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The Relationship between Habitat Altitude, Enviromental Factors and Morphological Characteristics of *Pluchea Indica*, *Ageratum Conyzoides* and *Elephantopus Scaber*

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Abstract: Asteraceae family has various benefit as herbal medicine and phytochemical affect (biopesticides). It can grow in different habitats but the morphological and physiological characters of Asteraceae depend on the environmental factor. The aims of the study is to describe the variation of height of stems and width of leaves from three species of Asteraceae family (*Pluchea indica, Ageratum conyzoides and Elephantopus scaber*), on three types of habitat which differed by its altitude and learn the correlation between altitude and morphological characteristics of Asteraceae. Samples of Asteraceae were obtained from Bangkalan-Madura (28, 3-31, 72 m asl), Trawas-Mojokerto (727-937 m asl), Coban Talun-Bumiaji Batu (1303-1322 m asl). The results were then analyzed by cluster analysis and Canonical Correspondence Analysis (ACA). The results show that there are correlation between altitude and environmental factors (climate and soil) to morphological characteristics especially height of stems and width of leaves of *Pluchea indica, Ageratum conyzoides and Elephantopus scaber*. The highest stem is found on *Pluchea*, while the widest leaves are found on *Pluchea* and *Elephantopus*. The habitat altitude and the environmental factors were determined by measuring altitude, light intensity, oxygen levels (climate), organic compound, C level, N level, pH (soil chemical character), soil temperature, water levels, porosity, dust, sand and soil humidity (soil physical character). Asteraceae which grows at intermediate-altitude has the highest stems. While, Asteraceae at low-altitude has the widest leaf.

Keywords: Asteraceae, Altitude, Height of Stems, Width of Leaf

Introduction

Asteraceae has around 1.100 genera and 20.000 species, including Magnoliopsida (Dycotyledoneae) class and Asterales order (Cronquist, 1981). Generally, Asteraceae, grows in an open habitat such as field, garden, roadside, river, under the trees at 1-2100 m asl. Herbaceous and shrubs were included in this family. This family had several benefits, such as herbal medicine and vegetable pesticides (insecticide, fungicide and nematicide). Asteraceae has various phytochemical effects, such as insecticide effect like pyrethrum, triterpenoid, saponin, phenolic, coumarin and flavonoid (Ozgen *et al*., 2004). At several conditions, Asteraceae can be used as biopesticide or herbs due to its effect on secondary metabolites production.

The environment affects to morphological and physiological characters of Asteraceae. Usually, plants were genetically similar, although their morphology were different due to their environments (ecophenes) or genetically different in certain species due to their regional distributions (ecotype) (Salisbury and Ross, 1992).

The correlation between altitude and morphology was caused by the differences on temperature or CO_2, so there were possibility of acclimatization and adaptation of the plants due to the situations (Hovanden and Vander Schoor, 2003).

Every plants were able to change one or more their morphological characteristics as response from abiotic (climate and weather) and biotic factors (competition). For example, the size and wide of Alpine leaves was

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changing simultaneously with the altitude. On the other way, some plants could produce a wider leaves in summer than in winter (Stenstrom *et al*., 2002). In addition, each of environmental factors could interact with the others, Douglas (1981) showed that competition could reduce the size of *Mimulis primuloide* at low-altitude, while low temperature could reduce the size of plants at high-altitude and could cause the bigger plants size at intermediate-altitude.

Recent study about *Andographis paniculata* showed that plants which grew at intermediate-altitude has higher stems and wider leaves than plants at low and high altitude (Pujiasmanto *et al*., 2007).

Plants which grew at high-altitude have differences in their morphology and physiology compared with lower-altitude plants. The altitude has a big impact on leaves, morphology and physiology. Generally, the size (such as broad, wide and length) of leaves were decreasing simultaneously with the increasing of its height and thickness which causing the reduction of its wide (Korner *et al*., 1989; Hovanden and Vander Schoor, 2003).

Primary metabolites were affected by environmental factors. For example, CO_2 concentration or deficiency of organic compounds (such as carbon) could affect plants growth and development. Primary metabolites in plants were depended on the variety of organ, tissues, developmental period and environmental factors, such as temperature, UV, light, organic compounds, the availability of water and CO_2 concentration on the atmosphere (Mazid *et al*., 2011; Sharafzadeh and Kourosh, 2011). Species diversity in the scope of habitat was controlled by environmental factors, either the soil fertility or the height or other factors (Fitter and Hay, 1981).

