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RESEARCH ARTICLE

Diversity and abundance of longhorn beetles (Coleoptera: Cerambycidae) in Gunung Walat Educational Forest, West Java, Indonesia

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Abstract: Gunung Walat Educational Forest is located at an altitude of 500-700 m asl and has a variety of forest types. This research investigated the diversity and abundance of longhorn beetles found in several types of plantation forest. The beetles were collected using *Artocarpus traps* in September and October 2014. Sixteen species of longhorn beetle were found; these belonged to 7 tribes and 12 genera. The highest diversity and evenness of longhorn beetles were found in the natural forest (H=1.80, E=0.75) and the lowest of both measures in the *Agathis* forest (H=0.556, E=0.232). The highest similarity index (0.75) was found between the natural forest and the pine forest. Five of the species found, i.e. *Sybra binotata*, *Sybra fuscotriangularis*, *Ropica strandi*, *Acalolepta rusticatrix*, and *Pterolophia melanura* were highly abundant. Two of these, *R. strandi* and *S. fuscotriangularis*, as well as 4 other species found, *Cleptometopus montanus*, *Myagrus javanicus*, *Notomulciber notatus*, and *Exocentrus artocarpi*, are only found in Java. Finding *Ropica marmorata* was the first such record of this species on the island of Java.

Key words: Diversity, abundance, longhorn beetles, Gunung Walat, West Java.

Introduction

Longhorn beetles are an important insect family in these forest ecosystems due to the beetles' dependence on food sources from various species of trees. In some natural ecosystems, longhorn beetles play an important role in nutrient cycling (Nieto & Alexander 2010) and pollination processes (Gutowski 1990; Hawkeswood & Turner 2007). The

diversity of longhorn beetles has been shown to vary among different forest types (Maeto *et al*. 2002; Ohsawa 2004), and to be affected by forest diversity (monoculture or polyculture) (Ohsawa 2004), and forest size (Pavuk & Wadsworth 2013).

Larvae of longhorn beetles are wood borers and tend to choose dead or decaying wood, and some species are considered pests (Noerdjito 2010). The structure of a community of longhorn beetles in a region is very closely related to the composition and development of trees. Different species of longhorn beetle will choose different species of tree or shrub (Sakenin *et al*. 2011). Some species of longhorn beetle live only in specific host plants, while other species can inhabit a variety of plants (Waqa-Sakiti *et al*. 2014). The longhorn beetle's life depends on the presence of trees, and it can therefore be used as an indicator of the condition of a forest (Ohsawa 2010; Noerdjito 2011; Lachat *et al*. 2012).

Gunung Walat Educational Forest (GWEF) is located at an altitude of 500-700 m asl. The current area is approximately 349 ha (Syaufina *et al*. 2007) with a variety of tree species, from several genera, including *Agathis*, pine, and *Schima* (Haneda & Firmansyah 2012). The aim of this research was to study the diversity and abundance of longhorn beetle communities in different types of plantation forest within Gunung Walat Educational Forest, West Java, Indonesia.

Material and methods

Description of study sites. The study was conducted from September 2014 to January 2015 in five plantation forests, differentiated by location, and predominant tree genus or genus mix: *Schima* forest (SF), *Agathis* forest (AF), pine forest (PF), mixed forest (MF), and natural forest (NF); all within Gunung Walat Educational Forest, West Java, Indonesia. The ***Schima*** **Forest** (578 m asl, 06º54'76.8 "S, 06º49'14.1"E) was dominated by *Schima* trees, with varied understorey plants. The ***Agathis*** **Forest** (576 m asl, 06º55'04.7"S, 106º49'43.2"E) was dominated by *Agathis* trees, and the understorey plants were predominantly ferns and orchids. The **Pine Forest** (669 m asl, 06º54'93.6"S, 106º49'71.1"E) was dominated by pine trees; most of this region did not produce an overgrowth of understorey plants, but the part of pine forest that was adjacent to the natural forest had various types of understorey plants. The **Mixed Forest** (689 m asl, 06º54'566"S, 106º49'101"E) was dominated by *Agathis*, pine, and *Schima* trees; many understorey plants were found here. The **Natural Forest** (591 m asl, 06º54'931"S, 106º49'860"E) had various types of trees, and a high canopy level.

