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Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai, East Kalimantan, Indonesia

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Abstract. *Matius P, Tjwa SJM, Raharja M, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai, East Kalimantan, Indonesia. Biodiversitas 19: 1280-1288.* Munaans are traditional fruit gardens of the Benuaq and Tunjung Dayaks tribes of West Kutai, East Kalimantan, Indonesia. This research was conducted in Mencimai, a Benuaq Dayak's village and Sekolaq Darat, a Tunjung Dayak' village. A 1.0 ha plot of old munaan lou (lembo lamin) in Mencimai Village was used as representative study site for Benuaq ethnic traditional fruit garden and 1.0 ha plot of old munaan luuq (lembo lamin) in Sekolaq Darat Village as the study site representing Tunjung ethnic fruit gardens. Index of diversity was calculated by using Shannon-Wiener (H') formulae and evenness by using Pielou. Species richness in munaan lou of Mencimai was 174 and munaan luuq of Sekolaq Darat was 165, which consisted of trees and understorey plants such as tree saplings, seedlings, shrubs, herbs, bamboos, lianas, and rattans. Diversity indices (H') for all stage of plants within both munaan lou of Mencimai and munaan luuq of Sekolaq Darat were 4.45 and 4.21 with the evenness (E) were 0.86 and 0.82 respectively. The common species of fruit trees found in munaan lou of Mencimai were *Lansium domesticum, Durio zibethinus, Nephelium* sp., *Artocarpus integer, Nephelium lappaceum, Baccaurea macrocarpa,* and *Baccaurea edulis.* Meanwhile, *D. zibethinus, L. domesticum, Artocarpus anisophyllus, A. integer, Nephelium uncinatum,* and *B. macrocarpa* were the common fruit species in munaan luuq of Sekolaq Darat. The munaans serve many functions in the local context, and the local communities mainly use them as sources of fruits, wood, medicinal plants, tools, and legality of land tenure.

Keywords: Diversity indices, function, munaan, species richness, traditional fruit gardens

INTRODUCTION

Ecosystem services research suggests that the social benefits that agrosystems provide generally transcend those related to production services (Porter et al. 2009; Sandhu et al. 2010). Moreover, these age-old traditional systems are evolving rapidly in response to changes in the socio-economic, socio-ecological and biophysical environment (Descheemaeker et al. 2016; Mellisse et al. 2017).

Munaan, lembo or simpuknng are the local terms for the traditional home gardens or fruit gardens belonging to the ethnics groups of Benuaq dan Tunjung Dayaks in West Kutai, East Kalimantan, Indonesia, which have many species of local plants including fruit species (Kojima et al. 2017). Munaans have normally been maintained for hundreds of years and considered as the community forest gardens at West Kutai (Chaiphar et al. 2013, Apuy et al. 2017). Forest gardens have been considered as one of the models of agroforestry in which the local people cultivate farmlands with trees such as durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), langsat (*Lansium domesticum*), cempedak (*Artocarpus champeden*), ihau (*Dimocarpus didyma*), kapur (*Dryobalanops aromatica*) and meranti (*Shorea* sp.) (Mulyoutami et al. 2009; Winarni et al. 2018). In Central Kalimantan, similar types of traditional agroforestry gardens called Kaleka managed by local people have been reported Rahu et al. (2014). Various types of agroforestry practice have been applied by local community, for example, the integration between woody plant with livestock (Hartoyo et al. 2015).

Munaan lou or munaan luuq is a traditional fruit garden located behind or on both sides of a longhouse (lamin) of Benuaq and Tunjung community. Benuaq Dayak tribe called a traditional fruit garden surrounding longhouse (lamin) "munaan lou" (lou means lamin), while Tunjung tribe called its "munaan luuq" (luuq means lamin). When Indonesia got its freedom from Dutch colonialism, the government encouraged the community to build smaller private houses. The local community cultivated many species of fruits behind and on both sides of their houses. These gardens are called lembo rumah (private house fruit gardens). Benuaq Dayak tribe called private house fruit garden "munaan belaai", while Tunjung tribe called it "munaan dapeeq". Local people make their farms (ladang) away from the village, for growing rice and other crops. They also grow many kinds of fruits around their hut, together with other natural plants. These fruit gardens are known as lembo ladang (farmland fruit gardens) or "munaan umaq" in both Benuaq and Tunjung language.

The cultivation of munaan by the communities started with the cultivation of rice, vegetables, fruits, and wood by using traditional ecological knowledge system namely shifting cultivation, followed by the cultivation of the generation forest gardens which was preserved for the next generation (Apuy et al. 2017; Hutauruk et al. 2018). Wood product consumption will keep increasing. Thus, a method

to minimized wood harvesting from natural forest has become needful if the biodiversity of tropical forests is to be managed (Ruslim et al. 2016).