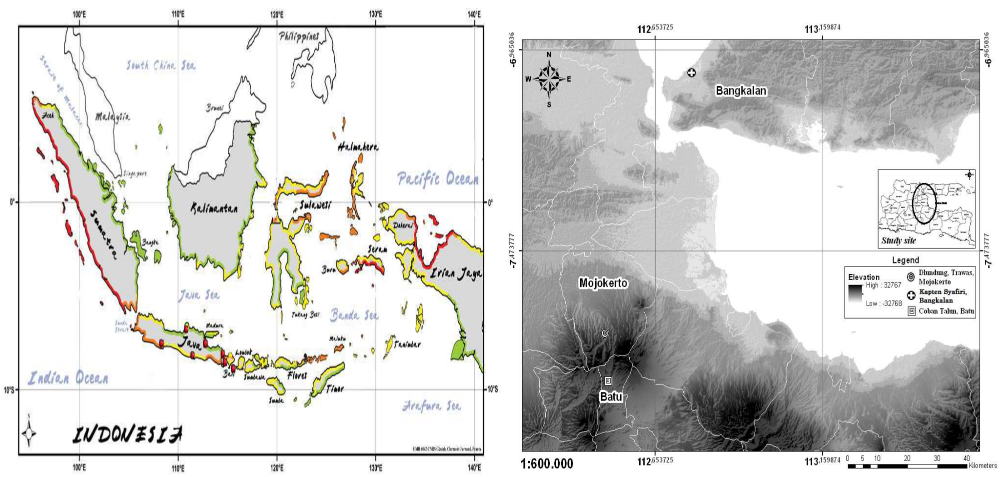
According to the background, this research was aimed to describe the variation of height of stems width of leaves from three species of Asteraceae (*Pluchea indica, Ageratum conyzoides and Elephantopus scaber*) at three different altitude and learn the correlation between altitude and morphological characteristic of Asteraceae.

Materials and Methods

This research was conducted from November 2012-March 2013 in East Java, Indonesia. Sites location were chosen based on its altitude and used *purposive sampling* method.The samples were taken from Bangkalan-Madura at low-altitude (28, 3-31, 72 m asl; E112.763368;S-7.021999), Trawas-Mojokerto at intermediate-altitude (727-937 m asl; E112.59425;S-7.681328) and Bumiaji-Batu at high-altitude (1303-1322 m asl; E112.517002;S-7.804258) (Fig. 1).

The height of stems and width of leaves from three species of Asteraceae at various altitude was measured by using the method below:

- The width of leaves
    - *Pluchea indica*. At least 240 leaves were taken at each sites location. Two branches were taken from each 10 pieces of *Pluchea*. Each branches were measured from node 1 to 6, so overall there were 12 leaves. Thus, 24 leaves were measured from each plants and 240 leaves were measured from 10 plants. The results were averaged for 10 width of leaves. The measurement of width of leaves was done by using leaf area meter
    - *Elephantopus scaber*. 20 plants were taken from each sites which consisted of 8 to 12 leaves, so overall there were 190-260 leaves
    - *Ageratum conyzoides*. 20 plants were taken from each sites from node 1 to 4, so overall there were 8 leaves in each plants. Total number of leaves from *Ageratum conyzoides* were 160 leaves
- The measurement of height of stems were based on their diameter, *P. indica* has diameter 42,11±2,91 mm; *A. conyzoides* 1,99± and *E.scaber* 4,65±0,93 mm. 10 plants of Asteraceae were measured in each habitat



(a) (b)

Fig. 1. Sites Location: Overview map of Indonesia (a) and sites location in East Java (b)

Morphological Measurement

The Measurement of Geographical and Climate Characteristic, including: the altitude, temperature, air humidity, light intensity and oxygen levels.

The Measurement of Physical and Chemical Properties on Soil, including: Soil pH, soil temperature, soil humidity, C compound, total N, organic compounds, texture, porosity and water capacity.

The climate measurement and soil sampling were repeated 10 times for each sites, so overall there were 30 data for climate, physical and chemical characteristic. The measurement of soil and climate were done simultaneously with the uptake of plants sampling. The soil samples were analyzed in laboratory to obtained the physical and chemical data. The data were analyzed by Canonic Corelation Analysis (CCA) using CHIC software v.1.0 and descriptive cluster analysis to know the correlation of the altitude and morphological characters (height of stems and width of leaves).