Collection of beetles. Longhorn beetles were collected in September and October 2014, using Jackfruit tree (*Artocarpus heterophyllus)* leaves and branches (Noerdjito 2008), which were tied to target tree trunks at a height of approximately 1.5 m from the ground. Ten such traps were set up, approximately 100m apart, in each type of forest. Collection of longhorn beetles, using the 'beating' method, was conducted on days 4, 8, 12, 16, and 20, in September, and days 4, 8, 12, and 16 in October.

Preservation and identification of specimens. Preservation of the specimens was done in the Laboratory of Entomology, Zoology Division, Research Center for Biology, Indonesian Institute of Sciences, Cibinong, Indonesia. Larger beetles (>10 mm length) were pinned, while smaller ones (<10 mm length) were mounted on triangle paper. All beetle specimens were labelled according to field collection data. The specimens were identified using established principles [Cherepanov (1990), Makihara (1999), Makihara *et al*. (2002), Makihara & Noerdjito (2004), Heffern (2013), and Bezark (2015)]. Beetle specimens were also verified by reference to the specimen collection in the Museum Zoologicum Bogoriense.

Data analysis. Data about collected longhorn beetles included the number of individuals and species. The diversity of the longhorn beetles collected from each location was analyzed according to the Shannon-Wiener index (H'), an evenness index (E) using R program version 3.1.3 (https://www.r-project.org), and the Bray-Curtis similarity index, using PAST program (http://folk.uio.no/ohammer/past) version 2.17c.

Results

Diversity and abundance of longhorn beetles in several habitat types

A total of 2,065 individuals were found during this study, and these comprised 16 species, 12 genera, and 7 tribes (Table 1). The highest number of individuals were found in the *Agathis* forest (655 individuals), followed in order by the mixed forest (416 individuals), the natural forest (386 individuals), the pine forest (364 individuals), and the *Schima* forest (244 individuals). The most highly abundant species of longhorn beetle found were, in descending order, *Sybra binotata* (1247 individuals), *Ropica strandi* (249 individuals), *Acalolepta rusticatrix* (178 individuals), *Sybra fuscotriangularis* (146 individuals), and *Pterolophia melanura* (129 individuals).

Table 1. Number of individuals and species of longhorn beetles collected in pine forest (PF), *Agathis* forest (AF), *Schima* forest (SF), mixed forest (MF), and natural forest (NF).

Subfamily/Tribe/Species	**Number of individuals**					
	PF	**AF**	**SF**	**MF**	**NF**	**Total**
Lamiinae						
Agapanthiini						
Cleptometopus montanus Pascoe, 1866	0	1	1	0	0	2
Apomecynini						
Ropica strandi Breuning, 1942	87	3	17	16	126	249
Ropica honesta Pascoe, 1865	0	0	2	1	0	3
Ropica marmorata Breuning, 1938	0	0	1	1	0	2
Sybra binotata Gahan, 1907	155	575	183	256	78	1247
Sybra fuscotriangularis Breuning, 1939	33	2	8	60	43	146
Apomecynini sp.	0	0	0	0	1	1
Gnomini						
Gnoma sticticollis Thomson, 1857	0	0	0	0	1	1
Homonoeini						
Notomulciber notatus Fisher, 1936	1	1	1	3	0	6
Monochamini						
Acalolepta rusticatrix Fabricius, 1801	34	38	7	55	44	178
Myagrus javanicus Breuning, 1957	0	0	0	0	2	2
Epepeotes luscus Fabricius, 1787	3	1	0	3	1	8
Pelargoderus bipunctatus Dalman, 1815	3	2	1	1	0	7
Pogonocherini						
Exocentrus artocarpi Fisher, 1934	6	2	0	5	6	19
Pteropliini						
Pterolophia melanura Pascoe, 1857	32	21	15	14	47	129
Pterolophia uniformis Pascoe, 1865	10	9	8	1	37	65
Number of individuals	**364**	**655**	**244**	**416**	**386**	**2065**
Number of species	**10**	**11**	**11**	**12**	**11**	
Shannon Index (H')	**1,62**	**0,55**	**1,03**	**1,26**	**1,80**	
Evenness index (E)	**0,70**	**0,23**	**0,43**	**0,51**	**0,75**	

The total number of individuals collected in both months (Figs 1A and 1B) followed similar patterns but October totals were approximately half of those in September (which might be random or seasonal variation, or partly, the reducing effect of collecting activity). In each month, the second collection total (on the 8th of the month) was up about two-thirds on the first collection, (on the 4th), but thereafter dropped to just below the first collection total, and continued to fall for subsequent collections. (That numbers should fall consecutively might, logically, be in part the reducing effect of earlier collections, as individuals were not returned post-counting). The main contributor to this apparent trend was the collections from the Agathis forest, which produced far more individuals than the other forests on the 8th of both months; presumably, one or more unknown variables were at play on those dates.