Long time ago, the people trip from their villages to another village on foot. At the middle way of country road when they tired, they take a break and eating their supply such as fruits. Then, they grew fruit seeds surrounding the rest area. The fruits seed will grow become a fruit garden. This garden is known as lembo jalan/munaan perakaatn (country road fruit gardens). This garden is known as lembo jalan (country road fruit gardens) or "munaan perakaatn" in Benuaq and Tunjung languages. Forest gardens are considered a dynamic form of a social, economic, and ecological process of the traditional communities, in which the realization of forest gardens for the farmers living in the villages around the village will be a pattern created by the ideas of sustainable forest management (Kettle 2010). Local wisdom is the solution to environmental problems, as it consists of values to balance and preserve the environment (Fahrianoor et al. 2013). This research was focused on munaan lou (Benuaq) and munaan luuq (Tunjung).

MATERIALS AND METHODS

Study area

The study was conducted in two villages of West Kutai (Kutai Barat) District, East Kalimantan, Indonesia, namely Mencimai Village (Benuaq Dayak ethnic) in Barong Tongkok Subdistrict and Sekolaq Darat Village in Sekolaq Darat Subdistrict (Tanjung Dayak ethnic) (Figure 1). These villages still have relatively well-maintained munaans and other external support for their agricultural activities. The reasons behind choosing these villages were: (i) Benuaq and Tunjung ethnics practice the same culture to grow various of fruit species around their long house (lou in Benuaq language and luuq in Tunjung language for long house term), (ii) they have a long history of protecting and managing primary forest based on their cultural wisdom, (iii) old munaan lou (lembo lamin) in Mencimai Village was used as a representative of Benuaq ethnic traditional fruit garden and old munaan luuq in Sekolaq Darat Village was used as a representative of Tunjung ethnic fruit gardens, and (iv) both villages have been differenties floristic composition and species diversity of two munaan surrounding the long house in both Dayak tribes.

Data collection

The plants of both of munaans were divided into 3 growth stages, trees, saplings and seedlings for data collection. Trees mean all plants with diameter at breast height (dbh) of 10 cm and more and were recorded from 100 subplots, each of 10 m x 10 m size. Saplings stage means plants with 10 cm or less diameter breast height (dbh) which includes saplings of trees, shrubs, lianas, bamboo, palm/rattan with height more than 1 m. Sapling stage was recorded from 100 subplots, each of 5 m × 5 m size. Seedling stage included all plants with 1.5 m or less height. Seedling stage was recorded from a total of 100 subplots, each of 2 m × 2 m size. Both sapling and seedling stages belonged to understorey vegetation.

The importance value index (IVI) was calculated using the following formula (Curtis and Cottam 1964; Muller-Dombois 1984; Wijana 2014):

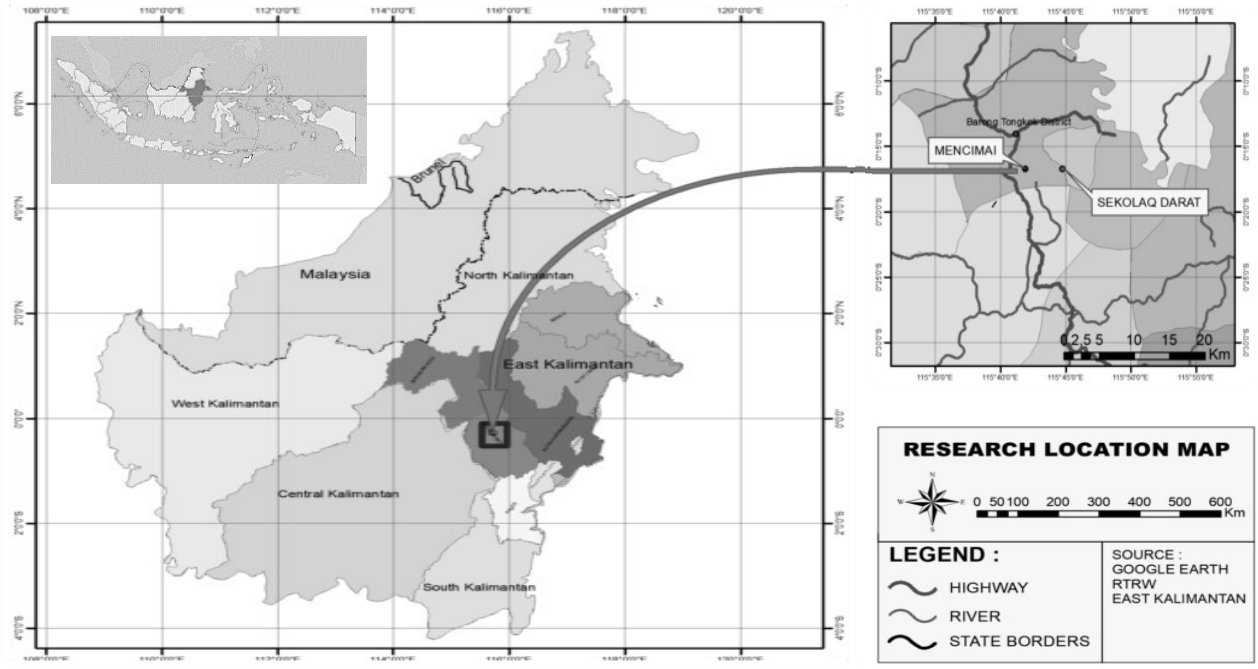

Figure 1. Study locations at Mencimai and Sekolaq Darat Villages (□), West Kutai District, East Kalimantan, Indonesia

