes in the first, second, and third study zones

Note: + = positive association; - = negative association;

* = no association

B. Abiotic and Nutritional Factors Around the Three Study Zones

The measurements of abiotic environmental factors on the sand dunes in the first study zone are 29-34°C of soil temperature, 73,000-98,500 lux of illuminance, 69-90% of humidity, 29-35°C of air temperature, pH 6.7-6.9 of soil acidity, 20-30% of soil moisture, and 0.2-1.5 m/s of wind speeds.

In the middle zone, soil temperature stands at 29-30°C, illuminance at 54,000-120,000 lux, humidity at 71-76%, air temperature at 29-30°C, soil pH at 6.9, soil moisture at 10-20%, and wind speeds at 0.1-1.5 m/s.

Meanwhile, the soil temperature of the third zone is 4-30°C, illuminance 87,100-160,900 lux, humidity 10%, air temperature 32-46°C, soil pH 7, soil moisture 10-30%, and wind speeds 0.2-1.6 m/s.

Analysis of soil nutrients including available nitrogen (NH4), K, and P (P2O5) unveils that the first zone holds the highest rate of K at 45 ppm, while the third zone boasts both top ratios of N and P at 44.3 ppm and 8.0 ppm in that order. This plausibly stems from the remoteness of the third zone from the shoreline, thereby enjoying less environmental pressure and thicker vegetation.

C. Educational Assessment

A basic competency of the 2013 Curriculum that grade X students are required to grasp is basic competency (KD) 4.14. Findings of this study were therefore assessed for their potential use as learning resource for biology in grade X of high school on ecosystem structure and function, using Djohar's six criteria [3]: 1) clear potential access to the study object and issue, 2) compliance with learning objectives, 3) material targets and its application, 4) information to divulge, 5) directions for exploration, and 6) expected gains.

The output of this assessment discloses that the outcomes of this research is suitable for use as learning resource on the topic of ecosystem structure and function for grade X biology in high school.

IV. CONCLUSION

This study found various positive and negative associations in three distinct areas from the shoreline to the mainland. The farther from the coast, the fewer the associating combination pairs of herbs, either they are positively, negatively, or not associated. The most potent positive association of herbaceous species was between Tridax procumbens and Spinifex littorea. Results of this study are considered feasible as learning resource for grade X high school biology on ecosystem structure and function. Besides, they are also potential learning sources for biology subject, especially structures and functions of ecosystem, for grade X senior high school. It refers to Djohar Suhardi's ideas, which are based on: 1) clear potential access to the study object and issue, 2) compliance with learning objectives, 3) material targets and its application, 4) information to divulge, 5) directions for exploration, and 6) expected gains.

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