Phenetic analysis of turkey berry (Solanum torvum Sw.) based on morphological character in Semarang region

M Martina, J Jumari, M Murningsih
Department of Biology, Faculty of Science and Mathematics, Diponegoro University Jl. Prof. Soedarto, SH Kampus Undip Tembalang Semarang, 50275
Corresponding author: martinaadelia88@gmail.com

Abstract. Turkey berry (Solanum torvum Sw.) plant is originated from America, then spread widely to Asian regions. They used as food and pharmaceutical. The differences of latitude affecting morphological variations of Turkey berry since it affecting the physicochemical condition of their habitat, namely temperature and pH. Environmental temperature is one of important factor since it influencing the interaction process, while pH determines the growth and formation of chlorophyll. Morphological variations in turkey berry plant cause a similarity relationship that can examined using phenetic analysis. Currently, studies of turkey berry phenetic analysis based on morphological characters have not been done yet. This study examines the morphological variations of turkey berry that grow in different altitude specifically in the Semarang area. The sampling method which used in this study is the purposive sampling method. Turkey berry samples were obtained from altitude of 300, 600 and 900 above sea level respectively. Data analysis was performed using MVSP (MultiVariate Statistical Package) application. The algorithm used in the MVSP application is UPGMA (Unweighted Pair Group Method with Arithmatic Mean) with the Simple Matching Coefficient method, or grouping method with the complaints of paired pairs by analysis of the distance between pairs. The Operations Taxonomic Units (OTUs) analyzes 27 individuals, with 33 different morphological characters. Phenetic analysis shows the coefficient correlation between OTUs reaches 0.81 which is divided into 2 main clusters and 11 sub-clusters. This shows that turkey berry does not form subspecies to grow in different inner regions.

1. Introduction
Turkey berry (Solanum torvum Sw.) plant is originated from America, then spread widely to the Asian regions. The turkey berry grows in forests, river banks, fields, gardens and sometimes cultivated in the yard. Turkey berry fruit is generally used as a vegetable and has medicinal properties, to improves blood circulation, relieves pain (analgesics) and relieves coughs (antitussive) [1,2]. Most of Turkey berry that distributed in Indonesia is grow in Sumatra and Java, with an elevation range between 1 - 1,600 meters above sea level. The ideal environment of this plant is moderately watery, with moderate intensity sunlight [3]. This causes the turkey berry to easily grow anywhere.

The utilization of turkey berry is common in various regions in Indonesia, for instance, in Java island, especially Bogor region, it used as an alternative medicine [4]. In Kalimantan island, especially Dayak tribe, the root of the turkey berry is used as medicine for back pain [5]. However, not all the people aware about the medicinal properties of turkey berry fruit. Moreover, the use of turkey berry fruit as a food ingredient has not been widely used.
An aspect that affects plant growth and development is environmental conditions. Phenotypic appearance is strongly affected by environmental changes [6]. The environment variation is strongly affected by geographical conditions and climatic conditions. This condition will affect the growth of the plants, moreover, it caused the variation of the phenotypic properties of the plant, both morphologically or physiologically. One of the environmental factors that can affect plant morphological variations is an altitude. The differences of the altitude cause a difference in ambient temperature. The ambient temperature will decrease by 0.6°C for every 100 meters above sea level [7]. Environmental temperature is strongly affected the metabolic processes of the plant [8].

Each plant has similarities with other plants. The level of similarity between plants can be determined using phenetic analysis. Phenetic analysis is an analysis performed to classify organisms based on morphological similarities or similarities from other observable characteristics. The method that can be used for phenetic analysis is numerical taxonomy. Numerical taxonomy is used to integrate data from various sources such as morphology, physiology, phytochemistry, embryology, anatomy, palinology, chromosomes, ultrastructure, and micromorphology. Data is presented in numerical form and then integrated with data processing systems used for the creation of descriptions, keys, catalogs, maps and other documents [9].

