# Inventory of Invasive Plant Species at Bukit Duabelas National Park and the Vicinity, Jambi, Sumatra

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## ABSTRACT

Sumatra, the Indonesia's second largest island, has the forest that harbor some world's highest biodiversity. However, the Sumatran forest have been largely replaced by plantation development i.e. acacia, rubber and oil palm plantation. Exploitation of resources will enhance the development of plant species which are potentially invasive. Bukit Duabelas National Park is one of the remaining forest in the lowlands of Sumatra which has to be conserved. Illegal logging and conversion of the surrounding areas into rubber and oil palm plantations might lead to an increase invasive plant species in the forest. The inventory of invasive plant species in Jambi is necessary as an initial step for further studies. Exploration and sample collections were carried out in the permanent plots of the Collaborative Research Center 990 EFForTS in each of the land-use type, natural forest, jungle rubber, rubber plantation, oil palm plantation, and in surrounding areas. There are 76 invasive plant species belongs to 64 genera and 30 families identified. High risk of invasive plant species infestation was found at the disturbed areas. Oil palm plantation (28 sp.) and rubber plantation (27 sp.) had higher number of invasive plant species compared to jungle rubber (10 sp.). In terms of species abundance, *Clidemia hirta* and *Dicranopteris linearis* were found to be far more invasive. Invasive plant species was not found in the natural forest plots. The invasive plant species cannot reach the forest interior where the canopy cover is still relatively intact.
Keywords: Bukit Duabelas National Park, *Clidemia hirta*, *Dicranopteris linearis,* invasive plant species

## INTRODUCTION

Invasive plants are generally defined as floras that live outside their natural habitat, and able to dominate the vegetation in new habitats. It usually has no natural enemies and inflicted negative impact on local species, habitat, and human interests (Wijanarko 2001; Radosevich *et al*. 2007). Invasive plants constitute one of the most serious environmental issues facing Indonesia. They disrupt ecosystems by altering physical processes, displacing native plants, and degrading wildlife habitat (Cal-IPC 2006).

Sumatra, the Indonesia's second largest island, has the forest that harbored some world's highest biodiversity. However, the Sumatran forest have been largely replaced by plantation development i.e. acacia, rubber and oil palm plantation. Approximately 12.5 million hectares or 49% of the total area of forest in Sumatra disappeared within a period of a quarter century (1985-2009) (WWF 2010). Jambi province was the third largest of forest loss occurred in Sumatra with 13.4% of the total area of forest loss over period of 1985 – 2009. According to Sanderson *et al*. (2012), exploitation of resources will enhance the development of the alien plant species which potentially invasive. In addition, this biological invasion is also supported by human activities, for

example people introduce nonindigenous species through gardening, horticulture, and traffic (Yang and Nakagoshi 2004).

In 2005, an inventory of the invasive alien plant species in Indonesia was conducted based on the existing references and herbarium (Tjitrosoedirdjo 2005). There are 1936 alien plant species found in Indonesia which belongs to 187 families and 17% among that number are recognized as an invasive species. The inventory of invasive plant species in Jambi are also necessary as an initial step for further studies. The inventory of invasive species is fundamental importance and has been given high priority in the research field of ecological invasions.

## MATERIALS AND METHODS

### Study Site

The study was carried out at Bukit Duabelas on four different ecosystem types and the vicinity of Jambi Province, Sumatra. The research locations was located at Bukit Duabelas National Park and at three different villages, i.e. Dusun Baru, Lubuk Kepayang, and Pauh. The fourth ecosystem types were lowland rain forest, jungle rubber, rubber plantation, and oil palm plantation. The locations of each ecosystems followed the permanent plots of EFForTS project (Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems, http://www.uni-goettingen.de/crc990) measuring 50 m × 50 m with 2 replications for each ecosystems, in total of 8 permanent plots were studied.

