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Dung beetle assemblages in lowland forests of Pangandaran Nature Reserve, West Java, Indonesia

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Abstract. *Priawandiputra W, Tsuji Y, Widayati KA, Suryobroto B. 2020. Dung beetle assemblages in lowland forests of Pangandaran Nature Reserve, West Java, Indonesia. Biodiversitas 21: 497-504.* Dung beetles play crucial role in forest ecosystem, but no information on the dung beetle fauna has been reported in lowland forest of Java Island, Indonesia. Pangandaran Nature Reserve (PNR) area, which is recognized as lowland habitat of wildlife, can also support diversity of dung beetles. This study was conducted to examine the dung beetle diversity in lowland forests of PNR. The dung beetles were collected using pitfall traps baited with five species of mammal's feces and hand collection of beetles found on dung along the road, between 2016 and 2018. During the study, 853 individuals of dung beetles from 17 species were collected. The dominant species were *Onthophagus babirussa* with 434 individuals (50.8%). The species were not dominant in the mountainous forests of West Java and in lowland forests of Southeast Sulawesi and East Kalimantan. The highest dung beetle abundances were found during the dry season (August): 335 individuals in 2017 and 286 in 2018. However, the diversity index value of dung beetles in this study was lower in the dry season than in the wet season (*t-test* of diversity index, $P<0.05$). The dung beetle assemblages in PNR were barely similar to most dung beetle studies of other regions.

Keywords: Conservation, decomposition, tropical, forest, seasonal, Scarabaeidae

INTRODUCTION

The dung beetles (Scarabaeidae) are important insects for tropical ecosystem functioning such as in dung decomposition, nutrient cycling, and indicator of habitat quality (Hanski and Cambefort 1991; Davis et al. 2001; Doll et al. 2014). Recently, several information on the tropical dung beetles has been published in Indonesian mountainous and lowland forests. In mountainous forests of Java Island, the research of dung beetles has been conducted in some places such as Gunung Halimun Salak National Park (TNGHS) (Noerjito 2003), Gunung Ciremai National Park (TNGC) (Noerjito 2009), Gunung Gede Pangrango National Park (TNGP) (Kahono and Kundarsetiadi 2007), West Java and Mount Slamet, Central Java (Widhiono et al. 2017). Dung beetles in mountainous forest of other Islands also have been reported from Lembah Harau Nature Reserve, West Sumatra (Putri et al. 2014), Gunung Palung National Park, West Kalimantan (Malina et al. 2018) and Lore Lindu National Park, Central Sulawesi (Shahabuddin 2010). Unfortunately, compared with mountainous forests, the information of dung beetle fauna in Indonesian lowland forests is lacking. There is no publication of dung beetles in Java lowland forests. Meanwhile, there are only two studies of dung beetles in lowland forests near Java Island, one in Buton, Sulawesi (Moy et al. 2016) and one in Balikpapan, East Kalimantan (Ueda et al. 2017).

Due to high degradation of the lowland forests, some regions in west part of Java were established as conservation areas such as national park, wildlife and nature reserves (Whitten et al. 1997; Polosakan 2010). The Ujung Kulon national park (including Panaitan and Peucang islands) (120,000 ha) in Banten is designed to conserve Javan rhinoceros (*Rhinoceros sondaicus*) (Rushayati and Arief 1997). Other lowland forests, which are less than 2,200 ha, are located in Cikepuh wildlife reserve and nature reserves of Cibanteng, Sukawayana, Dungus Iwul, Yanlappa, Leuweung Sancang, and Pangandaran (Sumardja and Kartawinata 1977; Whitten et al. 1997; Polosakan 2010; Hendrawan et al. 2019). All conservation areas are designed as biodiversity reservoir in Java (Sumardja and Kartawinata 1977; Whitten et al. 1997)