2. Materials and methods
The research was conducted in the different areas of Semarang City and Semarang Regency, with different altitude for each sampling site. The research was conducted in June - August 2019. Observation map can be seen in Figure 1 and Figure 2. The tools used are stationery, measuring tape, thread, scissors, camera, plant collection equipment including duplex paper, nylon thread, manila paper, masking tape, label paper, plastic for collecting samples, and tools used for measuring. Environmental factors include soil pH, thermometer, hygrometer, and GPS. The material used in this data collection was samples of turkey berry plants.

Figure 1. Observation map at Tembalang Station (Semarang City)
The research is divided into 3 stages, namely:

2.1. **Collection**
This activity begins with seeking information about general conditions of the research location, then determining the location for sampling. The research locations are divided into 3 stations, namely Station 1 (altitude of ± 300 masl), located in Tembalang area, Station 2 (altitude of ± 600 masl) located in Bawen area, and Station 3 (± 900 masl) located in Bandungan area.

The sample was taken by using purposive sampling method. According to Endraswara, purposive sampling or judgment sampling is the process of taking samples by selecting all samples and grouping them according to certain variables according to the objectives to be achieved by the researcher [10].

2.2. **Characterization of morphological data**
Characterization of morphological data has been done by observing and measuring the length, width and diameter of the vegetative and generative organs of the turkey berry plant including stems, leaves, flowers, fruit and seeds. Environmental factors were measured at each sampling point to determine the surrounding physical conditions.

2.3. **Phenetic analysis**
The characterization data of the turkey berry plants were collected from each station, tabulated and analyzed. Phenetic analysis was conducted in several stages, namely:
1. Selection of OTUs. The first thing that is done in phenetic analysis is the selection of objects that represent certain groups of organisms or called OTUs.
2. Characterization. Select each character contained in OTUs to make easier grouping.
3. Calculating the similarity of OTUs. Each OTUs that has been characterized is calculated for its similarity to find similarities between OTUs. In addition to calculating the similarity of OTUs, distribution diagram analysis was also conducted for each OTUs to determine the characters that affect morphological variations in turkey berry.
4. Grouping based on Similarity Index among OTUs. The results obtained are similarity index. Each OTUs that has close or very close similarity becomes one group based on the similarity index value.

3. Results and discussion

3.1. Collection
The research was conducted at 3 stations, namely Tembalang, Bawen, and Bandungan stations. Each station is divided into 3 observation points. Each observation point was observed by 3 individual turkey berry plants. The samples observed at each station were 9, so the number of samples observed at 3 stations was 27 samples. Abiotic factors observed in the observation of turkey berry plants include elevation, soil pH, soil moisture, light intensity, wind speed, temperature, and humidity. Each station has abiotic factors that vary quantitatively. Abiotic factors data can be seen in Table 1.

| No. | Characters       | Station 1 | Station 2 | Station 3 |
|-----|-----------------|-----------|-----------|-----------|
| 1.  | Elevation (masl)| 212       | 497       | 818       |
| 2.  | Soil pH         | 6.53      | 6.73      | 6.7       |
| 3.  | Soil moisture (%)| 1.46      | 0.73      | 0.77      |
| 4.  | Light intensity (ft-cd)| 333.6 | 866.7 | 774.6 |
| 5.  | Wind speed (fpm) | 320       | 117.7     | 161       |
| 6.  | Temperature (°C) | 32.6      | 35.4      | 32.2      |
| 7.  | Humidity (%)    | 42.9      | 39.6      | 38.6      |

Note: masl: meters above sea level, ft-cd: foot candle, fpm: feet per minute

According to Saroya, turkey berry is widespread in all tropical regions around the world and does not have special living conditions to support life [11]. This ability of the turkey berry makes this plant able to grow everywhere and does not require special adaptations to survive external stresses.