Results

Bangkalan is a low-land which located at 24,9-31,7 m asl. The sites location in Bangkalan were included sideways and field which have so much herbs and shrubs. Trawas-Mojokerto is a region near by Dlundung waterfall in sideways and has a lot of trees. Trawas-Mojokerto is an intermediate-land which located at 725-937 m asl. Bumiaji-Batu has fields with a lot of shrubs and located at 1300-1323 m asl. The sites condition was analyzed by ecological characteristic data which measured at 10 sites location in three differents altitudes that shown below in Table 1.

According to Table 1., the ecological characteristic in three different sites support the growth of Asteraceae, including the altitude between 28,7 m asl and 1312,2 m asl; temperature at 27,57-38,63°C; air humidity at 59-83,5%; air oxygen levels at 17,35-21,25% and light intensity around 153,21-808,580 lux. Based on the soil physical and chemical analysis, *Pluchea*, *Ageratum and Elephantopus* grow at soil pH levels 6,26-7; C organic levels 1,18-3,31%; N total 0,127-0,335%; porosity 46,25-70,08% with water levels 0,19-0,46 cm^3.

The results of soil sampling and ecological characteristic at each sites show that the climate in each altitude were significantly different (Fig. 2).

The results of Biplot Analysis mapping on Fig. 2 show that each sites, Bangkalan, Trawas and Batu, have different environmental factors. The result shows three groups of habitat which have similarity or specific characteristic. That groups are: (1) low-altitude in Bangkalan has a high water content, sandy soil on its texture, low organic matters and also a high level of soil temperature, soil humidity and light intensity, (2) intermediate-altitude in Trawas has a clayey on the soil, high level on C and N content, high level in air humidity and good humidity on the soil, (3) high-altitude in Batu has a sandy texture with high water levels, N total, oxygen level, porosity, soil pH and organic matters. The sandy texture tend to has organic matters, C/N compound and low water levels. While dusty texture is more fertile.

Morphological characteristic (including height of stems and width of leaves) from three species of Asteraceae at three differents altitudes were shown in (Fig. 3 and 4).

The results show that *Ageratum conyzoides*, which grow at intermediate-altitude, is the highest (53,8 cm) plant than at high-altitude (36,94 cm) and low-altitude (20,88 cm). Similarly, *Elephantopus scaber*, which grows at intermediate-altitude, is the highest (6,86 cm) plants than plnat at high-altitude (3,66 cm) and low-altitude (4,89 cm). While, *Pluchea*, which grows at high-altitude, is the highest plants (203 cm) than plant at intermediate-altitude (179,5 cm) and low-altitude (145,2 cm). Those proven that height variation of Asteraceae was affected by altitude.

The width of leaves of Asteraceae show the same pattern in each sites location (Fig. 4).

The leaves of *Pluchea, Ageratum and Elephantopus* which grow at low-altitude (Bangkalan) have the widest size (9,69-32,23 cm) than plant at intermediate-altitude, Trawas (6,96-13,75 cm) and high-altitude, Batu (3,55-12,92 cm). *Pluchea* width of leaves are around 18,18 cm at low-altitude; 10,17 cm at intermediate-altitude; and 3,55 cm at high-altitude. *Ageratum* width of leaves are around 9,62 cm at low-altitude; 6,96 cm at intermediate-altitude; and 7,51 cm at high-altitude. *Elephantopus scaber* width of leaves are around 32,23 cm at low-altitude; 13,75 cm at intermediate-altitude; and 12,92 cm at high-altitude. Therefore, there are variation of width of leaves on three different altitudes.

The profile of morphological characteristics on *Ageratum, Pluchea and Elephantophus* on each altitudes was shown in (Fig. 5).

Based on the mapping above, it can be concluded that (1) The morphological characteristic which dominant at low-altitude (Bangkalan) was the width of leaves of *Ageratum*, *Pluchea and Elephantopus* and the height of stems of *Elephantopus.* In other words, leaves at low-altitude have the widest surface than other in general. Then, the height of stems of *Elephantopus* in Bangkalan are the highest than the others. (2) The morphological characteristics which dominant at intermediate-altitude (Trawas) was the height of *Ageratum*. *Ageratum* which grows in Trawas has the highest stems than plant in other places. (3) The morphological characteristic which dominant at high-altitude (Batu) was the height of *Pluchea*. So, *Pluchea* which grows in Batu has the highest stems than plant in other places.