IVI = RD (%) + RF (%) + Rdo (%)

Where :

$$Relative\ density\ (RD) = \frac{Total\ number\ of\ individuals\ of\ species}{Total\ number\ of\ individuals\ of\ all\ species} \times 100\%$$

$$Relative\ frequency\ (RF) = \frac{Total\ frequency\ of\ species\ occur\ in\ all\ plots}{Total\ frequency\ of\ all\ species\ occur\ in\ all\ plots} \times 100\%$$

$$Relative\ dominance\ (RDo) = \frac{Total\ basal\ area\ of\ species}{Total\ basal\ area\ all\ species} \times 100\%$$

The diversity within both communities was calculated with Shannon-Wiener index using the following formula (Magurran 1988):

$H' = \sum (pi) (\log 2\ pi)$

Where:

H' : Shannon-Wiener index of diversity

pi : Proportion of the total sample belonging to i-th species

$E = \frac{H}{H_{max}}$ (Pielou 1966)

In which: E (evenness) = proportion of observed diversity index to maximum diversity index.

The similarity between plant communities of both munaans was calculated using Soerensen's Similarity formula (IS_S) following Mueller-Dombois and Ellenberg (1984), as shown below:

$$IS_S = \frac{2c}{A \times B} \times 100$$

Where:

c : Number of similar species in both munaan

A : Total number of species in munaan lou of Mencimai

B : Total number of species in munaan luuq of Sekolaq Darat

RESULTS AND DISCUSSION

Species richness and floristic composition

Total number of species belonging to all of the three plant stages in munaan lou of Mencimai was 174, and in munaan luuq of Sekolaq Darat was 165, which consisted of trees and understorey plants such as tree saplings and seedlings, shrubs, herbs, bamboos, lianas, and rattans. The observed species richness in both these munaans is higher than the reported species richness in home gardens from several other areas in the world, such as Eastern Himalayan Region of Northwest India (an average of 78 species per home garden) (Barbhuiya et al. 2016), Guatemala with an average 54 species (Marquez and Schwartz, 2008) and Benin with an average of 10 species per home garden (Salako et al. 2014).

The tree composition of both sample plots consisted of fruit trees and non-fruit trees species. Total tree species richness in both sample plots was 49 species. The fruit trees of munaan lou in Mencimai consisted of 33 species, while in munaan luuq of Sekolaq Darat 23 species were found. Non-fruit trees in munaan lou of Mencimai were 16 species, and in munaan luuq of Sekolaq Darat were 26 species. Non-fruit trees species present in both munaans are from non-intensive cultivation of munaans which gave the chance for natural plants of non-fruit trees to grow along with the fruit trees. These non-fruit trees are also the source of local people's various needs, such as building materials, firewood and tools.

Table 1 shows that both munaans also contain various understorey forms such as tree saplings, tree seedlings, shrubs, bamboo, palm, rattan, herbs, and lianas. The understorey species richness in munaan lou of Mencimai consisted of 108 species for saplings stage and 100 species for seedling stage, while in munaan luuq of Sekolaq Darat 98 species of sapling stage and 104 species of seedling stage were observed. All plants of the understorey vegetation (sapling and seedling stages) were from natural regeneration of trees of fruit and natural non-fruit species, shrubs, herbs, liana, rattan, and bamboo. Similar result was also reported by Tynsong and Tiwari (2010).

Table 2 showed the 10 common species in both munaans, based on their important value index (IVI). Out of the 10 most common trees in munaan lou of Mencimai, 9 are fruit species and only one is non-fruit trees (*Schima wallichii*) that is growing naturally. *S. wallichii* is a pioneer species which can reach over 100 cm of diameter at breast height (dbh), and 47 m of total height of which 25 m is branchless (Slik 2013). The local people use this species as source of building materials and tools. Common plants of munaan luuq Sekolaq Darat consist of six species of fruit trees and four species of non-fruit trees (*Monocarpia kalimantanensis*, *Ficus benjamina*, *Canarium decumanum* and *Koompassia excelsa*). *C. decumanum* and *K. excelsa* are giant sized non-fruit tree species reaching about 150 cm dbh and 60 m of total height, and are maintained as honey bee trees (Slik, 2013). The highest IVI in both munaans is recorded for *L. domesticum* (lisaat, langsat), which is followed by *D. zibethinus* (kalaakng, durian).

In the sapling stages of munaan lou of Mencimai, fruit species were less common. There were only 4 fruit species among 10 common species. They were *Nephelium* sp, *Artocarpus integer*, *Artocarpus anisophyllus* and *D. zibethinus*. Non-fruit species consisted of five tree saplings (*Peronema canescens*, *Timonius lasianthoides*, *Hevea brasiliensis*, *Pithecellobium jiringa*, and *Syzygium polyanthum*) and one shrub (*Coffea robusta*). In munaan luuq of Tunjung tribe in Sekolaq Darat, only *L. domesticum* was recorded as common fruit tree species in sapling stage, while the other nine species were shrubs (*Fordia* sp., *Lepisanthes amoena*, *Tarrena* sp.), non-fruit tree saplings (*H. brasiliensis*, and *P. canescens*), bamboo (*Bambusa* sp.), herb (*Alpinia* sp.), rattan (*Daemonorops grandis*), and liana (*Friesodielsia* sp.) (Table 3).