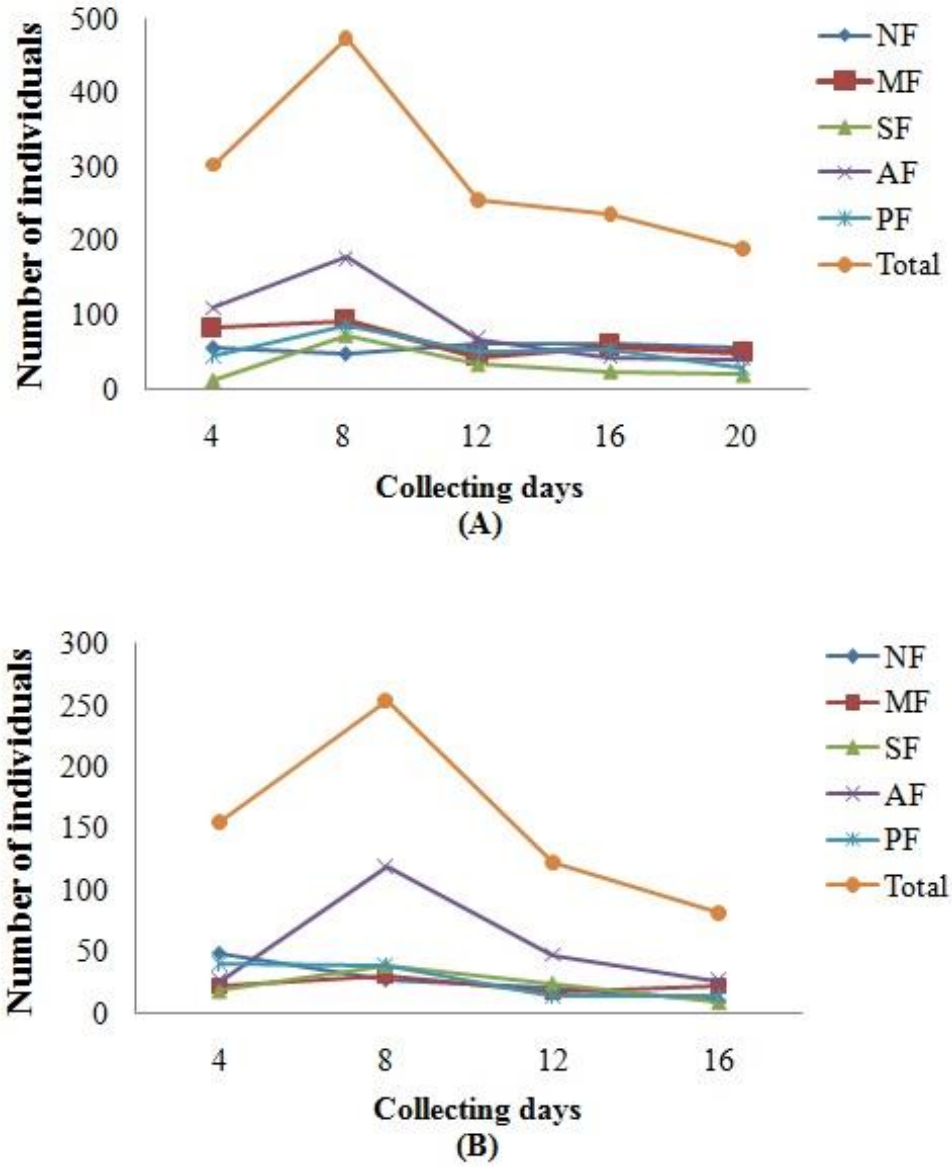

Figure 1. Number of longhorn beetle individuals collected by *Artocarpus trap* in natural forest (NF), mixed forest (MF), *Schima* forest (SF), *Agathis* forest (AF), and pine forest (PF); in September (A) and October (B).