Pangandaran Nature Reserve (PNR) is a site for conserving biodiversity in coastal forests of West Java. It was originally established to protect the exotic plant, *Rafflesia patma*, and the grasslands were designed to support introduced ungulate (*Bos javanicus*) and *Rusa timorensis* (Sumardja and Kartawinata 1977; Rosleine and Suzuki 2012). Thirty-four plant families with 85 species were reported in PNR (Mitani et al. 2009), such as *Barringtonia asiatica*, *Rhodamnia cinerea*, *Imperata cylindrica*, etc (Sumardja and Kartawinata 1977; Mitani et al. 2009; Rosleine and Suzuki 2012; Azrai and Eryanti 2015). Meanwhile, twenty-three species of mammals and 62 species of birds were identified in PNR where there are mammals and birds such as diurnal primates

(*Trachypithecus auratus* and *Macaca fascicularis*), flying lemurs (*Galeopterus variegatus*), Javan mouse-deer (*Tragulus javanicus*), common iora (*Aegithina tiphia*), white-bellied sea-eagle (*Haliaeetus leucogaster*), Javan kingfisher (*Halcyon cyanoventris*), etc (Sumardja and Kartawinata 1977; Tsuji et al. 2016; Safanah et al. 2017). Meanwhile, there was only one information about insects (butterflies) in Pangandaran (Lestari et al. 2018). It showed that there is still lacking information on insects, especially dung beetles in PNR, as first record in lowland of Java. The aim of present study was to examine the dung beetle diversity in the lowland forest of PNR.

MATERIALS AND METHODS

Study area

The study was carried in PNR area, which is located on the southeastern coast of West Java, Indonesia with altitude ranging from sea level to 150 m above sea level (asl), latitude 7°42'S-7°44'S, and longitude 108°38'E-108°40'E (Figure 1). The reserve is separated into forest park (38 ha) and nature reserve (370 ha) (Mitani et al. 2009; Tsuji et al. 2015). The mainland cover types of nature reserves are forest including *B. asiatica* formation in coastal area and secondary forest dominated by *R. cinerea*, *Vitex pinnata*, *Dillenia excels*, etc (Rosleine and Suzuki 2012). However, there also other habitats in the reserves such as grasslands dominated by *Imperata cylindrical* and plantation of *Swietenia macrophylla* and *Tectona grandis* (Mitani et al. 2009; Rosleine and Suzuki 2012).

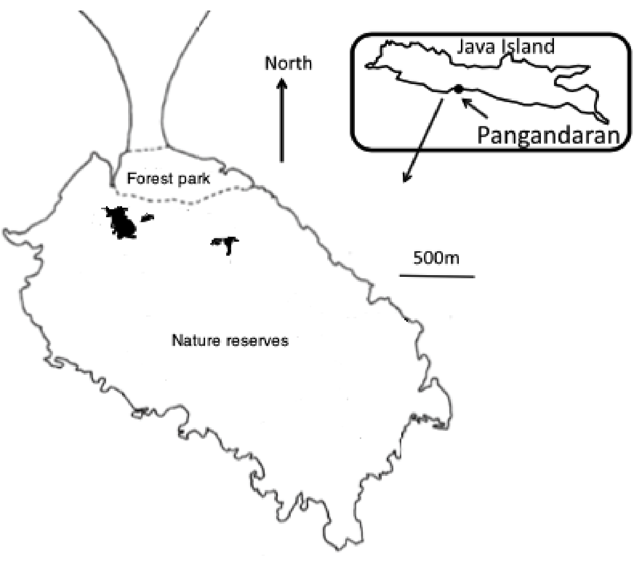

Figure 1. Location of Pangandaran Nature Reserve in Pangandaran Peninsula, which was modified from Rosleine and Suzuki (2012). Broken line area represents the forest park while the bottom area of forest park represents nature reserves. The black polygons in nature reserves show the grassland

As similar general seasonal in Indonesia, PNR has belonged to tropical seasonal regime with high precipitation. Based on data from WorldWeatherOnline.com, the temperature, moisture, and precipitation in Pangandaran varied among five survey cycles, i.e. September 2016 (26°C, 244%, 78.55 mm), August 2017 (24, 251, 32.25), October 2017 (25, 242, 125.20), February 2018 (26, 237, 159.21), August 2018 (23, 246, 18.48). In this case only, August is categorized as the dry season, which has less than 50 mm of precipitation while other months are categorized as the rainy season because of high precipitation (more than 50 mm).