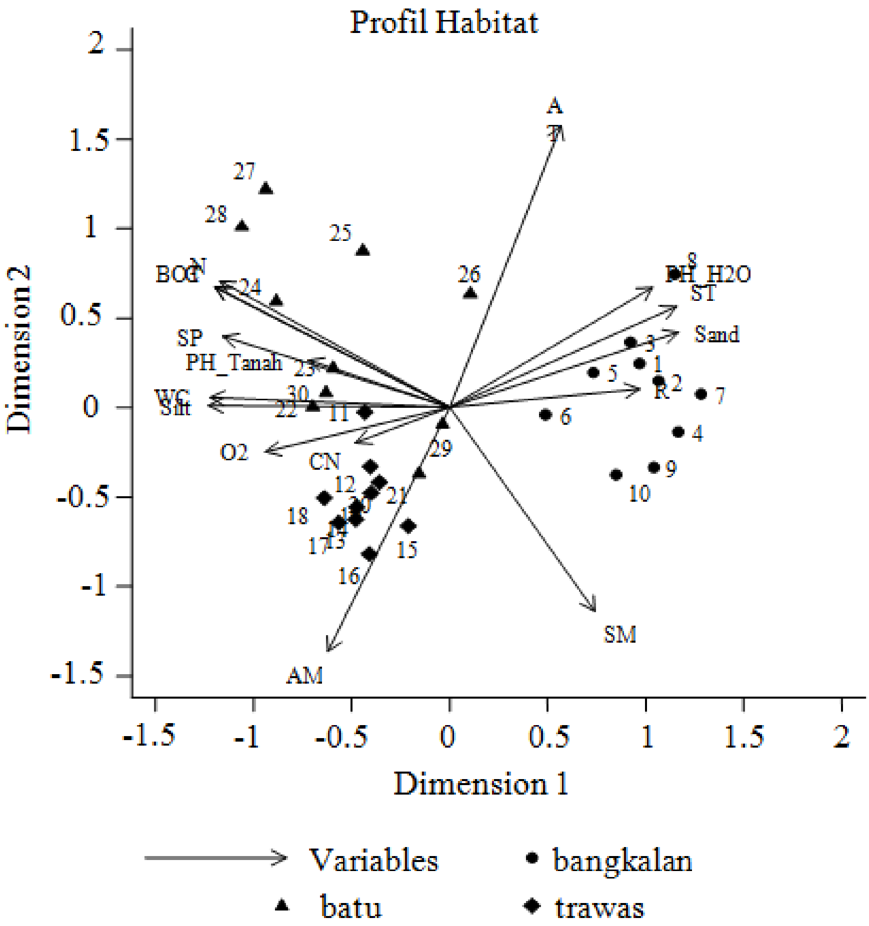
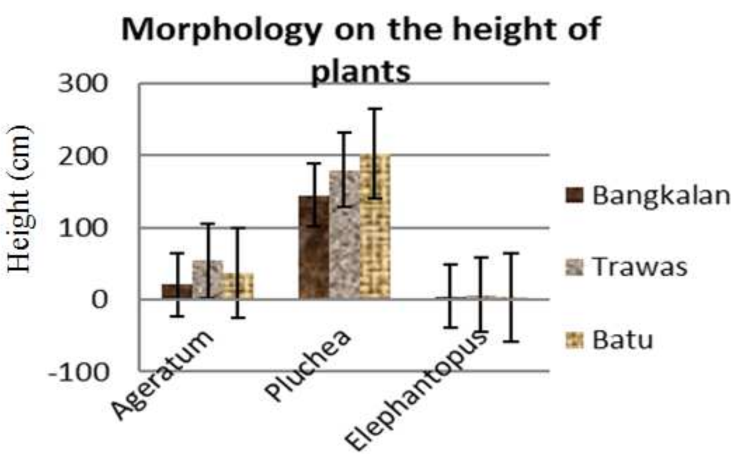
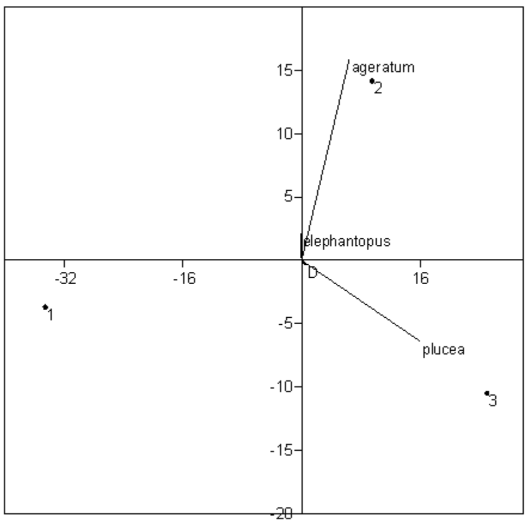