Table 1. Number of tree species in the munaans of Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

Growth stages	Sample size (ha)	Number of species		
		Fruit	Non-fruit	Total
Munaan lou * (Mencimai)				
Trees	1.00	33	16	49
Sapling stage	0.25	17	91	108
Seedling stage	0.04	13	87	100
Munaan luuq * (Sekolaq Darat)				
Trees	1.00	23	26	49
Sapling stage	0.25	14	84	98
Seedling stage	0.04	12	92	104

Note: *Lou (Benuaq language) and Luuq (Tunjung language) mean a long traditional house

Table 2. List of 10 most common tree species based on important value index (IVI) in munaans of Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

Munaan lou (Mencimai)	Fruit/non-fruit	Munaan luuq (Sekolaq Darat)	Fruit/non-fruit
Lansium domesticum	Fruit	*Lansium domesticum*	Fruit
Durio zibethinus	Fruit	*Durio zibethinus*	Fruit
Nephelium sp.	Fruit	*Artocarpus anisophyllus*	Fruit
Artocarpus integer	Fruit	*Artocarpus integer*	Fruit
Mangifera odorata	Fruit	*Nephelium uncinatum*	Fruit
Cocos nucifera	Fruit	*Monocarpia kalimantanensis*	Non fruit
Nephelium lappaceum	Fruit	*Ficus benjamina*	Non fruit
Baccaurea macrocarpa	Fruit	*Canarium decumanum*	Non fruit
Schima wallichii	Non fruit	*Koompassia excelsa*	Non fruit
Baccaurea edulis	Fruit	*Baccauea macrocarpa*	Fruit

Table 3. List of 10 common species in sapling stage in munaans of Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

IVI	Munaan lou (Mencimai)		Munaan luuq (Sekolaq Darat)	
rank	Species	Lifeform	Species	Lifeform
1	*Coffea robusta*	Shrub	*Bambusa* sp.	Bamboo
2	*Peronema canescens*	Tree sapling	*Fordia* sp.	Shrub
3	*Timonius lasianthoides*	Tree sapling	*Alpinia* sp.	Herb
4	*Pithecellobium jiringa*	Tree sapling	*Lepisanthes amoena*	Shrub
5	*Nephelium* sp.	Tree sapling	*Tarrena* sp.	Tree sapling
6	*Artocarpus integer*	Tree sapling	*Lansium domesticum*	Tree sapling
7	*Artocarpus anisophyllus*	Tree sapling	*Hevea brasiliensis*	Tree sapling
8	*Hevea brasiliensis*	Tree sapling	*Peronema canescens*	Tree sapling
9	*Eugenia polyantha*	Tree sapling	*Daemonorops grandis*	Rattan
10	*Durio zibethinus*	Tree sapling	*Friesodielsia* sp.	Liana

Table 4. List of 10 common species in seedling stages in munaans of Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

IVI	Munaan lou (Mencimai)		Munaan luuq (Sekolaq Darat)	
rank	Species	Lifeform	Species	Lifeform
1	*Paspalum conjugatum*	Herb	*Lansium domesticum*	Tree seedling
2	*Rubiaceae*	Tree seedling	*Philodendron* sp.	Herb
3	*Tetracera indica*	Liana	*Connarus semidecandrus*	Liana
4	*Scleria ciliaris*	Herb	*Leptaspis urceolata*	Herb
5	*Panicum trigonum*	Herb	*Leptonychia heteroclita*	Shrub
6	*Lansium domesticum*	Tree seedling	*Tetracera asiatica*	Liana
7	*Caesalpinia sappan*	Tree seedling	*Paspalum conjugatum*	Herb
8	*Ageratum conyzoides*	Herb	*Lepisanthes amoena*	Shrub
9	*Leptaspis urceolata*	Herb	*Peronema canescens*	Tree seedling
10	*Nephrolepis biserrata*	Herb/fern	*Fordia* sp.	Shrub

Seedling stages of both munaans showed that most common species were non-fruit species, except the seedlings of *L. domesticum* (lisaat). They consist of herbs (*Paspalum conjugatum*, *Scleria ciliaris*, *Panicum trigonum*, *Leptaspis urceolata* and *Nephrolepis biserrata*), non-fruit tree species (Rubiaceae, *Caesalpinia sappan*) and liana (*Tetracera indica*) in munaan lou of Mencimai (Benuaq tribe). Munaan luuq of Sekolaq Darat (Tunjung tribe) consisted of herbs (*Philodendron* sp., *L. urceolata*, *P. conjugatum*), shrubs (*Leptonychia heteroclita*, *L. amoena*, and *Fordia* sp.), liana (*Connarus semidecandrus*, and *Tetracera asiatica*) and non-fruit tree species (*P. canescens*) (Table 4).

