Ecological Linkages Between Snails and Litters In Mount Gandang Dewata, West Sulawesi [Hubungan Ekologis antara Siput dan Serasah di Gunung Gandang Dewata, Sulawesi Barat]

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ABSTRACT

Mount Gandang Dewata in West Sulawesi was recently granted National Park status. Exploration of land snails in Taman Nasional Gandang Dewata (TNGD) has never been carried out. Therefore, a study of land snails in the National Park was conducted in April 2016 to examine the composition of land snails in different habitats, namely primary and secondary forests. Overall, 43 specimens (21 species from 8 families) were found from eight study sites. Snails are not found in steep areas, on moderate slopes 1-10 snails are found, and in flat areas 8-13 snails are found. The analysis was carried out by the principal components (PCA). According to the PCA, three groups of snails were formed. Environmental factors such as litter, altitude, humidity, calcium (Ca), nitrogen (N), and sodium (Na) are discussed in relation to snails. In this paper, litter factors are discussed in greater depth than other environmental factors. Snails and litter interact in an ecological relationship in the forest ecosystem of Mount Gandang Dewata.

Key words: environment, forest, snail, litter, Gandang Dewata

ABSTRAK

Gunung Gandang Dewata di Sulawesi Barat baru-baru ini diberikan status Taman Nasional. Eksplorasi keong mas di TNGD belum pernah dilakukan. Oleh karena itu, penelitian terhadap siput darat di Taman Nasional dilakukan pada bulan April 2016 untuk mengkaji komposisi siput darat pada habitat yang berbeda yaitu hutan primer dan sekunder. Secara keseluruhan, 43 spesimen (21 spesies dari 8 famili) ditemukan dari delapan lokasi penelitian. Keong tidak ditemukan di daerah curam, di kemiringan sedang ditemukan 1-10 keong, dan di daerah datar 8-13 keong ditemukan. Analisis dilakukan dengan melibatkan komponen utama (PCA). Menurut PCA, tiga kelompok siput terbentuk. Faktor lingkungan seperti serasah, ketinggian, kelembaban, kalsium (Ca), nitrogen (N), dan natrium (Na) dibahas dalam kaitannya dengan siput. Dalam tulisan ini, faktor serasah dibahas secara lebih mendalam daripada faktor lingkungan lainnya. Siput dan serasah berinteraksi dalam hubungan ekologis di ekosistem hutan Gunung Gandang Dewata.

Kata Kunci: lingkungan, hutan, keong, serasah, Gandang Dewata

INTRODUCTION

Mount Gandang Dewata with an elevation of 3074 meters is the highest mount in West Sulawesi Province. The mount is the second highest mountain in Sulawesi Island only encompassed by Mount Latimojong (3478 meters). It is a National Park (GDNP) as decreed by the Minister of Environment and Forestry numbered SK.773/MENLHK/Setjen/PLA.2/10/2016, located at 6° 32'-6° 55'S and 106°13'-106°46' E. with altitude

ranges 500 - 2200 m a.s.l.

The park has several function such as animal diversity conservation, ecological processes preservation, water sources preservation, consumption function, research and education, and recreation (Rhama 2019). Since most of National Parks share border with villages, the park is divided into 4 zones, namely core zone, utilization zone, traditional zone, and jungle zone (Ministerial Regulation of Environment and Forestry Republic of Indonesia numbered P.76/Menlhk-Setjen/2015).

Accordingly, some parts of the core zone and utilization zone of the park are located within Tondok Bakaru village (Anon 2018). The Tondok Bakaru Village area consists of primary forests and secondary forests, which are included in the Park. The other are consist of paddy field and settlements.

As we know, Sulawesi is one of the world's biodiversity and endemic hotspots (Cannon *et al.* 2007, Whitten *et al.* 2002, Natus 2005). There is some improvement in Sulawesi's snails knowledges especially for land snails in the last two decades (Marwoto 2008, Heryanto 2020, Maassen *et al.* 1996, Maassen 1998, 2003, 2007, 2009). Most of publications are descriptive, and only few related with environment whereas snail play an important role in the dynamics of decomposition and interactions litter substrates in forest litter (De Oliveira *et al.* 2010). In tropical rain forest areas such as Gandang Dewata with its thick canopy, the litter production is very large. There are lack of information about the interaction of the snails and litters in Mount Gandang Dewata. Hence, ecological relationship of snail assemblages with litters have not been well studied. The purpose of this study was to examine snail assemblage in relation with litters.