Fig. 2. The Habitat Profile of Asteraceae; Description: Soil Porosity (SP), Soil Temperature (ST), Soil Humidity (SM), Water Content Field Capacity (WC), Nitrogen Total (N), R (Light intensity), AM (Humidity), AT (temperature), BOT (Organic material), O2 (O2 concentration in air)



(a)



(b)

Fig. 3. (a) The height of plants at each sites; (b) The mapping of height of stems at each sites

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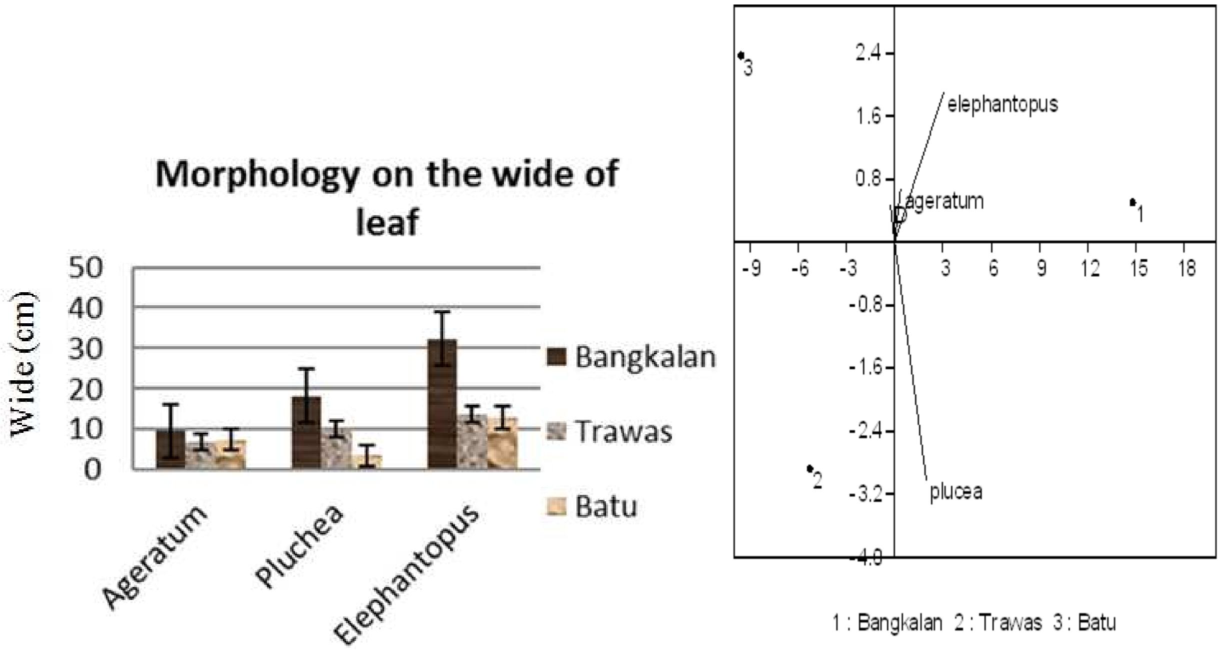

(a) (b)

Fig. 4. (a) The width of leaves at each sites; (b) The mapping of the width of leaves at each sites

