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Morphology and morphometry of rangrang ants [*Oecophylla smaragdina*] (Hymenoptera: formicidae) from two different habitats in Manado city, north Sulawesi

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Abstract

Rangrang ants (*Oecophylla smaragdina*) are included in the order Hymenoptera. The ants were arboreal and generally form nesting on the leaves of the forest, but nowadays they are mostly found in urban or rural areas in Manado city. This study was conducted to determine the morphological characteristics of Rangrang ants from two different habitat, namely around the hospital (RS) and around the garbage disposal site (TPA) in the city of Manado. Morphological characterization using a digital microscope equipped with measurement software. Accuracy of measurements on a micrometer (µm) scale. Twelve main morphological characters were measured. The measurement results were analyzed descriptively. The similarity of morphometric characters was analyzed using multivariate analysis, namely cluster analysis. The results of this study showed that the qualitative morphological characteristics of the body color, shape of the ant organ of the two populations of the RS and TPA did not have a significant difference. Differences are shown in quantitative morphological characteristics. Rangrang ants from hospitals have an average body length greater than that of ant ants from the TPA population. Based on cluster analysis, the morphological characters of LTTT and LTTB are the highest morphological characters in the equation between the RS and TPA populations. While the highest morphological characters are the difference between PT and PSCA.

Keywords: rangrang ants, *Oecophylla smaragdina, morphometry, morphology*

Introduction

In the world there are estimated 12,571 species of ants, consisting of sub 22 families and all of them belonging to the family formicidae (Bolton, 2003; Chavhan and Pawar, 2011) [7, 8]. Rangrang ants belong to the genus Oecophylla. There are two species in the genus Oecophylla which have similar morphology and behavior, but have variations in body color. *Oecophylla smaragdina* is spread from tropical regions of Asia to the northern part of Australia and the western Pacific islands. *Oecophylla smaragdina* has a brownish red body color to dark brown (Way and Kho, 1992) [16]. Other species which are very similar are *Oecophylla longinoda* (Latr) which has a brownish red body color and is found on the African continent (Offenberg et.al. 2004; Migani et.al. 2017) [14, 11]. Until now there have been many reports on the ecology and distribution of *Oecophylla smaragdina* host plants, but there are still very few reports on the variations in the morphology of field ants in urban and rural areas.

O. smaragdina shows a high level of morphological variation, especially in the body color of the worker, which is light to dark brown in Southeast Asia but is known as green tree ants because of the green color of the abdomen in Australia. Although some researchers have classified the local population into several subspecies based on morphological variations, the phylogenetic relationship of this population is still unknown (Azuma et.al. 2002) [1].

The morphological variation of intraspecies is very striking in Rangrang ants. This results in an interesting study of the morphology of the Ranrang ants. The population of sample ants in this study came from urban and rural areas in the city of Manado. Based on previous research, in urban and rural areas in the city of Manado, Ranrang ants have made residents' houses adjacent to their nests a place to find food. There is still much debate about habitat characteristics affecting behavior and morphology. This research has been conducted to obtain scientific data on the morphological characteristics of space ants from urban areas, namely hospitals and waste disposal sites, in the city of Manado.

Materials and Methods

Samples

Rangrang ant samples are obtained from hospitals (RS) and waste disposal sites (TPA). Ant samples are captured directly on the nest, then carried out sorting of worker ants. Each location was isolated by 25 worker ants so that the total sample was 50 adult worker ants. The sample was preserved with 50 ml of 95% ethanol in the sample bottle. One adult ant worker is preserved in a sample bottle. Samples were observed less than 24 hours after being captured and preserved with ethanol.

Tools and materials

The tools used for morphometric analysis include: Hirox KH8700 3-dimensional digital microscope, brushes, Carl Zeiss Stereomicroscope, glass objects, petri dishes, nicon cameras and surgical instruments. Materials used for morphometric analysis: 95% alcohol from Kimia Farma, writing instruments and aquades.