MATERIALS AND METHODS

The study was conducted in April 2016. The study was carried out in the primary and secondary forest in Mamasa District (Figure 1) on a fluctuate area of montane zone (Cannon *et al.* 2007). The location is pass by Tetean River (Figure 1). The climate of this area according to Schmidt Ferguson (1951) is categorized to D1/

B1 zone with an average yearly precipitation is 2,140 mm and 11 wet months (Anon 2). Characteristics of different sites to collect samples were provided by following Table 1.

The snails, either living snails or empty shells, were handpicked by the first author from suitable macrohabitat viz. leaf litter, under stone, woods, decaying logs, herbaceous vegetation, humus and litter. In each site, large and small snails (more than 10 mm height) were sought in a range of 5 m² separately. In each square, all off litter and vegetation was put aside by a hooked twig to found the snail. Subsequently, the microsnailes (less than 10 mm height), were explored in a 33.33 x 33.33 cm² frames where litters and vegetations removed individually.

Discovered living snails were photographed immediately in the field, prior to stored in a plastic bag and then preserved in 70% etanol solution. Samples of microsnailes were

Figure 1. The research location in Gandang Dewata National Park of West Sulawesi showing sites A – H. Insert: research location relatives to West Sulawesi. (Base maps: Google@2021)

Table 1. Characteristics of the research sites in Gandang Dewata National Park

Indicative	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H
Position	2°52'52.1"S 119°22'53.3	2°52'49.6"S 119°22'57.6	2°52'54.1"S 119°22'57.6"E	2°52'56.0"S 119°22'58.6"	2°52'56.8"S 119°23'01.9"E	2°53'05.8"S 119°23'10.9"	2°53'03.7"S 119°23'11.9"	2°53'01.0"S 119°23'12.1
Elevation	1707	1590	1633	1635	1638	1619	1580	1575
Steepness	Steep	Flat	gentle	gentle	gentle	gentle	gentle	Flat
Coverage	Primary forest	Primary forest	Secondary forest	Secondary forest	Secondary forest	Secondary forest	Secondary forest	Primary forest
Litter	Thin	Thick	Moderate	Moderate	Moderate	Moderate	Moderate	Thick

stored in plastics vials. All specimens were transported to MZB for cleaning, sorting, and identifying. All specimens were deposited at the Malacology Laboratory, Museum Zoological Bogoriense in Cibinong, Bogor.

Ten subplots 50 x 50 cm were made for leaves litter sampling from 1600 and 1700 masl. Analysis of macronutrient elements in litter using Atomic Absorption Spectrophotometers (AAS) includes Calcium (Ca) and Sodium (Na). The N analysis using C/N Analyzer at the Plant Ecology Laboratory, Botany, Research Center for Biology, LIPI. Sampling of the litter at each height is taken at five points diagonally then they are composited.

To support information about litter producers, two sampling vegetation plots of 30 m x 30 m each, located at an altitude of 1600 and 1700 masl were established. Each plot is divided into 9 sub-plots, 10 m x 10 m. All woody plants with a circumference more than 15 cm which were found in each sub-plot, were measured at breast height (DBH) 130 cm and the total height. Each species recorded in each plot was made as specimens of ecological evidence for identification at Herbarium Bogoriense, LIPI.

PAST (Paleontological Statistics) software program Version 3.14 of Hammer (Hammer *et al.* 2001) was applied for the whole analysis since the samples were less than 50 the test were done by Shapiro–Wilk test. Considering the sample were distributed normally, subsequent analysis was to observe the species composition in relation with environmental variables by Principal Component Analysis (PCA). Due the environmental variables in this research (altitude, humidity, calcium (Ca), nitrogen (N), and natrium (Na) were not represent all sites and covered in the discussion.

RESULTS

A total of 43 snails specimen belonging to 21 species (8 families) of land were extracted from the investigated area of Gandang Dewata National Park (Table 2). In the steep site (1693–1707 masl), where overgrown by large tree such as *Castanopsis acuminatissima* with hard leaves and thin litter, no snail were found, whereas in the gentle sites with found 1 – 10 snails per site

(5 sites), and in the two flat sites found 8 and 13 snails. There are 71 individual of trees in the altitude around 1700 masl of the forest, including 18 species, 16 genus, 13 families and 83 individual of saplings, with 19 species, 17 genus, 13 families.