As regards number of species found (Figs 2A and 2B), there was obviously a connection with numbers of individuals found, and this was reflected in September totals again generally being almost double October ones. There was considerable variation between days, and at different sites, but within a relatively small range (min=1 at SF, 4th and 12th Oct; max = 9 at MF, 8th Sept, but most sites producing much closer to the average figure on most collection days).

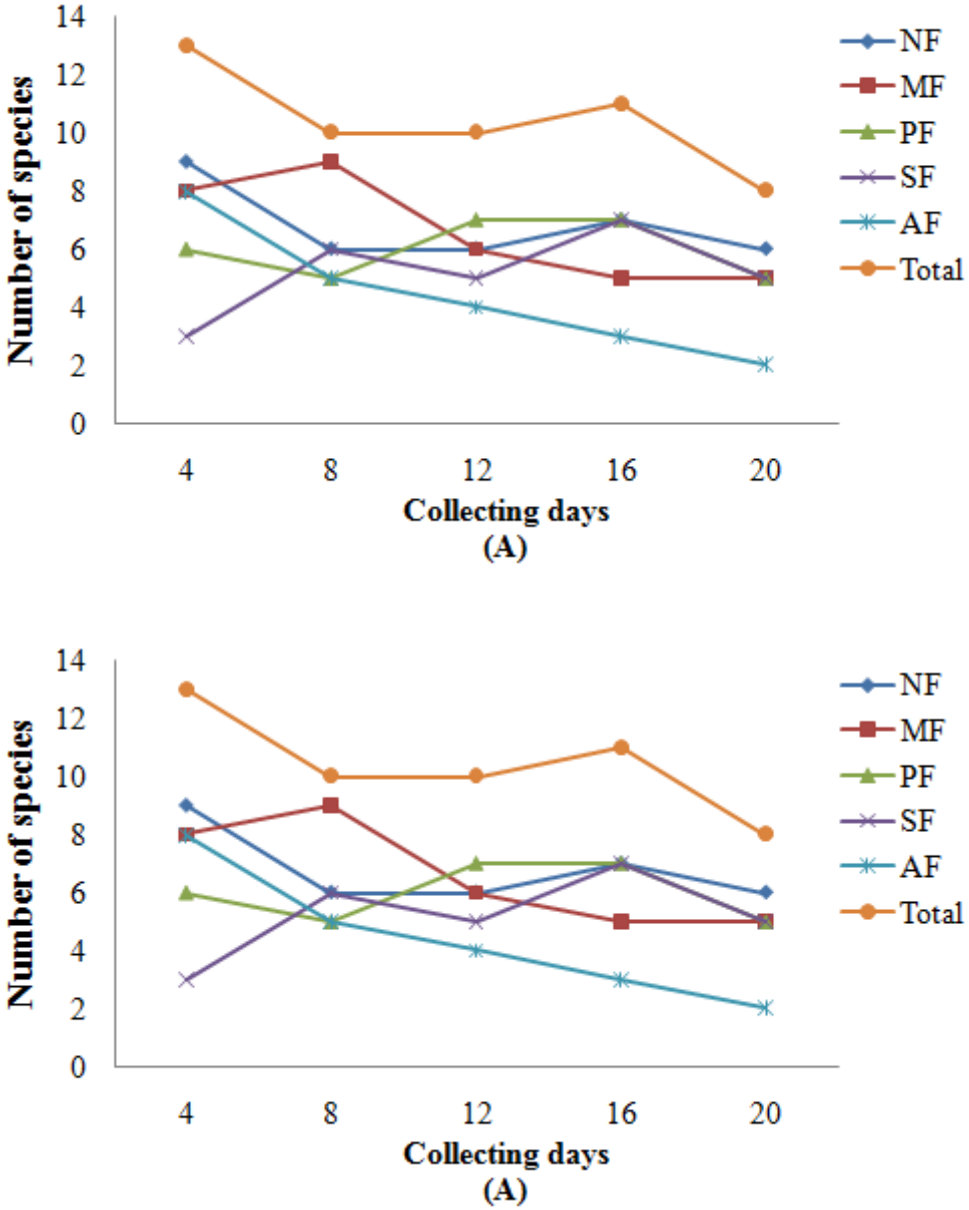

Figure 2. Number of longhorn beetle species collected by *Artocarpus trap* in natural forest (NF), mixed forest (MF), *Schima* forest (SF), *Agathis* forest (AF), and pine forest (PF); in September (A) and October (B).