Research procedure

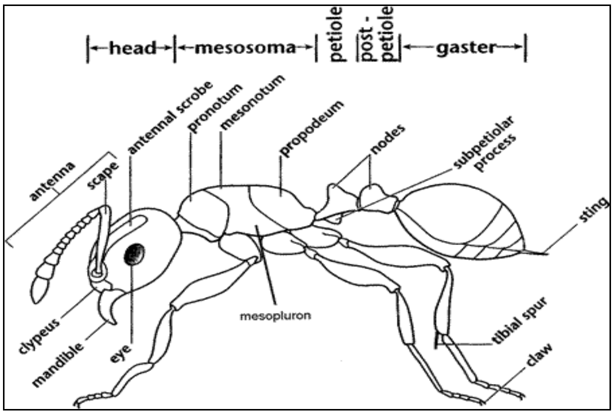

Fig 1: Morphology of Rangrang ants. https://askabiologist.asu.edu/explore/ant-anatomy

The characterization of Rangrang ant morphometry uses the method of Hadisoesilo et.al., (2007) [10] and Mokosuli (2013) [13] which is commonly applied to Hymenoptera. Modifications are carried out by researchers according to their needs and samples. Twelve morphological characters (Figure 1) were examined, namely:

Table 1

PT	: lenght of body
PSCA	: lenghtof scapel antenna
PFTD	: lenght of fore legs femur
LFTD	: widthof fore legs femur
PFTT	: length of midle legs tibia
LTTT	: widthof midle legs tibia
PFTB	: lenght ofhind legs femur
LTTB	: widthofhind legs femur
Pabd	: lenght of abdomen
PPt	: lenght of petiole
Lpet	: width of petiole
Pmand	: lenght of mandibula

Morphological analysis with Carl Zeizz "Stemi DV 4" Stereomicroscope.

Qualitative morphometry were analyzed using Carl Zeizz "Stemi DV 4" Stereomicroscope. Qualitative data include body color, petiole, abdomen and thorax. After the CPU is turned on, click the Carl Zeizz Stemi DV4 program, then the ant sample is placed on the sample site then observe on the monitor. Magnification and lighting are arranged until good images are generated on the monitor screen. This microscope is used to observe ants samples as a whole (not yet surgery). The microscope used has been calibrated.

Morphological analysis with three-dimensional stereo microscope model Hirox KH-8700.

Mikroksop is turned on then the object will appear immediately on the monitor screen. The sample is placed on the sample site and then set to magnification using the remote controller. Magnifications will be automatically set by microscope software. Program measuring (legend and statistics) is activated, then sample the body part of the ant is measured by putting a pointer using the mouse at the starting point of measurement until the end point. Each end of measurement is captured. Data is stored for further analysis. The Mikroksop used has been calibrated.

Results and Discussion

A. Qualitative Morphology

Rangrang ants (*Oecophylla smaragdina*) from the hospital population and population of waste landfills had body color from head to thorax is yellowish red. In general, the color of the body surface and the shape of the Rangrang ant organ which are from the two origins of the sample were the same.The abdomen was brownish-yellow in color. The special morphological structure of ant ranrang was two segments between the thorax and abdomen called petiole. Petiole distinguishes ants from other insect species. Petiole allows circular movement in the ant (Figure 2).

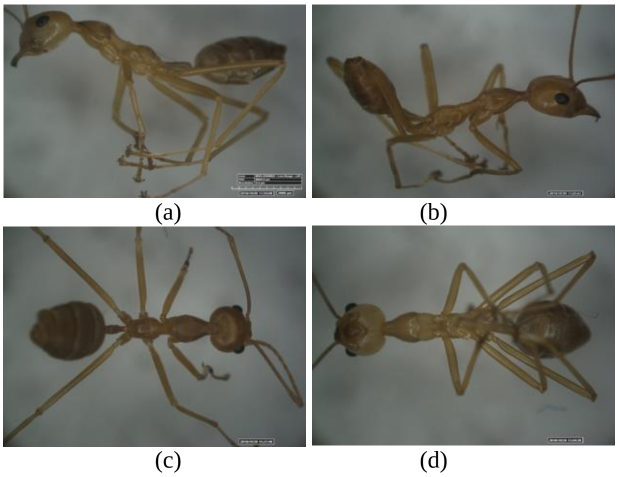

Fig 2: Comparison of the ant morphology of the samples from the RS (figure a and figure b) and the TPA sample (figure c and figure d). Observed with Hirox KH8700 Microscope, MXG-2500REZ: Low range: 35 x; resolution of 5.4 µm.