Figures 2 and 3 indicates the various growth form-wise distribution of species in sapling and seedling stages respectively, in munaans. In both munaans, highest number of saplings belonged to tree species. In munaan lou of Mencimai, shrub saplings showed second highest species richness followed by liana, herbs, and rattan. But, in munaan luuq of Sekolaq Darat, second highest species richness was of liana forms which are followed by shrubs, herbs, rattan, and bamboo.

With regard to seedling stage, the highest species richness in munaan lou Menicimai was observed for shrubs, followed by trees, herbs, and liana. In munaan luuq of Sekolaq Darat, the highest species richness was for tree seedlings, followed by liana, herbs, shrub, rattan, and bamboo (Figure 3).

Graphical analysis of relationship between diameter and number of species showed a typical J-reverse shape (Figure 4). The highest number of species were found in diameter class of 10.0-19.9 cm, and further, the species richness gradually decreased as the diameter increased.

Number of species with diameter less than 50 cm were 87.1% in munaan lou of Mencimai and 85.5% in munaan luuq of Sekolaq Darat. About 15 species reached diameter over 50 cm. They are *A. anisophyllus*, *A. integer*, *Durio kutejensis*, *Durio oxleyanus*, *D. zibethinus*, *Eugenia* sp., *Ficus* sp., *Mangifera foetida*, *Mangifera pajang*, *Mangifera similis*, *Nephelium mutabile*, *Nephelium* sp., *Parkia speciosa*, *Santiria apiculata* and *S. wallichii*.

Plant diversity and similarity

Diversity indices (H') for all stages of plants in both munaan lou of Mencimai and munaan luuq of Sekolaq Darat were 4.45 and 4.21 with the evenness (E) of 0.86 and 0.82 respectively. Tree diversity in both fruit gardens as indicated by Shannon -Wiener index (H') H' is 3.18 in munaan lou Mencimai and 3.04 in munaan luuq of Sekolaq Darat. Shannon-Wiener indices (H') within munaan lou of Mencimai and munaan luuq of Sekolaq Darat for sapling stage were 4.02 and 3.85 with the evenness value of 0.86 and 0.84 respectively. In seedling stage, H' within munaan lou of Mencimai and munaan luuq of Sekolaq Darat were 3.93 and 3.76 with the evenness of 0.85 and 0.81 respectively. Similar result was for indigenous home gardens of Eastern Himalayan Region of Mizoram, Northeast India with species diversity indices of 4.76, 4.39, and 4.58 for trees, shrubs, and herbs, respectively (Barbhuiya et al. 2016). Similarity between both munaans as indicated by Soerensen similarity index (IS_S) for all stages of vegetation (trees and understorey) was 44.8%, or dissimilarity was 55.2%, with the similarity of 76 species. Soerensen similarity index (IS_S) for trees stage was 40.8%, or dissimilarity was 59.2%, with the similarity of 20 species.

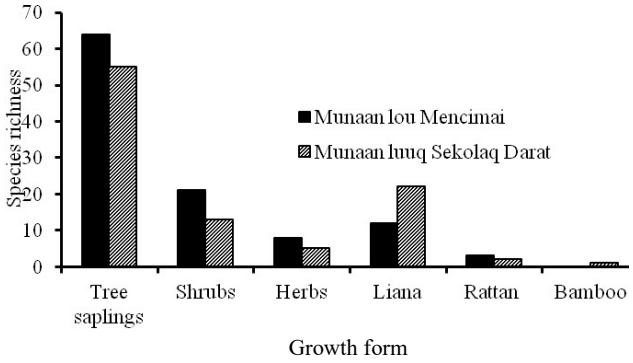

Figure 2. Distribution of species based on growth form of saplings in munaans of Benuaq and Tunjung ethnics of West Kutai, East Kalimantan, Indonesia

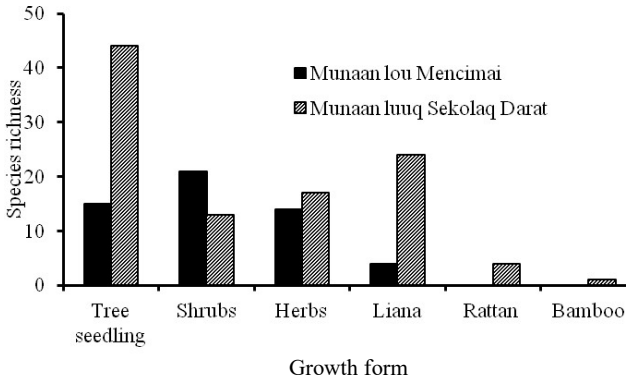

Figure 3. Distribution of species based on growth form of seedlings in munaan of Benuaq and Tunjung ethnics of West Kutai, East Kalimantan