Based on the Shannon-Wiener diversity index, the highest diversity of longhorn beetles was in the natural forest (H'=1.80), followed in order, by the pine forest (H'=1.62), the mixed forest (H'=1.267), the *Schima* forest (H'=1.028), and the *Agathis* forest (H'=0.556).

The statitistical evenness of beetle species found followed the same order: NF (E= 0.750), PF (E= 0.703), MF (E= 0.509), SF (E= 0.428), and AF (E= 0.232) (Table 2).

Table 2. Matrix similarity of longhorn beetles in pine forest (PF), *Agathis* forest (AF), *Schima* forest (SF), mixed forest (MF), and natural forest (NF), using *Bray-Curtis distance* method.

	PF	AF	SF	MF	NF
PF	1	0,45	0,70	0,67	0,75
AF	0,45	1	0,49	0,60	0,30
SF	0,70	0,49	1	0,71	0,42
MF	0,67	0,60	0,71	1	0,50
NF	0,75	0,30	0,42	0,50	1

Based on the Bray-Curtis similarity index, the species similarity of longhorn beetles was highest between the natural forest and pine forest (0,75) (Table 2). A dendogram also showed that the communities of longhorn beetle in the natural and pine forests had a high similarity (Fig. 3).

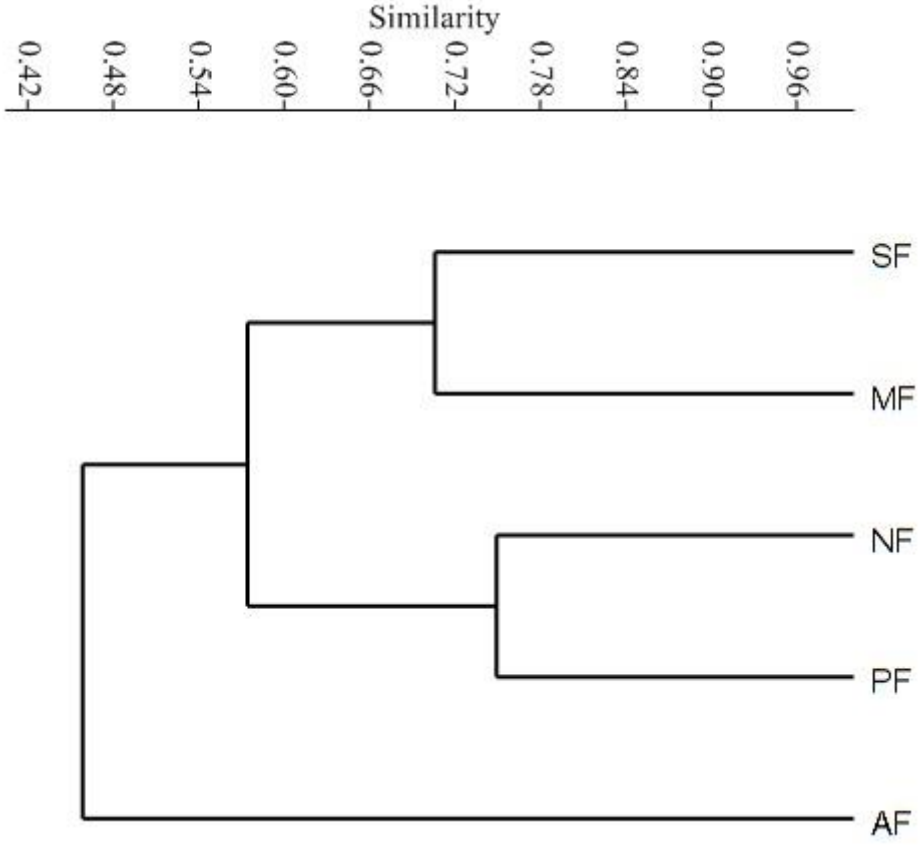

Figure 3. Dendogram showing similarity of longhorn beetles in pine forest (PF), *Agathis* forest (AF), *Schima* forest (SF), mix forest (MF), and natural forest (NF), using *pair-group average*.