Collection of dung beetles

Collections of dung beetles were surveyed for five cycles (September 2016, August 2017, October 2017 and February 2018 and August 2018) at forest sites of PNR. Dung beetles were collected using pitfall traps baited with feces from mammals such as lutungs (*T. auratus*), macaque (*M. fascicularis*), flying lemurs (*G. variegatus*), rusa deer (*Rusa timorensis*) and civets (*Paradoxurus hermaphroditus*). Pitfall traps were made of plastic cups (height: 10 cm, width: 5 cm, and volume: 217 ml). To eliminate the effects of bait size on the dung beetle attraction (Peck and Howden 1984), we set a fixed amount of feces (approximately 5-10 g in fresh weight) for each trap. To ensure the beetles easily drop down into the cup, we placed the cup so that the opening area was horizontal to the ground surface. Each survey, we set various numbers of traps from 10 until 17 at secondary forest park near the ranger station (Tsuji et al. 2019) on the first day. We set the traps at a distance of >5 m apart. Traps were put in different lengths of time for 1 until 5 nights in each survey. After the traps were installed, traps were inspected every 24-hour. Commencing on the second day, we checked the traps in the morning (15:00-17:00), collected the captured dung beetles, and changed the bait. Besides using pitfall traps, we also collect the dung beetles by active sampling method, which is hand collecting any beetles found on the fresh dung pat along the road. All collected dung beetles were put in bottles filled with 70% ethanol. The dung beetles were sorted, pinned and stored in Animals Biosystematic and Ecology Laboratory of Department of Biology, Bogor Agricultural University. The length of all dung beetles was measured using caliper from anterior to posterior of body. All specimens were identified based on Balthasar (1963) and Creedy and Mann (2011). They were also compared by beetle taxonomist with the specimen collection in Museum Zoologicum Bogoriense, The Indonesian Institute of Science, Cibinong, Indonesia. Based on Hanski and Cambefort (1991), the species of dung beetles were categorized into three functional groups: dwellers, tunnelers, and rollers.

Data analysis

Prior to analyze dung beetle diversity, sampling efficiency was evaluated using species accumulation model (Hernandez et al. 2014). Diversity was analyzed using alpha diversity (Shannon-Wiener diversity index (H’), Evenness index (E), and Chao1 estimator) for all collection periods (Magurran 1988; Chao et al. 2014). Small sample sizes can be appropriate to estimate using Chao1 estimator

(Hernandez et al. 2014). Species accumulation model and alpha diversity were performed using R with Vegan package (R Core Team 2013; Oksanen et al. 2018). Sampling coverage ratio was calculated using formula: species richness divided by Chao1 estimators times 100% (Priawandiputra et al. 2015). The *t-test* of diversity index was used to compare significance of diversity index among collection period. The *t-test* of diversity index was calculated using formula (1-4) as below (Hutcheson 1970; Magurran 1988):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i - \frac{S-1}{2N} \quad [1]$$

$$\text{Var } H' = \frac{\sum p_i (\ln p_i)^2 - \left[\sum (p_i \ln p_i)\right]^2}{N} + \frac{S-1}{2N^2} \quad [2]$$

$$t = \frac{H'_1 - H'_2}{\sqrt{\text{Var } H'_1 + \text{Var } H'_2}} \quad [3]$$

$$df = \frac{\left(\text{Var } H'_1 + \text{Var } H'_2\right)^2}{\frac{\left(\text{Var } H'_1\right)^2}{N_1} + \frac{\left(\text{Var } H'_2\right)^2}{N_2}} \quad [4]$$

Where, *H'* is Shannon-Wiener diversity index; p_i is the proportion of taxon *i*; *S* is the number of taxa; *N* is number of individuals; Var *H'* is the variance of the estimator; *t* is the *t* test statistic value; and *df* is degree of freedom of *t*-test. The standard of significance (α) was set as 0.05. The statistical analyses were performed by PAST software version 3.14 (Hammer et al. 2001).