### Exploration and Collection of Invasive Plant Species

Exploration and sample collection were conducted inside the plots and their vicinity such as along roadside of forest, jungle rubber, rubber and oil palm plantations, and residential area. The specimens that has been collected covering the whole plants of grasses and small herbs, their respective flower buds and seeds of the plants, fertile and sterile fronds of fern and some field notes on the locality information and details of appearance of the plant in the field. These data were important for identification purposes. Herbarium specimens were identified at the Herbarium BIOTROP, and Herbarium Bogoriense, Bogor, Indonesia. Each species was then classified into its family name, habitus types (herbs, liana, shrubs, trees), and their invasiveness status according to some invasive species database, such as invasive alien plant species in Indonesia database by BIOTROP, Invasive Species Specialist Group database (ISSG database), the Global Compendium of Weeds (GCW), and some references.

## RESULTS AND DISCUSSIONS

### The Diversity of Invasive Plants Species

There are a total of 76 invasive plants species at Bukit Duabelas plots and surrounding area which belongs to 64 genera and 30 families. The highest number is found in Poaceae (15 species), followed by Asteraceae (11 species), and Euphorbiaceae (5 species). The remaining families consist of one to four species (Figure 1). Germer (2003) reported that Asteraceae, Rubiaceae, and Euphorbiaceae were the richest families of weeds that grow in association with oil palm plantation in West Sumatra. Another publication revealed that Poaceae is the highest family of weeds in Indonesia, followed by Asteraceae, Cyperaceae, and Euphorbiaceae (Tjitrosoedirdjo 2005).

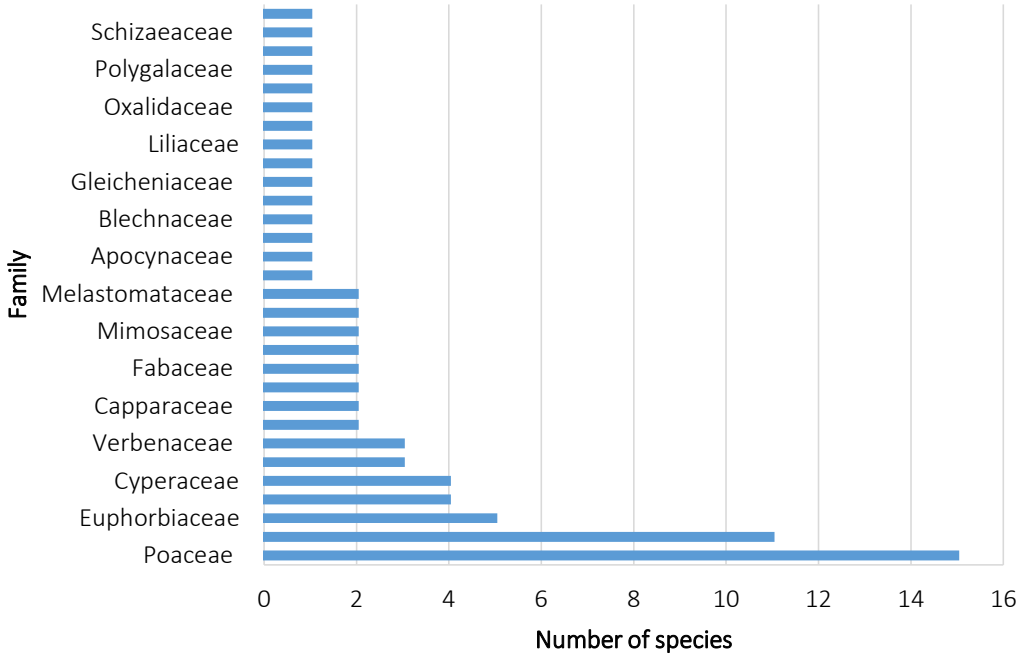


Figure 1. Species number of invasive plant species at Bukit Duabelas, Jambi, Sumatra