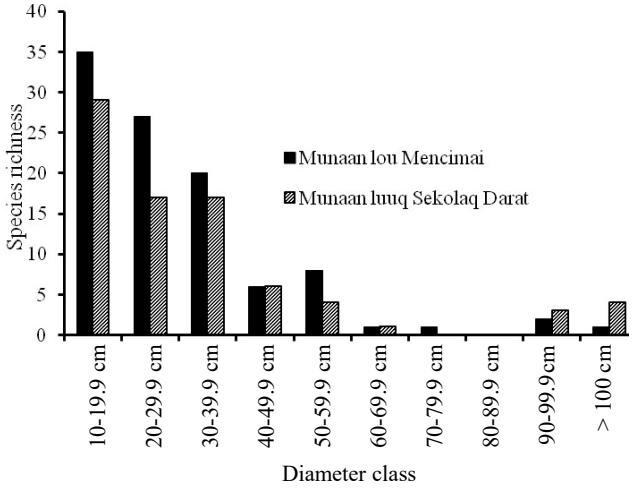

Figure 4. Species distribution based on diameter of plants in munaans of Benuaq and Tunjung ethnics of West Kutai, East Kalimantan, Indonesia

In sapling stage, similarity between both munaans was 43.7% or dissimilarity was 56.3% with 45 similar species, while in seedling stage, similarity was 43.3% or dissimilarity was 56.7% and the number of similar species was 44. In the indigenous home gardens in the Eastern Himalayan Region of Mizoram, Northeast India, the species similarity within each life form were 50% for trees, 38% for shrubs, and 49% for herbs (Barbhuiya et al. 2016).

Stand density, diameter and height distribution

Stand density in munaan lou (Mencimai) consisted of 257 tree stage individuals, 3367 sapling stage individuals and 36491 seedling stage individuals per ha, while munaan luuq (Sekolaq Darat) consisted of 252 individuals of trees, 6744 of saplings and 36500 seedlings per ha.

Both munaan lou in Mencimai (Benuaq) and munaan luuq in Sekolaq Darat (Tunjung) showed typical reversed-J shaped graph when number of plants is plotted against different diameter classes (Figure 4). This diameter distribution shape is similar to that of natural primary forest. This is a typical feature for uneven-aged and multi-species stands in tropical rainforests as studied by Kang et al. (2014), Nguyen et al. (2014), De Lima et al. (2016) and also in logged forest (Kuswandi and Murdjoko 2015).

The highest density of trees was in the diameter class of 10.0-to 19.9 cm, and it further decreased gradually with the increase of diameter. In munaan lou of Mencimai, 41.4% plants belonged to diameter class of 10.0-19.9 cm and in munaan luuq of Sekolaq Darat, this figure was 41%. 92.2% plants in munaan lou of Mencimai and 90.4% in munaan luuq of Sekolaq Darat were of less than 50cm diameter. Plants of more than 50cm diameter were only 7.8% in munaan lou of Mencimai and 9.6% in munaan luuq of Sekolaq Darat (Figure 5).

Figure 6 shows the height class-wise distribution of plants in munaans of Benuaq and Tunjung tribes. In both munaans, the highest number of plants were recorded in the height class of 10 -19.9 m (stratum C) and this is followed respectively by 20 to 29.9 m (stratum B), < 10 m (stratum D) and 30 m and more (stratum A). The stratum A (top storey) was occupied by trees like *D. zibethinus*, *M. pajang*, *M. similis*, *K. excelsa*, *C. decumanum*, *P. speciosa*, *Ficus albipila*, *Ficus* sp., *Dillenia* sp., *A. integer* and *Nephelium* sp. This means that the munaans have a multilayered structure consisting of A strata (30 m and more), B strata (20 to 30 m), C strata (10-20 m) and forest floor strata (understoreid strata), which is similar to the structure of natural tropical forests (Figure 7). Similar structure is also found in the traditional home gardens of Batticaloa District, Sri Lanka (Krishnal and Weerahewa 2014).

Munaan functions and plant utilization

Munaans of Benuaq and Tunjung tribes serve multiple functions for the local communities, such as legality of land tenure, source of various local fruits, reserves for raw materials for building construction, tools, medicine, ritual ceremonies, firewood and others (Table 6). Therefore, they are comparable to home gardens of Central Vietnam (Vlkova et al. 2011) and Amazonian home gardens of Ecuador (Caballero-Serano et al. 2016) which are also multifunctional, such as sources of food, medicine, firewood, and used for various other purposes. In home-gardens of Dumbara (Knuckles) Conservation Area, Sri Lanka the local community use trees with big dbh for timber purposes (Dissanayake and Hettiarachchi 2013).

Table 5. Tree, sapling and seedling stage density in 100-year-old munaans in Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

Munaan and stage	Number of plants ha^{-1}
Munaan lou (Mencimai)	
Trees stage	257
Sapling stage	3367
Seedling stage	36491
Munaan luuq (Sekolaq Darat)	
Trees stage	252
Sapling stage	6744
Seedling stage	36500

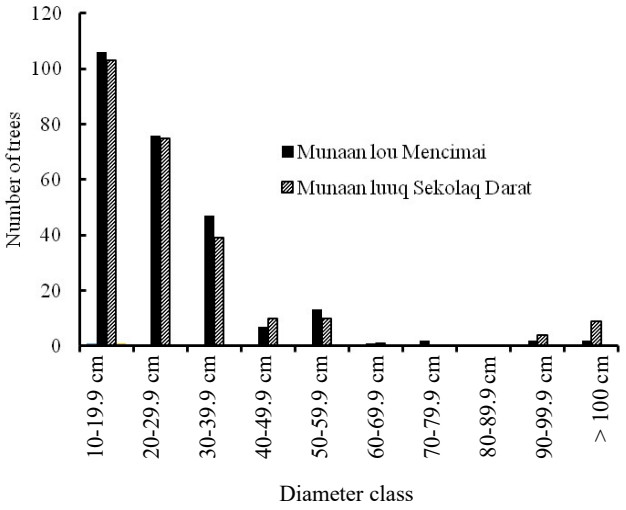

Figure 5. Number of trees of different diameter classes in munaans of Benuaq and Tunjung tribes of West Kutai, East Kalimantan, Indonesia

