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Original research article

Diversity and Abundance of Carabidae and Staphylinidae (Insecta: Coleoptera) in Four Montane Habitat Types on Mt. Bawakaraeng, South Sulawesi

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ABSTRACT

Carabidae and Staphylinidae are the two beetle families frequently found to be most abundant and diverse in forest ecosystem. Their roles especially as generalist predators are important in forest ecosystem. No studies reported diversity and abundance of Carabidae and Staphylinidae in forest ecosystem on Mt. Bawakaraeng, specifically in montane habitat yet. The aim of this study was to analyze diversity and abundance of Carabidae and Staphylinidae in four montane habitat types, i.e. agricultural area, pine forest, eucalypts and natural forest (1835 m asl), and natural forest (2165 m asl). They were collected using pitfall traps. A total of 42 carabid beetles belonging to nine species and 260 staphylinid beetles belonging to 37 species were collected. Diversity and abundance of Staphylinidae were higher than Carabidae, this is predicted because of higher mobility in Staphylinidae compared to Carabidae. In Carabidae, the highest species richness was recorded in agricultural area, whereas the highest species richness of Staphylinidae occurred in natural forest (2165 m asl). In Staphylinidae, the two largest subfamilies are Aleocharinae and Staphylininae. *Aephinidius adelioides* occupied the highest abundance of Carabidae and found in agricultural area. The differences in each montane habitat type are presumed to cause variation in species richness of soil beetles, especially for Carabidae.

1. Introduction

The geological history of Sulawesi Island in forming four different arm (north, south, east, southeast) was caused by tectonic processes of active plate boundaries (Hamilton 1979). Mt. Bawakaraeng (2830 m asl) is located in the south arm in Gowa district, South Sulawesi, and the mountain was formed through the volcanic activity in the Pleistocene (Hasnawir & Kubota 2008). Sulawesi has several types of forest, i.e. lowland (0–400 m asl), hill (400–850 m asl), upland (850–1500 m asl), montane (1500–2500 m asl), and tropalpine forest (>2500 m asl) (Cannon *et al.* 2007). Montane forest is often considered as less diverse area than lowland forest, but high endemism occurs in this area (Anderson & Ashe 2000).

In forest ecosystems, soil beetles show important roles in soil food chain being predators, decomposers, and phytophagous. Carabidae is one of the beetle families, which are predominantly predators (Nitzu *et al.* 2008), especially as generalist predators (feed on a variety of arthropod preys, such as Collembola, soil mites, and larvae of Diptera) (Ribera *et al.* 1999). Besides Carabidae, Staphylinidae is also a generalist predator (Pohl *et al.* 2008). As a generalist predator, they serve as seed eaters and pollen feeders, respectively (Steel 1970; Hanski & Hammond 1986).

The species richness of soil beetle decreased with the increasing altitude in montane forest (Hanski & Hammond 1986; Maveety *et al.* 2011). Thus, different types of montane forest or altitudes may inhabit different diversity of Carabidae and Staphylinidae. *Anotylus* sp. (Oxytelinae) and *Philonthus* sp. (Staphylininae) are the common staphylinids that occur in montane forests in Gunung Mulu National Park, Sarawak, Malaysia (Hanski & Hammond 1986). Another example, the three genus of three tribes, i.e. *Pelmatellus* (Harpalini), *Dyscolus* (Platynini), and *Bembidion* (Bembidiini) are commonly found in tropical montane forest, Andes mountains, southeastern Peru (Maveety *et al.* 2011).

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Research on diversity and abundance of Carabidae and Staphylinidae in the area of Mt. Bawakaraeng particularly related to montane habitats has not been reported yet. Therefore, it is necessary to conduct a research on the diversity and abundance of Carabidae and Staphylinidae in various montane habitat types on Mt. Bawakaraeng. The objective of this study was to analyze diversity and abundance of Carabidae and Staphylinidae in four montane habitat types on Mt. Bawakaraeng, South Sulawesi. This result is expected to provide scientific information on the area richness related to diversity and abundance of Carabidae and Staphylinidae.

2. Materials and Methods

2.1. Study sites

Collecting sample of Carabidae and Staphylinidae was conducted once in dry season from September until October 2013 in four montane habitat types on Mt. Bawakaraeng. Those habitats are (1) agricultural area (1465 m asl), consisted of tomatoes (Solanaceae), gourds (Cucurbitaceae), leeks (Alliaceae), and mustards (Brassicaceae). There was no canopy cover in this habitat. (2) Pine forest (1545 m asl), dominated by pine trees and ferns. There were also weeds of *Ageratum* sp. in this habitat. (3) Mixed forest, i.e. partly eucalypts forest, partly natural forest (1835 m asl). The natural forest in this altitude was dominated by trees of *Magnolia vrieseana* (Magnoliaceae), and the trees of other families were coated by mosses and epiphytic plants. This habitat was overgrown by shrubs *Leucosyke capitellata* (Urticaceae). (4) Natural forest (2165 m asl), dominated by trees of *Melicope accedens* (Rutaceae) and the trees of other families were coated by bryophytes and epiphytic plants, as well as had the most dense canopy cover (Table 1).