In the head there had a pair of black, oval-shaped compound eyes; a pair of antennas, a pair of mandibles with structures like brownish spurs. The surface of the mandible was found in many fine hairs that also function as receptors. Fine hairs were also found on all surfaces of the head. The antenna consists of 12 segments. On the surface of each antenna, the segment was found a finer hair structure than the surface of the head. The first segment of the antenna was called a scape and has longer than all other segments. The entire antenna is brown (figure 2 and figure 3).

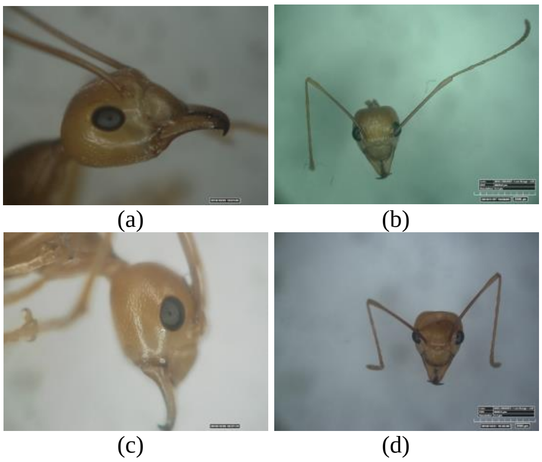

Fig 3: Comparison of head morphology, RS samples (figure a and picture c) and TPA samples (figure c and figure d). Observed with Hirox KH8700 Microscope, MXG-2500REZ: Low range: 35 x; resolution of 5.4 µm.

Brown thorax consists of three segments. The first segment of the head is bigger than the second and third segments. Between the first segment of the thorax there is a pair of legs. Abdominal consists of 5 segments, oval shaped. The abdomen is connected to the thorax by petiole. Unlike the thorax and head, the abdominal color is more brown with the dark brown stripe at the boundary between segments (Figure 4).

(a) (b)

Gambar 4: Comparison of abdominal morphology, RS samples (figure a) and TPA samples (figure b). Observed with Hirox KH8700 Microscope, MXG-2500REZ: Low range: 35 x; resolution of 5.4 µm.

Workers' Rangrang ants can reach body lengths of 8-10 mm, with long leg structures and large mandibles. Workers can reach a length of 8-10 millimeters (0.3-0.4 in), with long strong legs and a large mandible. Workers' Rangrang ants in this study had an average body length of 7.271 mm (RS) and 7.20 mm (TPA). Rangrang ants are arboreal or make nests on the tree (Figure 5). In one tree consists of several nests with each nest there is one queen. Colonies in one nest can move to another nest in one tree. In the abdomen the worker ants have poison glands and apparatus such as needles to remove poisons (Darajan, 2016).

Fig 5: Forms of nesting ants, in the leaves of trees.

Ranrang ants that live in Asia are different from the ants living in Australia. Although both are still grouped in the same species as *Oecophylla smaragdina*. The name smaragdina which means emerald comes from the green color of this ant species found in Australia. Australian worker ants have a brownish-green color. While Rangrang ants in Asia and Sulawesi workers are reddish-brown (Figure 6).