RESULTS AND DISCUSSION

Species accumulation model

The species accumulation curve of the dung beetles in PNR was shown in Figure 2. The accumulated number of species slightly increased from 5 species (1st survey) to 17 (5th). However, the number of species in 4th and 5th surveys was likely constant. The value of *Chao1* estimator in total was 19.5 species. Based on total sampling ratio in table 1, it showed high values (87.17). It indicated that the sampling coverage has covered 87.17% of dung beetles species in PNR.

Abundance, species richness, and composition

During the study, 853 individuals of dung beetles (4.60 individuals per trap) were collected in PNR, which were composed of 17 species of three genera (*Aphodius*, *Onthophagus*, and *Paragymnopleurus*) (Table 1). Abundance of dung beetles was high in August (6.72 and 6.97 individuals per trap in 2017 and 2018, respectively) and February (6.92), followed by October (4.80), and the lowest in September (0.27). Number of species collected was also rich in August (12 and 10 in 2018 and 2017, respectively) and February (11), followed by October (7), and the lowest in September (5) (Table 1).

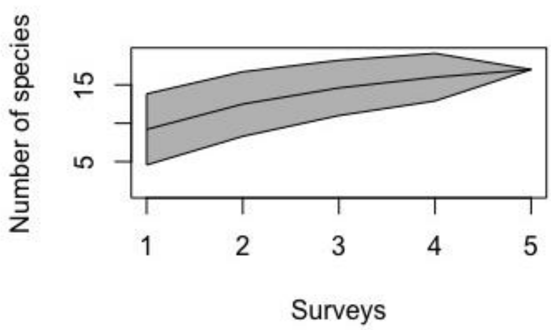

Figure 2. Species accumulation curve for dung beetles collected in total surveys

Abundance and species richness of dung beetles in lowland forests were lower than in the mountainous forests. According to Kahono and Kundarsetiadi (2007) and Noerdjito (2009), abundance of dung beetles in TNGP and TNGC were 1052 individuals (52.60 individuals per trap) and 1089 (15.55), respectively. It is thought that the abundance of dung beetles in mountainous forests was more than 2 times higher than that in lowland forest. Fifty species, 28 and 15 of dung beetles were found in TNGHS (Noerjito 2003), TNGP (Kahono and Kundarsetiadi 2007) and TNGC (Noerdjito 2009), respectively. According to Rahbek (1995), Begon et al. (2006), William et al. (2010), hump-shaped pattern with peaking at mid-elevation frequently showed in the relationship between altitude and species richness as well as abundance in many organisms. Based on Kahono and Kundarsetiadi (2007) and Noerdjito (2009), the abundance and species richness reached a peak at mid-elevation in Java mountain forests between 500-1600 m above sea level (asl) while the lowest abundance and species richness were above 2000 m asl. Many dung beetles might be suitable for the environmental and habitat condition within 500-1600 m asl.

The lowland forests in other islands (Kalimantan and Sulawesi) were shown a higher number on abundance and species richness than the observed in current study (Moy et al. 2016; Ueda et al. 2017). Moy et al. (2016) reported 1710 individuals from 29 species of dung beetles at three levels of disturbance of forests in Southeast Sulawesi where the highest abundance and species richness were found at intermediate disturbance. Meanwhile, a total of 8073 individuals from 65 species was collected in East Kalimantan (Ueda et al. 2017). The difference in number of individuals among research sites because of the different sampling time, the type of baits, traps number and sampling areas (many sites in East Kalimantan and Southeast Sulawesi) but the species richness was different among research sites because of the different on biogeographical history.