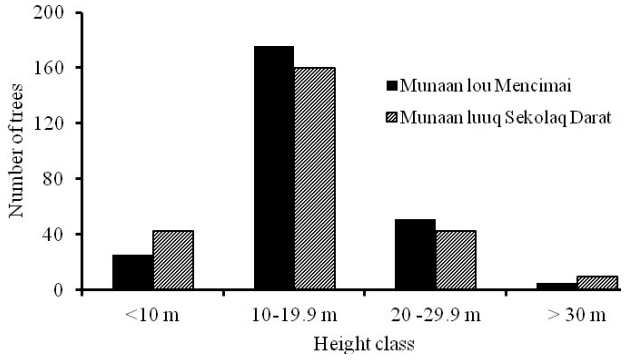

Figure 6. Height class-wise distribution of trees in munaan of Benuaq and Tunjung ethnics of West Kutai, East Kalimantan, Indonesia

Figure 7. The multilayered vertical structure of munaans of West Kutai, East Kalimantan, Indonesia which is similar to natural forests. A. Munaan lou of Mencimai; B. Munaan luuq of Sekolaq Darat

Many species, both fruit yielding and non-fruit yielding, can be used as building materials, tools and firewood. *D. zibethinus*, *Nephelium* sp., *A. integer*, *D. oxleyanus*, *M. pajang*, *M. similis* are the main fruit species that can also be used as building component and tools. *S. wallichii*, *S. apiculata*, and *Cinnamomum parthenoxylon* are the non-fruit tree species that are maintained by local community as sources of building stuff.

Local community also uses many plant species of munaans as medicines and in ritual ceremonies. For example, inner bark of *L. domesticum* is used for curing malarial disease while inner bark of *Aleurites moluccana* is used for curing typhus. Young leaves, fruits and inflorescences of *Cocos nucifera and Areca catechu* are also used for ritual events. *Knema* spp. are used for making redeeming statues. Many species of shrubs, herbs, bamboo, palm, and lianas such as *Galearia fulva*, *Alpinia* sp., *Bambusa* spp., *Tetracera* spp., *N. biserrata*, *L. urceolata*, *Calamus* spp. and *D. grandis* are also used for ritual rite.

Table 6. Number of species belonging to different utilization categories in munaans of Benuaq and Tunjung ethnics in West Kutai, East Kalimantan, Indonesia

Plant utilization	Number of species			
	Munaan lou Mencimai		Munaan luuq Sekolaq Darat	
	Trees	Saplings and seedlings stage	Trees	Saplings and seedlings stage
Food	33	33	23	34
Firewood	28	15	10	17
Building materials	21	18	31	38
Medicine	10	12	6	34
Tools	12	14	17	32
Ritual ceremony	6	9	3	11
Honey tree	1	-	2	4
Others	4	13	5	7

The common fruit yielding trees in munaan lou of Mencimai was *L. domesticum*, *D. zibethinus*, *Nephelium* sp., *A. integer*, *Baccaurea macrocarpa*, *Baccaurea edulis*, *C. nucifera*, *N. lappaceum*, *Mangifera odorata* and the common non-fruit tree was *S. wallichii* (Figure 8). In munaan luuq of Sekolaq Darat, the common fruit trees were *L. domesticum*, *D. zibethinus*, *A. anisophyllus*, *A. integer*, *Nephelium uncinatum* and *B. macrocarpa* while *M. kalimantanensis*, *F. benjamina*, *C. decumanum* and *K. excelsa* were the common non-fruit trees. The fruit yielding species commonly present in both munaans were *L. domesticum*, *D. zibethinus*, *A. integer* and *B. macrocarpa*. According to Joshi et al. (2004) after a year of harvest, the rice fields are later allowed, with enrichment planting of fruit trees and rattan, to develop into simpukng (forest gardens) that are an important resource for the Benuaq Dayak for collecting fruits, medicines, timber, firewood, rattan and wildlife. The utilization of forest gardens has been an inherited practice by the sub-ethnic groups of Benuaq Dayak, Tunjung Dayak, and Kutai. These forest gardens, which can be developed in over-logged forest areas, support plants that are both suitable for the ecology of tropical forests in Kalimantan and have agroforestry business potential (Chaiphar et al. 2013).

In both traditional gardens, many of understorey non-tree species are used as medicinal plants and they have important role in curing the diseases in this region which still lack health facilities for a long time. Munaans are also suitable and good sites for the conservation of both medicinal and other plants, similar to the traditional gardens of India which act as conservation sites of medicinal plants (Bajpai et al. 2013).