The large globular and subglobular snails of Helicidae and Zonitidae dominate the snail samples from flat sites B. They were *T. bulbulus bulbulus*, *Xesta limbifera*, and *Tricheulota* (juvenile). They live in the holes of fallen dead tree trunk which full grown of moss. The trunk was lying down close to waterfall on Tetean River. The site H, downstream of site B, with its wider area inhabited by smaller snails, even one the smallest such as *Diplommatina* sp. Most of the secondary forest sites (C, D, E, F, and G) were occupied by small snails such as *Helicarion* spp., *Liardetia* spp., *Paraphaedusa* spp., *Stenogyra kemensis*, and *Sitala* cf. *javana*. Some of them lives on the twig and branch of the saplings *Ficus ampelas*, *Ficus* sp., *Garcinia daedalanthera*, and *Saurauia tristyla* which were growing a lot in the area. The others stay as ground-dwelling, relied their life on moderate thickness of litters. There are generally more open forest around 1600 m asl with 86 individual trees including 22 species, 16 genera, 13 families and 114 individual sapling with 21 species, 16 genera, 14 families. The vegetation on Mount Gandang Dewata shows that as the altitude increases, the number of individuals, species, genera and families were decreases, inline with Whitten *et al.* (1987).

As a whole, there were three groups of snails in the research area. First group with the largest member of the group, most of the snails found in the area were incorporated. The member of this group were *Xesta limbifera*, *Xesta steursi*, *L.* cf. *javana*, *C. sitaliformis*, *I. albacuminatus*, *T. bulbulus bulbulus*, *H. adolfi*, *T. gloriosa gloriosa*, *T. zodiacus zodiacus*, and *Tricheulota* sp. (juvenile).

Second group, were *Diplommatina* sp., *H.* cf. *minahassae*, *L. inconspicuus*, *Leptopoma* sp., *T. zodiacus tuba*, *S.* cf. *javana*, although *Diplommatina* sp., was quite far from the group.

The third group has a small member of *C. bonthainensis*, *C. minahassae*, *L. acutiuscula*, *K. platyconus*, *S. kemensis*. *L. platyconus* itself was separate from the others.

Table 2. List of land snails taxa found in the researched area

Taxa	Moderate 1580-1638					Flat 1575-1590		
	n	C	D	E	F	G	B	H
Camaenidae								
<i>Tricheulota bulbulus bulbulus</i>	2							2
<i>Tricheulota zodiacus tuba</i>	1						1	
<i>Tricheulota zodiacus zodiacus</i>	1				1			
<i>Tricheulota gloriosa gloriosa</i>	1				1			
<i>Tricheulota</i> sp.(juvenile)	4							4
Helicarionidae								
<i>Helicarion adolfi</i>	1					1		
<i>Helicarion</i> cf. <i>minahassae</i>	1						1	
<i>Sitala</i> cf. <i>javana</i>	1			1				
<i>Ibycus albacuminatus</i>	1						1	
Ariophantidae								
<i>Xesta steursii</i>	1	1						
<i>Xesta limbifera</i>	2				2			
Cyclophoridae								
<i>Diplommatina</i> sp.	8						8	
<i>Lagocheilus inconspicuus</i>	1						1	
Pomatiidae								
<i>Leptopoma</i> sp.	1			1				
Euconulidae								
<i>Liardetia</i> cf. <i>javana</i>	1					1		
<i>Kaliella platyconus</i>	10	7	3					
<i>Liardetia acutiuscula</i>	2		2					
<i>Coneuplecta sitaliformis</i>	1					1		
Stenogyridae								
<i>Stenogyra kemensis</i>	1	1						
Clausilidae								
<i>Paraphaedusa minahassae</i>	1	1						
<i>Paraphaedusa bonthainensis</i>	1		1					

DISCUSSION

The Forest in Sulawesi consists of four types: lowland forest, lower montane forest, upper montane forest and subalpine forest (Whitten *et al.*, 1987) and this study was conducted in the lower mountain forest. No snail was found in Site A, most probable because they roll down hill (Baur *et al.* 1997) in consideration of steep position added with high precipitation. Another possibility was the thinness and hardness of litter the site not preferred by snails. Furthermore, the phenomenon in temperate place can be thought about that snails assemblages decrease in line with increasing altitude, even though the rate was slacken after attain elevation of 1500 masl. (Aubry *et al.* 2005).

Snails in site B were large and in spherical shape. It should be like that since this site close to waterfall. The spherical shape makes them

able to withstand the water from the waterfall. On the other hand, Site I on the side of the Tetean river, which is quite wide, were overgrown by large trees that make the place cold and humid. The ground was covered with thick litter, made appropriate for snails. It was not surprising that many snails live there.

All of the snails in the secondary forest sites were pulmonate. Similarly, studies in Indonesia and Malaysia found that in the secondary forest, pulmonate in term of individual number is higher than that of prosobranch which was substantially dominate the primary forest. (Nurinsiyah dkk. 2016 & Schilthuizen *et al.* 2005). The main reason behind this is that the small size of the snails makes it easier for them to burrow under the litter for the sake of protection, comfort and food. Decomposed leaves litter is preferable by snails to fresh fallen leaves (De Oliveira *et al.*, 2010)

Figure 2. Biplot diagram of Principal Component Analysis (PCA) shows the grouping of 21 species of snails in three different habitat types.