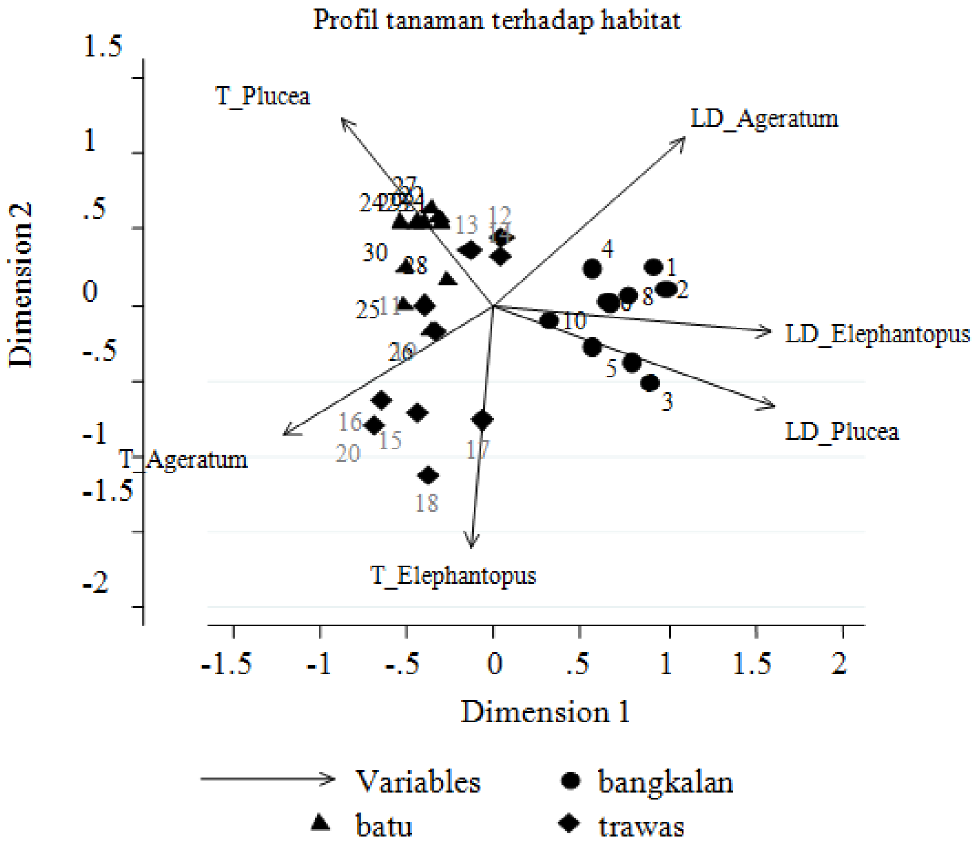

Fig. 5. The correlation between the morphological characteristic of three plants from Asteraceae and the altitudes Description: T (Height of Stem) LD (Width of Leaves)

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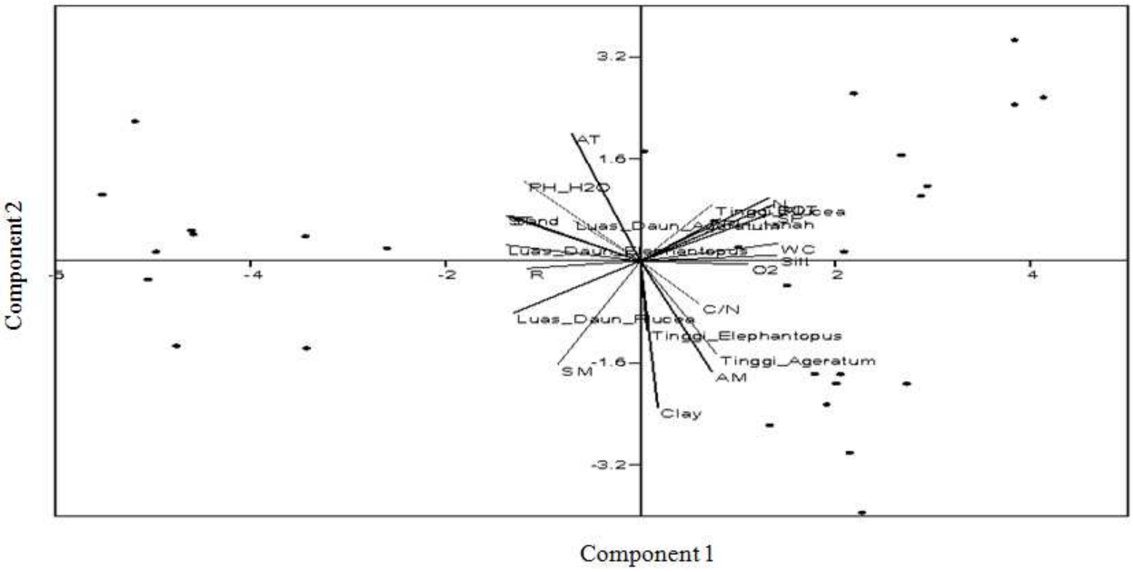

Fig. 6. Canonical mapping of the correlation between environmental factors and morphology of Asteraceae

Table 1. Ecological characteristic of each sites location

Ecological characteristic	Location Bangkalan-Madura (Low-altitude)	Trawas –Mojokerto (Intermediate-altitude)	Bumiaji-Batu (High-altitude)
Geographic and climate			
Altitude (m asl)	28.4 – 31,7 m asl	725-937 m asl	1300 - 1323 m asl
Temperature (°C)	38.63	27.57	35.85
Humidity (%)	59	83,5	64,7
Oxygen level (%)	17.35	20.91	21.25
Light intensity (lux meter)	808.580	153.21	655.00
Physical and chemical characteristic on Soil			
Soil temperature (°C)	34.1	24.3	26.3
Soil humidity (%)	57	50	34.5
C organic (%)	1.18	2.7	3.31
N total (%)	0.127	0.272	0.335
C/N ratio	9	10	10
Organic matters (%)	2.042	4.66	5.77
pH on soil	7.05	6.26	6.8
Porosity (% vol)	46.25	59.98	70.08
Water content field capacity pF($cm^3.cm^{-3}$)	0.19	0.3	0.46
Sand %	67	31.7	47.3
Dust %	23.5	49	48.3
Clay %	10	19.3	4.17
Soil criteria	Sandy loam	Loamy	Sandy loam