The species composition of dung beetles in lowland forest of West Java is barely similar to those in mountain forests (TNGP, TNGHS, and TNGC) (Noerjito 2003; Kahono and Kundarsetiadi 2007; Noerdjito 2009). This study only shared 5 species of dung beetles that found in TNGP (Kahono and Kundarsetiadi 2007) such as

Onthophagous angustatus, *O. drescheri*, *O. malangensis*, *O. variolaris* and *Paragymnopleurus sparsus*. These five species were only collected in small number (less than 10 individuals) in our study. Meanwhile, two of the five species (*O. malangensis* and *O. variolaris*) had found in high abundance (more than 90 individuals) in TNGP (Kahono and Kundarsetiadi 2007). Based on Kahono and Kundarsetiadi (2007) and this study, *O. angustatus, O. dresceri, O. malangensis,* and *O. variolaris* widely distributed in various altitude from lowland forest until 500-2000 m asl of mount Pangrango while *P. sparsus* has only occurred below 1000 m asl. In TNGHS, Noerjito (2003) has not identified species of all dung beetles but *Catharsius molossus*, *Heliocopris bucephalus*, and *Heliocopris dominis* were mentioned as common species. Those three species, which are belonged to Coprini, were not caught in recent study so those species might not distribute in lowland forests. Meanwhile, in TNGC, *Onthophagus babirussa*, which was the most abundant species in this study, was caught in low number at 1100-1600 m asl (Noerdjito 2009). It describes that this species prefer forest habitat in the lowland area to mountain forest.

When dung beetle composition of this study was compared with those in lowland forest in Southeast Sulawesi and East Kalimantan (Moy et al. 2016; Ueda et al. 2017), there was a contradictory finding. No shared species was presented between Buton in Sulawesi (Moy et al. 2016) and Pangandaran of this study. Meanwhile, six species (*Aphodius marginellus*, *Onthophagus armantus*, *O. borneensis*, *O. mulleri*, *O. pacificus*, and *O. trituber*) were found in both North of Balikpapan (Ueda et al. 2017) and Pangandaran. The difference of biogeographical history between Southeast Sulawesi and East Kalimantan explain the dissimilar pattern in dung beetle composition. Kalimantan and Java were fragments of Sunda continental shelf until it separated away in the Eocene while Easter Sulawesi including Southeast Sulawesi was originally part of Australasia until the early Miocene (Cox et al. 2016). Therefore, Sulawesi has many enormous and endemic fauna species including the dung beetles (*Onthophagus holosericeus*, *O. fuscotriatus*, *O. fulvus*, *O. cf. wallacei*, *O. scrutator*, *O. aureopilosus*, etc) that did not appear in other western islands including Java and Kalimantan (Balthasar 1963; Shahabuddin 2010).

Table 1. Nesting guild, mean body length, and abundance of dung beetles collected in each collection period. Parentheses represent insects collected from feces on the road