(a) (b)

Fig 6: Compare worker ants (a) Australian rangrang ants and, (b) rangrang ants from Manado (Sulawesi). Image source of Australian ranrang ants: http://termitesandants.blogspot.com/2010/04/oecophylla-smaragdina.html

Oecophylla smaragdina was dimorphic. This is one of several ant species that separates the true caste in which smaller and smaller workers tend to nest while foraging and hunting activities were carried out by the main workers. These ants stab and sting (by spraying formic acid from gaster) turning the stomach up and forward towards the head. Ranrang ants can also spray formic acid droplets from the tip of the abdomen. *Oecophylla smaragdina* like most subfamily species of Formicinae does not have 'functional' stings like other stinging ants.

B. Morphometry

1. Descriptive Analysis

Worker ants are ants with the most members in one rangrang ant colony. In this study, worker ants were used to compare morphological characteristics of rangrang ants from two different habitats. Each population is determined by a sample (n = 15). Each morphological character was measured in organ length (mm) and width (mm) using a digital microscope equipped with calibrated measurement software.

The results of measurements of 12 morphometric characters were obtained by comparison between rangrang ants originating from the RS and TPA. Morphological characters of the body length of ants rangrang from the hospital obtained an average body length of 7716.6 µm (or 7.7166 mm) with a standard deviation of 0.681. The largest body length is 8.76 mm while the smallest is 6.63 mm. A comparison of other morphometric characters is explained in table 1.

Table 1: Descriptive morphometry analysis of rangrang ants from RS.

Descriptive Statistics						
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
PT	15	6,63	8,76	7,7166	,68144	,464
PSCA	15	2,15	2,97	2,5913	,21413	,046
PFTD	15	2,37	2,98	2,7472	,18116	,033
LFTD	15	2,01	2,27	2,1383	,06413	,004
PFTT	15	1,86	2,53	2,0988	,18350	,034

LTTT	15	,21	,25	,2287	,01303	,000
PFTB	15	2,94	3,19	3,0677	,08522	,007
LTTB	15	,15	,20	,1727	,01318	,000
Pabd	15	2,36	2,89	2,6516	,16024	,026
PPt	15	,67	1,06	,9106	,11201	,013
Lpet	15	,23	,29	,2682	,02021	,000
Pmand	15	,69	,98	,8421	,09206	,008
Valid N (listwise)	15					

Rangrang ants from the TPA population have an average body length of 7,206 µm (7,206 mm) with a standard deviation of 0.418. The largest body length is 7.93 mm while the smallest body length is 6.53 mm. Other morphometric characters are shown in table 2. Based on body length morphometry, ants that work from the RS population are greater than those from the TPA population. Hadisoesilo (2003) [10], states that distance of foraging, food availability and body movement activities affect the development of insect bodies. Furthermore, research conducted by Mokosuli et.al. (2013) [13], it is known that honey Apis dorsata Binghami workers who live in areas with many food sources available around the hive tend to have smaller body sizes compared to those who live in areas with food sources far from the hive.

Table 2: Descriptive morphometry analysis of rangrang ants from TPA.

Descriptive Statistics						
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
PT	15	6,53	7,93	7,2061	,41860	,175
PSCA	15	1,36	2,78	2,1929	,38210	,146
PFTD	15	1,45	2,26	1,9107	,18058	,033
LFTD	15	,21	,31	,2545	,03261	,001
PFTT	15	1,37	2,23	1,9386	,25361	,064
LTTT	15	,21	,25	,2301	,01453	,000
PFTB	15	3,01	3,76	3,4035	,30759	,095
LTTB	15	,19	,25	,2156	,01558	,000
Pabd	15	2,15	3,57	2,4445	,36056	,130
PPt	15	,76	1,03	,8930	,08491	,007
Lpet	15	,23	,35	,2730	,03057	,001
Pmand	15	,61	,70	,6495	,02838	,001
Valid N (listwise)	15					

The petiole is a marker organ in the rangrang ant. The average length of rangrang ant petiole originating from the RS (0.910 ± 0.112) is greater than that of the TPA (0.893 ± 0.0849). The average size of limb morphometry characters from both RS and TPA did not show a significant difference. Although, it shows significant differences in morphometry of body length but not in limb organs (Figure 7). Limb organs are active devices in the rangrang ant. Limb organs are most often used as worker ants, especially for finding and carrying food to the nest.