Poaceae and Asteraceae are the largest plant families which distributed worldwide. The families are dispersed via generative and vegetative reproduction. They can grow from viable seeds or rhizome as commonly occur in Poaceae family. The Poaceae family has been reported producing the allelopathic substances as phenolic acids, hydroxamic acids, alkaloids, and quinones. The plant parts which contains those allelopathic compound could be located in the grains, pollen, root exudates residues, decomposing straw, etc. (Moreiras *et.al.* 2004). The allelopathic compound of the related invasive plant species are able to inhibit the germination and the growth of other vegetation (Wentwoth 2013). Whereas, Asteraceae family were widely distributed by its seeds which has pappus or other morphological adaptations for long distance dispersal. So it is possible to spread the seeds by wind and water.

The number of invasive plant species was varied on each location. The invasive plant species were found in the jungle rubber, rubber and oil palm plantation plots, and their surrounding areas. However, invasive plant species were not found in the inside of natural forest plots (Figure 2). It might be influence by the high canopy cover in the forest, so the lights penetration is low, and air temperature under the trees became low. This condition might not suitable for the invasive plant species growth. Junaedi and Dodo (2014) revealed that most of invasive plant species cannot reach the forest interior where the canopy cover is still relatively intact.

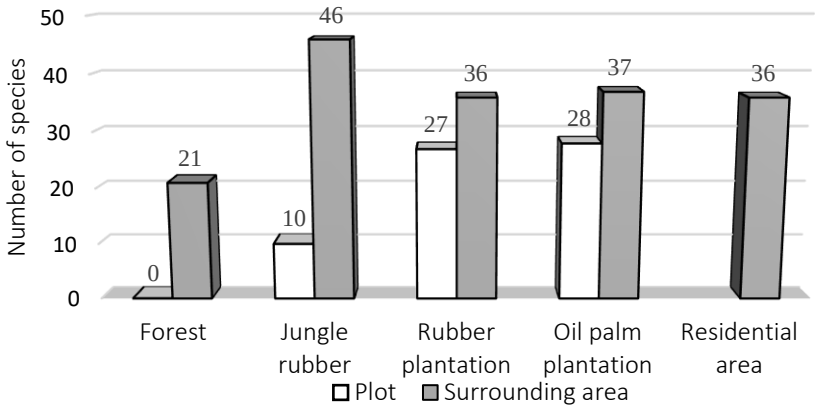


Figure 2. Number of invasive species found in the fourth ecosystems type: lowland forest (BF), jungle rubber, rubber monoculture plantation, oil palm monoculture plantation, and their surrounding area including residential area

High risk of invasive plant species infestations found at the disturbed areas and open areas. Surrounding areas has the high number of invasive plant species compared with the number of species in the plots. In the surrounding area of Bukit Duabelas, the highest number of invasive plant species were found at surrounding area of jungle rubber (46 species), followed by surrounding area of oil palm plantation, rubber plantation, residential area, and lowland rain forest with the number of species 37 species, 36 species, 36 species, and 21 species respectively (Figure 2). It is due to its soil fertility, and there is no weeding in jungle rubber and their surrounding areas. In this ecosystem type, rubber grew together with the secondary forest. According to Penot (2004), the advantages of this ecosystem type are no cost, no labor required, and it conserve soil fertility, and enable the renewal of the system every 30 or 40 years. However, there were 21 invasive species at the surrounding area of forest. These potentially invasive and harmful plant species should always be monitored.

### Origin of the Invasive Plant Species

A plant species maybe native or alien. Native species is one that is naturally found in a given ecosystem, with no human intervention. Whereas, an alien or non-native species is one which has been introduced by human action, deliberately or accidentally, into an area in which it was not naturally there. Both native and non-native plants species can be invasive (Booth *et.al.* 2010). As many as 23 species (30%) of invasive plants were recognized as native plant species and 53 species (70%) as alien plant species. Most of the alien species were originated from America (32 species). Seven species came from Asia, 4 species came from Africa, but the origin of 3 species are not known yet, and the rest of the species has a wide origin (Figure 3).