Species	Nesting guild*	Mean body length ± SE (mm)	Number of dung beetles collected (individuals)					Total
			2016	2017		2018		
			September	August	October	February	August	
Aphodius marginellus Fabricius	D	6.02 ± 0.35	0	1	0	12	0	13
Onthophagus angustatus Boucomont	T	8.65 ± 0.82	0	1	2	0	0	3
O. armantus Blanchard	T	7.14 ± 0.47	0	2	0	5 (1)	2	9
O. babirussa Eschscholtz	T	6.20 ± 0.99	4 (1)	254	24	120	32	434
O. borneensis Harold	T	9.45 ± 0.56	2	1	15	3	2	23
O. drescheri Paulian	T	6.45 ± 0.41	0	0	0	2	0	2
O. hirsuturus Lansberge	T	5.33 ± 0.43	0	0	0	0	2	2
O. malangensis Boucomont	T	7.91 ± 0.60	0	1	2	2	0	5
O. mulleri Lansberge	T	3.50 ± 0.31	1	11	2	7	5	26
O. nitidiceps Fairmaire	T	2.60 ± 0.32	0	0	0	0	7	7
O. orientalis Harold	T	9.21 ± 0.95	0	1 (1)	0	1 (1)	0	2
O. pacificus Lansberge	T	6.70 ± 0.23	0	4 (1)	1	1	1	7
O. tricolor Boucomont	T	5.18 ± 0.49	1	59 (2)	2	16	223	301
O. trituber Wiedemann	T	6.12 ± 0.82	0	0	0	0	7	7
O. variolaris Lansberge	T	5.13 ± 0.07	0	0	0	0	2	2
Paragymnopleurus melanarius Harold	R	13.00 ± 0.98	2 (2)	0	0	0	1	3
P. sparsus Sharp	R	11.45 ± 0.47	1	0	0	4 (4)	2 (1)	7
No. individuals collected			11 (3)	335 (4)	48	173 (6)	286 (1)	853 (14)
Species richness (a)			5	10	7	11	12	17
Chao1 (b)			7.0	15.0	7.0	11.33	12.16	19.5
Sampling coverage ratio (a/b x 100%)			71.42	66.66	100	97.34	98.68	87.17
Number of trap days			40	50	10	25	42	187
No. individuals/trap			0.27	6.72	4.80	6.92	6.97	4.60
Shannon-Wiener (*H'*)			1.64	0.79	1.32	1.21	0.90	1.31
Evenness (*E*)			0.86	0.22	0.53	0.30	0.20	0.21

Note: *D-Dweller, T-Tunneler, R-Rollers.

Dominant species

The two dominant species were *Onthophagus babirussa* with 434 individuals (50.8%) and *O. tricolor* with 301 individuals (35.2%) (Table 1). Meanwhile, the moderately abundant species (between 1.5 and 10% of total abundance) were *O. mulleri*, *O. borneensis*, and *Aphodius marginellus* with 26 individuals (3.0%), 23 (2.6%) and 13 (1.5%), respectively. The other species (*O. angustatus*, *O. armantus*, *O. drescheri*, *O. hirsuturus*, *O. malangensis*, *O. nitidiceps*, *O. orientalis*, *O. pacificus. O. trituber*, *O. variolaris*, *Paragymnopleurus melanarius*, and *P. striatus*) were categorized as the rare species, which were collected with less than 10 individuals each (less than 1.17% of total abundance). In August 2017, *O. babirussa* was the most dominant (254 individuals), while *O. tricolor* was the most dominant in August 2018 (223). *Onthophagus* was successfully spreading in many sites due to their smaller size, aggressive competitive behavior and high survival in disturbed habitats (Hanski and Cambefort 1991; Muhaimin et al. 2015). As similar to in Bangi Reserve Forest, Malaysia (Muhaimin et al. 2015), the food sources from the mammals in PNR can accommodate many small sizes of dung beetle but it is insufficient for large size of dung beetles.

The occurrences of *O. babirussa* and *O. tricolor* were compared with other studies (Balthasar 1963; Kabakov and Napolov 1999; Tarasov 2014; Sofiana 2015; Goh and Hashim 2018; Malina et al. 2018; Latifa 2019). *Onthophagus babirussa* commonly occurs in forest and widely distributes in Sundaland (Borneo, Malay Peninsula, Sumatra, Java, and Palawan) (Balthasar 1963; Goh and Hashim 2018). When compared to our study, Goh and Hashim (2018) reported similar results regarding dominant species, with *O. babirussa* being highly caught by both pitfall traps and burrowing interception traps in the Ulu Gombak Forest Reserve, Peninsular Malaysia. In contrast, low abundance of *O. babirussa* was collected in Gunung Palung National Park, Kalimantan (Malina et al. 2018). Meanwhile, *Onthophagus tricolor* was described not only in Bogor and Sukabumi of West Java but also at Hatuyen, Thanh hoa, and Cat Tien in Vietnam (Balthasar 1963; Kabakov and Napolov 1999; Tarasov 2014). In this case, we also add the occurrence data of *O. tricolor* in lowland forest of PNR. *Onthophagus tricolor* did not only occur in forest habitats but also in open organic agriculture and savanna (Sofiana 2015; Latifa 2019). *Onthophagus babirussa* mostly occurred in many forest habitats with different abundance while *O. tricolor* can be found in several habitats (forest, agriculture, and savanna).