Discussion

All species of longhorn beetle found belong to the subfamily Lamiinae. Lamiinae is the largest group in Cerambycidae (Hanks 1999; Noerdjito *et al*. 2002). The subfamily Lamiinae has also been reported in Gunung Halimun National Park (Makihara *et al*. 2002), Gunung Ciremai National Park (Noerdjito 2008), Bogor Botanical Gardens (Noerdjito 2010), Mount Slamet (Noerdjito 2011) and Mount Salak (Noerdjito 2012). The number of individuals found in each habitat in this study varied. The highest number of individuals was found in the *Agathis* forest, while the lowest was found in the *Schima* forest. The differences in numbers of individuals found were due to the different characteristics of each habitat. Alekseev (2007) suggested that the abundance of longhorn beetles was influenced by forest type.

High numbers of the longhorn beetle species *S. binotata, S. fuscotriangularis*, and *R. strandi* were found at GWEF;these are small-sized beetles (<10 mm in length). Two other studies produced similar results: Noerdjito (2011) reported the highest number of individuals for *S. binotata* and *S. fuscotriangularis* in forest areas on Mount Slamet, Central Java; and Noerdjito (2012) again reported that small-sized longhorn beetles (*S. fuscotriangularis* and *R. strandi*) had the highest abundance of individuals on Mount Salak, West Java. The larvae of small-sized longhorn beetles are able to live on small branches or twigs and are commonly found in various types of habitat (Noerdjito 2012). In the current research, two species with relatively large body sizes (*A. rusticatrix* and *P. melanura*) were found in high numbers in all types of habitats. Noerdjito (2010) had previously reported that large populations of these same two large-sized longhorn beetle species were found in Bogor Botanical Gardens.

Acalolepta rusticatrix can inhabit a wide range of host plants, i.e. *Afzelia bijuga, Artocarpus integra, Theobroma cacao, Ficus elastica,* and *Hevea brasiliensis* (Makihara 1999; Makihara *et al*. 2002). *Pterolophia melanura* also has a wide range of host plants, i.e. *Theobroma, Coffea, Hevea, Tectona, Ficus rempelas, Artocarpus integra, Pinus caribaea,* and *Acacia mangium* (Makihara 1999; Makihara *et al*. 2002); and *P. uniformis* was also found in various types of habitat, but in relatively low numbers (except in the natural forest: 37 individuals). Among species found in the study, *S. binotata* had the highest number of individuals (1247). We supposed that this forest has food resources. The *Agathis* forest (the most productive, in terms of abundance of individuals) was also dominated by understorey plants, like ferns and orchids; some species of longhorn beetles attack ferns (Kirk 1977) and orchids (Chen *et al*. 2001).

The number of species collected in September and October varied, due to the conditions of the habitat and traps. The *Artocarpus trap* is effective for collection of cerambycids (Noerdjito 2008). Makihara (1999) reported that of the 279 species (Lamiinae) found in East Kalimantan, 38 of them live on *Artocarpus* as their host plant. Female longhorn beetles are attracted to *Artocarpus traps* for oviposition. Generally, some species prefer dead, decaying, and dry wood (Noerdjito *et al*. 2009), but some species also like fresh host material (Ohsawa 2008).

Various longhorn beetle species have previously been reported in pine woods, i.e. *P. melanura* (Makihara *et al*. 2002), *Arhopalus coreanus, Cephalallus unicolor, Phloeopsis bioculata, Boninella degenerata, B. satoi, Monochamus alternatus* (Sugiura *et al*. 2008), *M. saltuarius* (Kim *et al*. 2006) and *Tragosoma depsarium* (Wikars 2004). Some species have been found in *Schima* woods i.e., *Psephactus scabripennis, Ceresium signaticolle, Xylotrechus ogasawarensis, Chlorophorus boninensis,* and *C. kobayashii* (Sugiura *et al*. 2008); and in *Agathis* woods i.e., *Sormida cinerea* (Waqa-Sakiti *et al*. 2014).