The results of *Canonical Correspondence Analysis* (CCA) show that there are correlation between the altitude of habitats and the environmental factors (e.g., climate and soil) to the morphological characteristic (height and wide of leaf) of *Pluchea indica, Ageratum conyzoides and Elephantopus scaber*. The canonical analysis from six variables show a high correlation value on three variables, including the height of *Pluchea*, the wide of leaves of *Pluchea* and *Elephantopus*. The correlation coefficient of the height variable of *Pluchea* is -0,6081 and 0,92208 for width of leaves. While, the correlation coefficient of the width of leaves variable of *Elephantopus* is 0,89261. The morphological variables which has low correlation value are the height of *Ageratum* and *Elephantopus* and the wide of *Ageratum* leaves.

The correlation value from 18 variables of altitudes and environmental factors have a high value on 13 variables, that are altitude, sand, dust, porosity, soil temperature, soil humidity, water level, light intensity,

O_2 level, organic matter, C compund, N compound and pH on H_2O. The coefficient value of the correlation on the height is -0.92571; light intensity (0,75798); O_2 level (-0,7033); soil temperature (0,83386); soil humidity (0,5752); C compound (-0.78724); N compound (-0.74365); organic matter (-0.78598); pH in H_2O (0.5672); porosity (-0.87129); water level (-0,81211); sand (0,66729); dust (-0.75633); Meanwhile, the coefficient value was low in air humidity, air temperature, C/N total, soil pH and loam. The result from canonical mapping was shown in (Fig. 6).

The result shows that the morphological characteristic (width of leaves and height of stems) of Asteraceae, were affected by altitude, climate and soil physical and chemical characteristic. The variables which have a big impact are altitudes, light intensity (climate), C compound/organic matter (soil chemical), porosity and water level (soil physical).

Discussion

Plants could not be separated with the environmental where they lived on. A lot of plants were able to change one or more their morphological characteristic as a response to their environmental factors, biotic and abiotic (climate and weather). The altitude condition is one of factor that affects to microsite, distribution, morphology, physiology and plant growth (Pan *et al*., 2009). For example, the shoot height of C. *aquatilis* subsp. *Aquatilis* has negative correlation to the altitude, as a result, *C. aquatilis* at the high-altitude has a short shoot because of the low temperature and high wind speed (Fitter and Hay, 1981; Stenstrom *et al*., 2002). Other factors that probably involved were temperature, rainfall and phosphate level and nutrient availability (Chapin III, 1981; Puijalon *et al*., 2007).

Study about *Pinus roxburghii* showed that the morphological characteristic were negatively correlated to the altitude. The length of the needle-like leaves was decreasing along with the higher altitudes. The effects of altitude to the morphological characteristic has been studied in *Pinus sylvestris* L, *Pinus pumila* Regel and *Pinus contorta* Douglas ex Louden. The results showed that the decreasing of leaves length, growth of buds and leaves productions were simultaneously with the increasing of altitude (Tiwari *et al*., 2013). The altitude levels (1200-1620 asl) can influence the leaves morphology in *Fargesia angustissima* (Pan *et al*., 2009).

Korner (2007) suggested a theory about the correlation of altitude to biological phenomenon, which had bad impacts to the plants communities, such as the reduction number of species, plants productivity, organel size and plants morphology and physiology.

Morphological characteristic and plants anatomy depend on abiotic factors. Physical factors, such as altitude, decreasing of temperature, atmosphere, pressure, rainfall and wind speed, would affect the plants growth at the highest-altitude, poor environmental condition would inhibit the growth and development of plants (Korner, 2007; Tiwari *et al*., 2013). The main factor that can affect to plant growth is light, it related to photosynthesis process in the plant (Zervoudakis *et al*., 2012). The intensity of the light is important for growth, morphogeneis and other physiological responses (Hogewoning *et al*., 2010; Macedo *et al*., 2011).

The characters of leaves often are affected by environment because it was directly exposed to the environment. In vascular plants, leaves are the most important part of physiological components for photosynthesis and transpiration.

The width of leaves is one of the indicator in plants growth. There are interaction between light intensity and the wide of leaves in three plants of Asteraceae. It provid some informations about photosynthesis capability of each plant.