The dominant species in this study have differed from other researches performance in Java mountainous forests and lowland forests of Kalimantan and Sulawesi (Kahono and Kundarsetiadi 2007; Noerdjito 2009; Moy et al. 2016; Ueda et al. 2017). The dominant species in TNGP and TNGC were *O. variolaris* and *O. luridipennis*, respectively (Kahono and Kundarsetiadi 2007; Noerdjito 2009). Meanwhile, *O. ribbei* and *O. limbatus* were the dominant species in lowland Sulawesi and Kalimantan, respectively (Moy et al. 2016; Ueda et al. 2017). The dung beetles showed the enormous dominant species in Indonesia.

Aphodius, *Onthophagus*, and *Paragymnopleurus* were classified into dwellers, tunnelers, and rollers, respectively (Hanski and Cambefort 1991). In this study, the percentages of dwellers and rollers were 1.52% and 1.28%, respectively. Both functional groups were infrequent in lowland forest in PNR. Meanwhile, the dominant dung beetles (97.18%) have belonged to genus *Onthophagus*, a group composed by small tunneler species. Tunnelers (paracoprids) use dung and dig holes into the soil beneath the dung so it can affect nutrition cycle and plant growing (Bertone 2004). Their tunneling behavior is associated with their horn (Emlen and Phillips 2006). Tunnelers were mostly abundant in forest habitats while dwellers in open agricultural habitats (Hanski and Cambefort 1991; Venugopal et al. 2012). The small tunnelers have more diverse food habits (coprophagous, necrophagous and generalist) and large niche forest habitat, so these dung beetles can be a majority dung beetles in Oriental region, especially in South-east Asian forests (Hanski and Cambefort 1991).

Diversity and seasonality

The highest diversity index value was found during the first survey (September 2016), although there were few individuals collected (Table 1). The dominant species occurred mostly during the dry season (August 2017 and 2018). Based on *Chao1*, the estimation of species richness in September 2016, August 2017, October 2017, February 2018 and August 2018 were 7.0, 15.0, 7.0, 11.33, 12.16, respectively. The two top high number of estimation species were in dry season (August 2017 and 2018). The dung beetle collection in dry season (August 2017 and 2018) was significantly lower in diversity index value among others of month (p<0.05) (Table 2).

Table 2. Comparison of dung beetle diversity among each time collection

	September 2016	August 2017	October 2017	February 2018
Sep 2016				
Aug 2017	t=3.70, df=12.76, p=0.002			
Oct 2017	t=1.12, df=21.41, p=0.23	t=-3.36, df= 66.78, p=0.001		
Feb 2018	t=1.77, df=16.32, p=0.09	t=-3.45, df=296.78, p=0.0006	t =0.61, df=103.15, p=0.53	
Aug 2018	t=-3.15, df=14.11, p=0.006	t =1.05, df=554.69, p=0.29	t =-2.54, df=81.56, p=0.01	t =2.35, df=364.78, p=0.01