The highest diversity of longhorn beetles was found in the natural forest, followed in order by the pine forest, the mixed forest, the *Schima* forest, and the *Agathis* forest. The high diversity of longhorn beetles in natural forests is related to the vegetation structure. The natural forest here included many species of plants; in contrast, the *Agathis* forest tended toward monoculture, with an understorey dominated by ferns and orchids. This result is supported by Keszthelyi (2015), who showed that the highest diversity of longhorn beetles was found in natural forest, rather than monoculture forest. The existence of longhorn beetles in the habitat is influenced by the types of tree or vegetation (Ohsawa 2004; 2010). Moreover, different species of longhorn beetle select different species of trees or shrubs. Although many species of longhorn beetle live in a wide range of plants, some species live only in or on a certain host plant (Noerdjito 2011). Meng *et al*. (2013) reported that there was a positive relationship between the number of longhorn beetle species and the number of tree species in a habitat. The diversity of trees reflected the availability of different types of dead wood. Results from the current study showed that the pine forest also had a high diversity of longhorn beetles. These results are supported by Peris-Felipo *et al*. (2011), who showed that the diversity of longhorn beetles in pine forest was higher than in quercus forest, mixed forest, and shrub vegetation. Vance *et al*. (2003) also reported that pine stands are potentially important for maintaining diversity of longhorn beetles. In our research, the location of the pine forest was close to natural forest and various species of understorey plant could be found. Diversity of saproxylic beetles in pine forest can be increased when pines are mixed with broad-leaved trees, e.g. oaks in the understorey layer (Buse *et al*. 2010).

Based on Bray-Curtis matrix and dendogram similarity, longhorn beetles in the natural and pine forests were similar. Likewise, longhorn beetles in the mixed forest were similar to those in the *Schima* forest (Fig. 3). In this research, the natural forest was located adjacent to the pine forest, and the mixed forest was adjacent to the *Schima* forest. The similarities of longhorn beetle found between these pairs of locations was due to the similarity of the habitat characteristics. Vegetation conditions in each area affect the composition of longhorn beetles (Noerdjito 2010).

There were some differences in longhorn beetle species found in GWEF compared to other areas in Java, when using jackfruit branch trap. Four species i.e., *R. honesta*, *R. marmorata*, *N. notatus*, and *E. artocarpi* were not found in Gunung Halimun National Park (Makihara *et al*. 2002), Gunung Ciremai National Park (Noerdjito 2008), Bogor Botanical Gardens (Noerdjito 2010), Mount Slamet (Noerdjito 2012) and Mount Salak (Noerdjito 2012). These species are only distributed at altitudes below 1000 m asl, although not recorded at Bogor Botanical Gardens, which is located at an altitude of 260 m.asl (Nakamura *et al*. 1995). Elevation gradient determines the number of species of longhorn beetle (Gobbi *et al*. 2012). *Ropica honesta* was found in Banyumas, Central Java in 1922 (Makihara & Noerdjito 2004). This species is distributed in Borneo, Sumatra, Java, New Guinea, Philippines, Taiwan, and China (Heffern 2013). *Exocentrus artocarpi* was found in Semarang, Central Java in 1931 (Fisher 1934) and this species is only distributed in Java (Bezark 2015). *Notomulciber notatus* was found in Nusakambangan, Central Java in 1927 (Fisher 1936) and this species is only distributed in Java (Bezark 2015). Previously, *R. marmorata* had only been reported in Sumatra (Breuning 1939), in East Kalimantan (Noerdjito *et al*. 2009), and in Jambi Province, Sumatra (Fahri 2013). This research in Gunung Walat Educational Forest produced the first ever record of this species in Java.

The species commonly found in Java are *A. rusticatrix*, *E. luscus*, and *P. melanura*, and these species are common in all habitat types (Noerdjito *et al*. 2009). *Acalolepta rusticatrix* is distributed in Borneo, Sumatra, Java, the Philippines, Taiwan (Heffern 2013), India (Mathew *et al*. 2004; Mitra 2013) and Central Sulawesi (Fahri & Sataral 2015).

Epepeotes luscus is distributed in India, Nikobar Island, Thailand, Vietnam, Laos, Malaysia, Borneo, China, Sumatra, Java (Hayashi 1976), Myanmar, Laos, Mentawai Island, Sumbawa, and Flores (Makihara 1999). *Pterolophia melanura* is distributed in Borneo, Java, Sumatra, Malaysia, Vietnam (Makihara 1999; Makihara *et al*. 2002). Some species found in this study are only distributed in Java: *C. montanus*, *R. strandi*, *S. fuscotriangularis*, *M. javanicus*, *N. notatus*, and *E. artocarpi*.

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