The light intensity at intermediate-altitude (Trawas-Mojokerto) and high-altitude (Bumiaji-Batu) in this study is lower than the light intensity at low-altitude (Bangkalan, Madura). It is proven by shadow-like plants of Asteraceae which has herbaceous appearance, such as *Ageratum* and *Elephantopus* at intermediate-altitude. Plants which grow under harborage condition have lower respiration rates per unit of width of leaves than plants which grow under full light continously. In low intensity of light can affect to root biomass, wood, leaves and photosynthesis rate and for protecting from high radiation, plant can adapt the width and thickness of leaves (Zervoudakis *et al*., 2012; Fan *et al*., 2013). The altitude condition affects the morphology of the width of leaves of Asteraceae. This research shows that the plant in low-altitude tends to have wider leaves than the leaves plant in high-altitude.

It was suggested by Salisbury and Ross (1992) that the wide and morphology of leaves were affected by light rates during their developments. The optimum rates of light intensity are needed to increase plants photosynthesis rates. The increasing of photosynthesis rates affect to the amount of carbohydrates that used at growth point. There is correlation between net photosynthesis rate and the intensity of the light (Fan *et al*., 2013).

The height of plants also related to photosyntesis rates, especially in competition for increasing the ability to capture lights (mainly in shadow-like places) and affected by temporal and spatial factors. Plants were known to has a short appearance at high-altitude because of the low temperature and high wind speed and rainfall (Fitter and Hay, 1981; Stenstrom *et al*., 2002; Pan *et al*., 2009). This proven by the height of *Ageratum* and *Elephantopus* as the highest plants at intermediate-altitude.

Plants growth also affected by organic matters and soil nutrient (Lambers *et al*., 1998; Taiz and Zeiger, 2010). The results of this study show that N compound and organic matters at high-altitude were the highest compared with the other altitudes. Organic matters and soil mineral have primary function as nutrients supplier to plants and soil biota. Mineral matters through its particles acted as compiler at soil pore, water and air storage and as spaces to penetrate roots. Organic matters were an energy sources and carbon to heterotrophic biota (organic matters users), so it also determine the population and their activities on releasing available nutrients. The content of soil nutrients (including N) could affect to the growth of vegetative plants at fertile soil (showed by the height of plants). In soil with high clay content could affect to the oxygen concentration in the root area so this condition can direct the Ethylene concentration in the leaves that is important for growth of plant (Puijalon *et al*., 2007; Gil *et al*., 2012).

Each of Asteraceae have different habitat characteristic, *Pluchea* and *Elephantopus* tend to grow well at low-altitude with high light intensity, sandy soil texture and high soil humidity. While *Ageratum* has a wide distribution, although it grows well at intermediate-altitude which had high C/N ratio with loamy texture.

Those three plants of Asteraceae are survive in various altitudes and environmental condition although it showed various morphology. This behaviour show that Asteraceae are able to expressed their potential to survive under environmental stresses. Morphological Variation in population, probably caused by genotipe differentiation or plasticity fenotipe. The Responses of Asteraceae which shown by variation of width of leaves and plants height are included at morphological fenotipe plasticity. The Wide of leaves give responses to the environmental changes and have plasticity characteristic. It was showed by the ability to adapt at width of leaves if the plants are moved to another place with differents light intensity. The plasticity of leaves is main factor for the plant to grow in temporally variable environments (Fitter and Hay, 1987; Gratani, 2014).

Conclusion

There are correlation between altitudes and environmental changes (temperature 27.57-38.63°C, humidity 59-83.5%, air oxygen level 17.35-21.25%, light intensity 153.21-808.580 lux, pH in soil 6.26-7, C organic 1.18-3.31%, N compound 0.127-0.335%, porosity 46.25-70.08%, soil oxygen level 0.19-0.46 $cm^3.cm^{-3}$) to the height of stems and width of leaves of *Pluchea indica, Ageratum conyzoides* and *Elephantopus scaber.*

Asteraceae which grows at intermediate-altitude are the highest plants. Meanwhile, Asteraceae which grows at low-altitude had the widest leaves. *Pluchea indica, Ageratum conyzoides and Elephantopus scaber* could grow at altitude ranges around 28.7 m asl to 1312.2 m asl.

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Author’s Contributions

Yuliani: Participated in all experiments, coordinated the data-analysis and contributed to the writing of the manuscript.

Soemarno, Bagyo Yanuwiadi and Amin Setyo Leksono: Designed the research plan and organized the study.

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