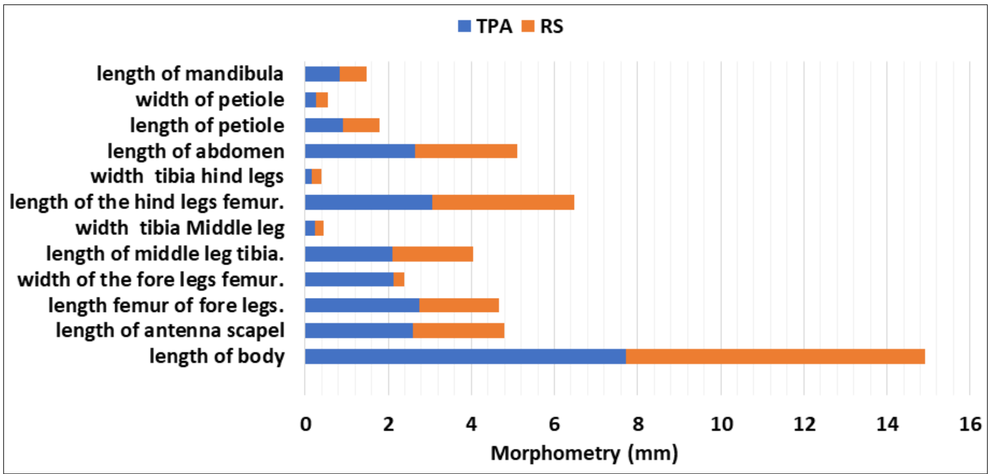

Fig 7: Comparison of rangrang ant morphometry from RS and TPA.

2. Cluster Analysis

Cluster analysis aims to determine the similarity in morphological characteristics between Rangrang ants originating from the RS population and the TPA population. Cluster analysis can show differences in quantitative morphology (morphometry) between two populations of rangrang ants. Cluster analysis can provide a description of morphological differences that are difficult to distinguish based on observations of the anatomy and morphology of insects. Cluster analysis is widely used to determine the morphological differences of insects from two or more different populations within one species.

In the proximity matrix table (Table 3), it can be seen the distance matrix between morphological characters of rangrang ants from the RS population and rangrang ants from the landfill population. The smaller the euclidian distance between morphological characters shows the more similar the morphometric characters. This is what causes similar morphological characters to form one cluster.

Table 3: Distance matrix between morphological characters of Semr rangrang from RS and TPA populations.

Proximity Matrix												
	Euclidean Distance											
	PT	PSCA	PFTD	LFTD	PFTT	LTTT	PFTB	LTTB	Pabd	PPt	Lpet	Pmand
PT	,000	27,904	28,291	34,649	29,967	39,745	23,440	39,947	27,121	36,074	39,521	36,917
PSCA	27,904	,000	2,211	7,879	3,039	12,004	5,259	12,211	2,789	8,388	11,779	9,188
PFTD	28,291	2,211	,000	6,909	2,812	11,767	6,083	11,975	2,794	8,214	11,545	8,910
LFTD	34,649	7,879	6,909	,000	6,617	7,401	12,771	7,619	8,845	5,391	7,250	5,271
PFTT	29,967	3,039	2,812	6,617	,000	9,878	6,965	10,077	3,324	6,262	9,658	7,093
LTTT	39,745	12,004	11,767	7,401	9,878	,000	16,533	,252	12,798	3,721	,265	2,903
PFTB	23,440	5,259	6,083	12,771	6,965	16,533	,000	16,721	4,533	12,874	16,305	13,765
LTTB	39,947	12,211	11,975	7,619	10,077	,252	16,721	,000	12,997	3,915	,460	3,109
Pabd	27,121	2,789	2,794	8,845	3,324	12,798	4,533	12,997	,000	9,148	12,576	10,001
PPt	36,074	8,388	8,214	5,391	6,262	3,721	12,874	3,915	9,148	,000	3,492	1,125
Lpet	39,521	11,779	11,545	7,250	9,658	,265	16,305	,460	12,576	3,492	,000	2,684
Pmand	36,917	9,188	8,910	5,271	7,093	2,903	13,765	3,109	10,001	1,125	2,684	,000