In this study, the dung beetle diversity showed a marked seasonality in the study region where the high abundance and species richness presented in dry season (August 2017 and 2018). In India, the study of Venugopal et al. (2012) in open agricultural field and Latha (2019) in forests showed the different results where the highest abundance of dung beetles was found during rainy period so the soil is softer to support the abundance of dung beetles. Andresen (2005) and Hernandez et al. (2014) also showed that dung beetles highly captured during rainy period in Mexican dry forests and Restinga forest, respectively. In other cases, research of Boonrotpong et al. (2004) in Thailand supports our result where the abundance of dung beetles in the dry season than in the wet season. Each dung beetle species in different region has own preferences to the seasonal. In this study, eurytopic species of dung beetles can tolerate the changing of environmental conditions. Some tunneler species (*Onthophagus*) tolerated the heavy rain but some other tunneler species, roller and dweller species preferred moderate rainfall and avoidance of the heavy rains (Latha 2019). There are two other reasons related the seasonal of dung beetles in this study: 1) dung beetles may reduce their activity during rainfalls resulted in the lower diversity during the rainy season and 2) season in tropical region (dry and rainy) are not the main parameter that regulates dung beetles activity where the dominant dung beetle showed completely aseasonal activity in North Sulawesi (Hanski and Cambefort 1991).

Implication to Conservation

Insects have different functional roles in forest ecosystems based on trophic groups (herbivores, pollinators, predators, and decomposers) (Greenwood 1987; Priawandiputra et al. 2015). As decomposer, dung beetles known as keystone species and an important component in ecosystems, especially tropical forests (Hanski and Cambefort 1991; Davis et al. 2001). The distribution and occurrence of wild big animals, which provide feces as food resources and reproduction subtract for dung beetles, could affect their abundance, composition, and diversity (Hanski and Cambefort 1991; Primack 1998; Davis et al. 2001; Kahono and Kundarsetiadi 2007; Noerjito 2009). *Onthophagus luridipennis* and other *Onthophagus* remove feces of Surili (*Presbytis comata*), Javan lutung (*T. auratus*), civets (*P. hermaphroditus*), and wild boar in TNGHS (Gunawan et al. 2008; Noerdjito 2009). Meanwhile, feces of Javan gibbon (*Hylobates moloch*), Javan surili (*P. comata*), Javan lutung (*T. auratus*), leopard (*Panthera pardus*), yellow-throated marten (*Mustela flavigula*), leopard cat (*Prionailurus bengalensis*), dhole (*Cuon alpinus javanica*), Sunda stink badger (*Mydaus javanensis*), Indian muntjac (*Muntiacus muntjak*), and Javan mouse-deer (*T. javanicus*) in TNGP brought the difference composition of dung beetles (Kahono and Kundarsetiadi 2007). Composition of dung beetles associated with population of vertebrate animals in their habitat so conservation of wild vertebrate animals indirectly could also conserve the diversity of dung beetles. The fragmented forests do not only threaten occurrence of wild mammals but also decrease the species richness and abundance of dung beetles (Andresen 2003; Filgueiras et al. 2011).

Some dung beetles might specifically use feces from only specific species or feeding-habit group of mammals. Some dwellers such as *Aphodius* preferred to inhabit inside big feces of wild boar in high altitude (1100-1400 asl) (Gunawan et al. 2008; Noerdjito 2009). Feces of carnivore attracted less dung beetle diversity comparing to feces of herbivores (Noerdjito 2009). Therefore, proposing that future studies should examine the generalist and specialist of dung beetles species from different feces of mammals in lowland forests. After that, the composition and diversity of dung beetles in other lowland forests of West Java such as the Ujung Kulon national park, Cikepuh wildlife reserve and nature reserves of Cibanteng, Sukawayana, Dungus Iwul, Yanlappa, and Leuweung Sancang will be needed to assess due to lacking data. The data will be important for national biodiversity data and hopefully, the new species can be discovered during the future study.

The dung beetles in lowland forest of PNR in terms of abundance and species richness were barely similar with dung beetles in West Java mountainous forest and lowland forests outside Java Islands. The two dominant dung beetle species in PNR were *Onthophagus babirussa* and *O. tricolor*, which known as the small size dung beetles. The diversity of dung beetles in dry seasons (August 2016 and 2017) was low although the abundance was high.

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