2.2. Specimen collection

Carabid and staphylinid beetles were collected using pitfall traps. Fifteen pitfall traps were positioned systematically in agricultural area and set up randomly in pine forest, mixed forest, and natural forest. The space between pitfall traps are 10–20 m in a plot area of 2400 m^2 in all the habitats, and with reference to Greenslade (1973) we kept the traps for 2 days. The differential arrangement model of pitfall traps between the three montane habitat types (pine forest, mixed forest, and natural forest) and agricultural area was due to the obstacles in those three montane types, such as the disarrangement of trees disposition and oblique soil surface contour. The pitfall traps were made of a plastic cup (height 10 cm, base diameter 5.7 cm, and diameter of upper base 9.2 cm) and were placed in the ground with the mouth flat against the soil surface. Each trap was filled with 70% alcohol which serves as a preservative agent of the specimens. Transparent roofs (20 × 20 cm) were used as the protective of pitfall trap from rain and litter. The distance between the roof and soil surface is 10 cm. Collected Carabidae and Staphylinidae were identified in the Laboratory of Entomology, Zoology Division, and Research Center for Biology LIPI.

2.3. Identification

Family level identification was identified using Triplehorn and Johnson (2005). Carabidae was identified according to Darlington (1970), Sawada and Wiesner (2000), Ito (2009), and specimen references in Museum Zoologicum Bogoriense (MZB) LIPI Cibinong. The further identification for Staphylinidae was performed using Cameron (1930) and specimen references in MZB. For morphospecies level was identified based on external morphology. Almost all species of Carabidae and Staphylinidae were verified by Coleopterists listed at Table 2. All specimens were deposited in MZB.

2.4. Environmental variables

We measured the environmental variables, i.e. temperature, humidity, soil temperature, soil moisture, and soil pH. Temperature and humidity were measured using digital thermohygrometer. Soil temperature was measured using soil thermometer. Soil moisture and pH were measured using soil tester Takemura. The range of soil moisture value at soil tester is 1%–8% and soil pH value ranges from 3 to 8.

2.5. Data analysis

Data of Carabidae and Staphylinidae were analyzed for species richness (*S*), Shannon's diversity index (*H'*), Pielou's evenness index (*E*), and Simpson's index/dominance of species (*D*) (Magurran 1988). The relationship among species, habitats, and environmental variables was analyzed using canonical correspondence analysis (CCA) implemented in the Paleontological Statistics (PAST) program version 1.93 (Hammer & Harper 2006).

3. Results

3.1. The diversity and abundance of Carabidae

Compared to Staphylinidae, number of collected Carabidae was less, i.e. a total of 42 individuals, those from three subfamilies and nine species of carabids. The subfamily Harpalinae was the most common carabids collected in the areas of Mt. Bawakaraeng, belonging to seven species. From each subfamily Cicindelinae and Scaritinae one species was collected, i.e. *Hipparidium shinjii* and *Clivina* sp., respectively. The highest Carabidae diversity was in natural forest (2165 m asl). However, agricultural area revealed home for the highest abundance and species richness of carabids and *Aephnidius adelioides* (Harpalinae) was the most dominant in this area. Nevertheless, the dominance of *A. adelioides* (Figure 1A) in agricultural area led to the lower diversity in that area compared to mixed forest and natural forest (2165 m asl). The other carabid species, i.e. *H. shinjii* (Cicindelinae) (Figure 1B), Trigonotomi (*Lesticus* sp.1) (Harpalinae) (Figure 1C), and Platynini sp.1 (Harpalinae), respectively were found in pine forest, in mixed forest: natural

Table 1. Description of montane habitat types at study sites on Mt. Bawakaraeng

Code	Coordinate	Montane habitat types	Altitude (m asl)
AA	S 05° 15′ 03.1″ E 119° 53′ 56.7″	Agricultural area	1465
PF	S 05° 15′ 29.3″ E 119° 54′ 31.8″	Pine forest	1545
MF	S 05° 16′ 42.5″ E 119° 54′ 58.5″	Mixed forest: eucalypts forest and natural forest	1835
NF	S 05° 17′ 11.4″ E 119° 55′ 47.6″	Natural forest	2165

In the four montane habitat types were found cattle dungs.

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