This is a dissimilarity matrix

Table 3 below shows the process of cluster formation between the morphological characters of the Rangrang ants from the RS and TPA. Classification occurs in stages. In stage 1, one cluster was obtained, namely between the LTTT character (6) and LTTB character (8) with a coefficient distance of 0.064. The coefficient value of LTTT and LTTB clusters is the smallest coefficient value of all cluster formation. This shows that the morphological characters of LTTT and LTTB are the most similar characters among the Ranrang ant population. The cluster with the largest coefficient is 1124,012, which is between Lpet (10) and PFTT (11). Thus the Lpet and PFTT morphological characters are the most different morphological characters between the Rangrang ant hospital population and the TPA population. A total of 11 clusters formed showed morphometric variations between the Rangrang Semut RS and TPA populations which were classified as high.

Table 4: Morphological cluster formation of Rangrang ants.

Agglomeration Schedule						
Stage	**Cluster Combined**		**Coefficients**	**Stage Cluster First Appears**		**Next Stage**
	Cluster 1	**Cluster 2**		**Cluster 1**	**Cluster 2**	
1	6	8	,064	0	0	2
2	6	11	,141	1	0	7
3	10	12	1,265	0	0	7
4	2	3	4,888	0	0	5
5	2	9	7,792	4	0	6
6	2	5	9,396	5	0	8
7	6	10	11,112	2	3	9
8	2	7	33,432	6	0	10
9	4	6	44,446	0	7	10
10	2	4	125,805	8	9	11
11	1	2	1124,012	0	10	0

In the process of forming a cluster (table 4). Only two clusters have a cofisien value below 1. This shows that the two clusters have the closest morphological similarity between the RS population and the TPA population. The two groups are LTTT and LTTB; and LTTT and LTP. Morphological characters of the width of the middle limbs and hind limbs are the most similar morphometric characters between RS ants and landfill ants. Furthermore, the width character of the middle limb is similar to the morphometry of the leaf stem width. In the dendrogram, morphological characters that have the smallest coofisen values will approach the zero point of the Y axis (Figure 2).

Based on the dendrogram formed, there are nine clusters that have the closest similarity level (cluster distance is less than 5). Only one cluster, namely PT (1) and PSCA (2) morphological characters, has a very large difference (cluster distance 25) (Figure 8). Thus the morphological characteristics of PT and PSCA were most different between the TPA and RS rangrang ant populations in the city of Manado (Figure 8).

Morphological characters that showed the biggest difference were the morphological characters of PT and PSCA. From the results of this study indicate that the length of the ants rangrang body is not very influential on the morphometry of other organs, especially the legs and petiole. Significant variations in the length of the first segment of the antenna or PSCA. The antenna is a communication tool and there are many sensors on the rangrang ant. The role of the antenna is very important in eusocial insects such as rangrang ants. Variations in the structure of the antenna can be influenced by the activity or task of the ants of the workers' castes. The workers caste consists of major workers and minor workers.

Minor workers do more activities in the nest and close to the nest while major workers have more activity outside the nest. Thus the major worker has a larger antenna structure than the minor worker.