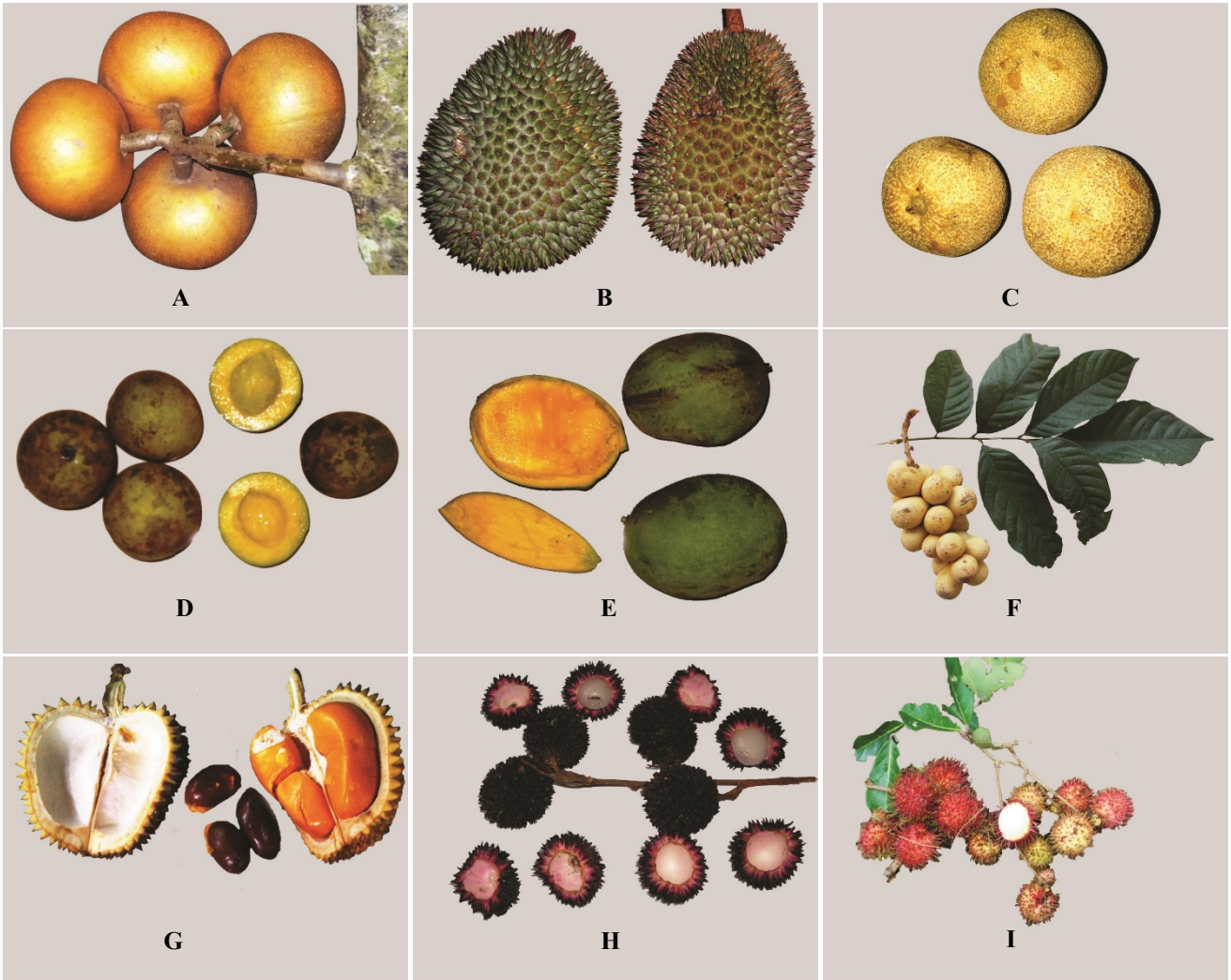

Figure 8. Common fruit yielding trees of munaans: A. Pasi (*Baccaurea macrocarpa)*, B. Durian (*Durio zibethinus*) C. Ruiq (*Baccaurea edulis)* D. Asam kuini (*Mangifera odorata*), E. Asam putar (*Mangifera torquenda*) F. Langsat (*Lansium domesticum*), G. Lai (*Durio kutejensis*), H. Semayap (*Nephelium ramboutan-ake*), I. Rambutan (*Nephelium lappaceum*)

Fruit species like durian (*Durio zibethinus*), lai (*Durio kutejensis*), ketungan (*Durio oxleyanus*), asam empelam (*Mangifera indica*), asam putar (*Mangifera torquenda*), asam kuini (*Mangifera odorata*), asam payang (*Mangifera pajang*), kapul (*Baccaurea macrocarpa*), ruiq (*Baccaurea edulis*), keliwatn (*Baccaurea pyriformis*), pepuaatn (*Artocarpus anisophyllus*), cempedak (*Artocarpus integer*), and several species of rambutans (*Nephelium* spp.) also serve as sources of economic income for local communities, besides serving as sources of food. Thus, the munaans contribute also to economic sustainability, in addition to subsistence needs of the local people.

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