3.2. Characterization of morphological variations
In observing the turkey berry plants, various characters are used to find morphological variations. The organs used to look for morphological variations of the turkey berry plant are stems, leaves, flowers, fruit, and seeds. The morphological characters used were 33 characters. This character consists of quantitative and qualitative characters. The quantitative characters observed in the turkey berry plant were 6 characters, while the qualitative characters were 27 characters. According to Fauziah morphological characters can be used to analyze kinship relationships [12]. One of the methods used is observing the character of organs, especially stems and leaves.

Based on observations, it can be seen that both quantitative and qualitative data can show variations in turkey berry. The difference in morphological data on the turkey berry plant can be caused by various factors. One of them is the ability of plants to absorb water and nutrients and the availability of nutrients for the photosynthesis process. According to Ludang, the factors that influence the photosynthetic process of a plant are external and internal factors [13]. External factors are light, chlorophyll, temperature, carbon dioxide, and water, while internal factors are age, stomata state and plant species.

3.3. Phenetic analysis
The phenetic analysis of turkey berry plants was conducted to classify (clustering) organisms based on their similarity. According to Hardiyanto, cluster analysis in taxymetry is used to organize groups into taxon categories based on the similarity of their properties [14].
Phenetic analysis was performed using the MVSP application. The algorithm used in the MVSP application is UPGMA, with the Simple Matching Coefficient and Euclid Biplot methods. The presentation of the results of phenetic analysis grouping is in the form of dendrogram.

**Dendrogram**

Dendrogram is a tree-shaped diagram that represents group arrangements based on certain analyzes. According to Bernadier and Naima, a dendrogram is a diagram that is generated to represent the results of a cluster analysis [15]. Dendrogram can be generated with the number of clusters or external characters and analyzed with certain applications/programs. Based on the phenetic analysis that has been carried out, the dendrogram that appears in the MVSP application shows the following results:

![Dendrogram result](image)

Based on the results of the dendrogram, it can be seen that the turkey berry is divided into 2 main clusters and 11 sub-clusters. The differences in each turkey berry sample are caused by several factors, namely genetic factors and environmental factors. According to Barbour and Pitts, environmental factors that affect plant morphological variations are light intensity, latitude, elevation, climate, temperature, humidity, type, condition, and soil fertility [16]. The continuous change for a long time will cause adaptation that ended by the alteration of the genes, then inherited to the next generation. This alteration is led to new and different expression. The existence of these differences causes variations in plants [17].

The results of dendrogram analysis showed that the turkey berry similarity index from the farthest to the closest was 0.81-1. Based on the results obtained, it can be seen that all observed OTUs have very close kinship, or are the same species. This is confirmed by [18] statement that the level of similarity is said to be far if it is less than 0.60 or 60%. The closer to the number 1, the more perfect the similarity level, while the closer to the number 0, the further the similarity level. According to [19], the similarities and differences in characters, both in the form of morphological characters, anatomical characters, and genetic characters, can show a similarity relationship. The similarity relationship is very close when the equation is more than 70%, close if the equation is 51-69%, not close if the equation is 26-50%, and very not close if the equation is less than 25%. The more similarities the closer the similarities are. Conversely, the more differences, the further the similarities
are. [19] states that in general a taxa group is declared as one species if it has a similarity index of $\geq 80\%$.

Based on dendrogram analysis, the similarity of the turkey berry plant is considered very close, even though it grows at different elevations. This can be related to the common environmental conditions at each station when the observations were conducted, namely the environment which tended to be dry. According to [20], turkey berry is a plant that tends to be fertile, lives in humid environmental conditions and is tolerant of dry and barren areas. The similar environmental conditions can cause each turkey berry to have a close resemblance.

4. Conclusion
The phenetic analysis of turkey berry ($S. \text{torvum}$ Sw.) showed that the similarity index between OTUs was 0.81-1. This indicates that the differences of the altitude in Semarang region does not allow turkey berry plant to specifically form subspecies.

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