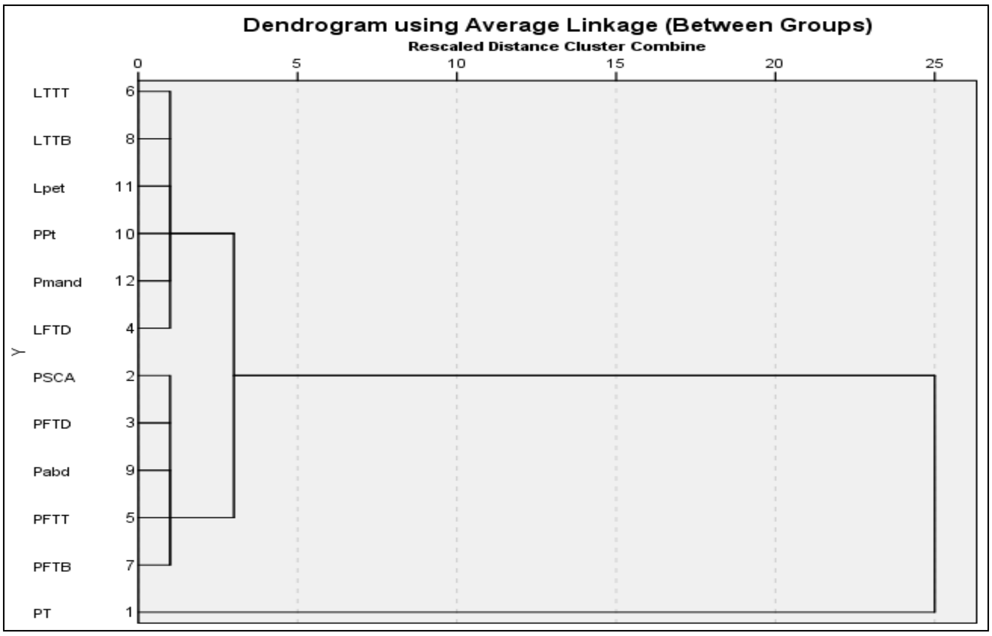

Fig 8: Dendrogram grouping morphological characters of rangrang ants from the RS population and TPA population.

Insects have the ability to make morphological modifications such as wing length and thorax. This phenomenon was reported in *Droshophilaananasae* (Vishalakshi and Singh, 2008), *Melitaecinxia* (Norberg and Leimar, 2002). Although in the same population found striking morphological variations in insects. *Lymantria disparum* moths have different flight capabilities in the same sub-population (Keena et.al. 2007). Thus the specific morphological parameters of insects can distinguish clearly between individuals and become an identifier of species and provide evidence of geographic isolation. However morphological variations in wing color, head size, body color etc. can reflect adaptations due to local climate (Moczek and Nijhout, 2002). This behavior is found in rangrang ants from two different populations in the city of Manado. Geographically, the two separate populations are quite significant in the city of Manado. The sample location of the landfill population is adjacent to forests or dense vegetation and is higher than sea level. Whereas the sample location in the hospital tends to be less in number and close to the beach. Local climate and habitat characteristics affect the morphology of the rangrang ant.

As a system, organisms are strongly influenced by their environment. Therefore, the phenotype of an organism can differ according to the state of its environment. The ability of an organism to express different phenotypes in different environments is also known as phenotypic plasticity (Whitman & Agrawal 2009) [18]. Phenotypic expression is the result of the genotypic expression, environmental factors, and interactions between genotypes and the environment (Noor 2008).

Genes that are plastic can be in the form of autosomal genes, or genital linked genes (Noor 2008; Mikolajewsky *et al*., 2008). Phenotypic plasticity is a common phenomenon in insects, which can be observed in body size, body-color, the presence or absence of wings, wing color and pattern, caste change, presence or absence of capid, etc. (Braendle *et al*. 2005; Whitman & Agrawal 2009) [6, 18]. Phenotypic plasticity was also observed in certain insects including feeding behavior, mating behavior, egg-laying, anti-predator behavior, etc. Animals exposed to extreme environmental changes have only 2 choices, namely to develop their plasticity or be eliminated from the environment (Badyaev 2005) [5].

Conclusion

From the results of this study, it can be concluded that the qualitative morphological characteristics, namely body color, the shape of the rangrang ant organs of the two populations of the hospital and landfill did not have significant differences. Differences are shown in qualitative morphological characteristics. Rangrang ants originating from hospitals have an average body length greater than the rangrang ants of the TPA population. Based on cluster analysis, the morphological characters of LTTT and LTTB are the morphological characters with the highest similarity between RS and TPA population. While the morphological characters with the highest difference are PT and PSCA.

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