Remarks: 1. *T. bulbulus bulbulus*, 2. *T. zodiacus tuba*, 3. *T. zodiacus zodiacus*, 4. *T. gloriosa gloriosa*, 5. *Tricheulota* sp.(juvenile), 6. *H. adolfi*, 7. *H. minahassae*?, 8. *S. javana* ?, 9. *I. albacuminatus*, 10. *X. steursii*, 11. *X. limbifera*, 12. *Diplommatina* sp., 13. *L. inconspicuus*, 14. *Leptopoma* sp., 15. *L. javana*, 16. *K. platyconus*, 17. *L. acutiuscula*, 18. *C. sitaliformis*, 19. *S. kemensis*, 20. *C. minahassae*, 21. *C. bonthainensis*.

Table 3. Principal Components loadings number

Species	PC 1	PC 2	PC 3
<i>Tricheulota bulbulus bulbulus</i>	-0.30	-10.63	14.50
<i>Tricheulota zodiacus tuba</i>	0.63	-0.16	-0.37
<i>Tricheulota zodiacus zodiacus</i>	-0.23	-0.72	-0.59
<i>Tricheulota gloriosa gloriosa</i>	-0.23	-0.72	-0.59
<i>Tricheulota</i> sp.(juvenile)	-0.38	-14.48	33.98
<i>Helicarion adolfi</i>	-0.30	-10.63	14.50
<i>Helicarion cf minahassae</i>	0.63	-0.16	-0.37
<i>Sitala cf javana</i>	0.63	-0.16	-0.37
<i>Ibycus albacuminatus</i>	-0.22	-0.69	-0.52
<i>Xesta steursii</i>	-0.23	-0.72	-0.59
<i>Xesta limbifera</i>	-0.23	-0.72	-0.59
<i>Diplommatina</i> sp.	65.21	34.77	0.56
<i>Lagocheilus inconspicuus</i>	0.63	-0.16	-0.37
<i>Leptopoma</i> sp.	0.63	-0.16	-0.37
<i>Liardetia cf javana</i>	-0.23	-0.72	-0.59
<i>Kaliella platyconus</i>	-43.09	56.47	0.53
<i>Liardetia acutiuscula</i>	-0.65	-0.03	-0.42
<i>Coneuplecta sitaliformis</i>	-0.23	-0.72	-0.59
<i>Stenogyra kemensis</i>	-0.71	0.09	-0.36
<i>Clausilia minahassae</i>	-0.71	0.09	-0.36
<i>Clausilia bonthainensis</i>	-0.71	0.09	-0.36

Thick litter can meet the needs of snails even at high altitudes. For example, in the tropical rain forest of Mount Ciremay at an altitude of 2,450 m above sea level, where the temperature is relatively cold, land snails are still found hidden under dense litter (Heryanto 2009). In addition to avoiding temperatures that are too cold, snails also use thick litter for protection from predators (Stringer *et al.* 2005). In addition, the presence of land snails is also influenced by the presence of vegetation and vice versa (Heryanto 2020 and Liew *et al.* 2021, De Oliveira *et al.* 2010).

The nature of mountainous soils changes with increasing altitude, becoming less rich in mineral substances (Whitten *et al.* 1987). The calcium content of leaves litters at 1600 masl (3.05) is higher than 1700 masl (0.9). Calcium (Ca) factor is needed by snails for the purpose of shell development. Calcium, as well as other chemical elements, enters the snail's body through its food, whether directly consumed or through other organisms (Ohta & Saeki 2020, Martin & Sommer 2004, Hotopp 2002). Soil moisture around 1600 masl (58.6) is greater than 1700 masl (42). Abundance of living snail specimens and eggs was positively correlated with litter, soil humidity and relative humidity (Barrientos 2000). Sodium (Na) plays a role in increasing the excitability of snail neurons in the feeding system (Vehovszky *et al.* 2005). Nitrogen (N) can affect the litter decomposition process (Hafect the litter decomposition proce in Oliveira *et al.* 2010). Nitrogen also one of the factors that affect the abundance and species richness of snails (Kappes *et al.* 2006). Snails and litters interact with each other in ecological linkage in Mount Gandang Dewata forest eco-system.

CONCLUSION

It is too early to conclude anything related to snails in this study because of the limited research time. However, this study can provide an overview of the life of land snails in tropical rain forests at high altitudes in Sulawesi. Subsequent research should look at snails in primary forest in a flat place and look at the nutrients contained in the litter.

AUTHOR CONTRIBUTION

All the author have equally contributed to the research and the writing of the paper.

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