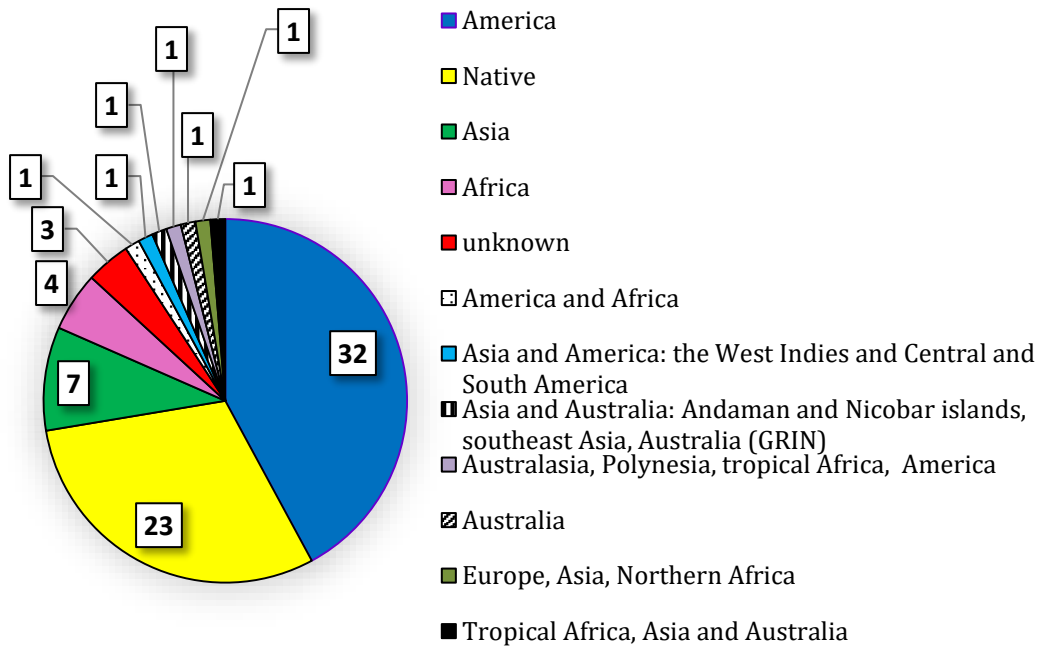


Figure 3. The origin of invasive plant species found at Bukit Duabelas, Jambi, Sumatra

The plant species originating from another country invade the study area at Bukit Duabelas and vicinity, as the alien plant species adapted to local settings. Disturbances in the ecosystem provide an opportunity for the expansion of invasive alien plant species (Raghubanshi and Tripathi 2009). Rubber and oil palm plantation development is one of the main factors causing disturbances in the ecosystem of Sumatra. According to Catford *et.al.* (2009), the successful of invasive plant species to invade novel areas might be due to a combination of propagule pressure (the number of individual introduced, genetic diversity of the plant, seedling competition), biotic characteristics (allelophatic compound, life form, time of flowering), and abiotic characteristics (light, moisture, soil pH, nutrients) with the additional influence of human.

## The Important Invasive Plant Species

The Important Value Index (IVI) of the invasive plant species was generally low (Table 1). *Clidemia hirta* was the most dominant species in jungle rubber (IVI = 34.23%) followed by *Dicranopteris linearis* (IVI=28.84%), and *Tetracera indica* (14.05%). *Clidemia hirta* (45.76%) was also the most dominant species in oil palm plantation followed by *Asystasia gangetica* subsp. *Micrantha* (11.76%), and *Dicranopteris linearis* (11.25%). In rubber plantation, the most dominant species was *Dicranopteris linearis* (17.45%), followed by *Scleria ciliaris* (8.23%), and *Stenochlaena palustris* (7.78%). These IVI values were summed up from the percentage values of relative frequency and relative dominance of each species. The low IVI values could be due to the sharing of resource spaces to minimize interactions among the species and to facilitate access to resources (Essandoh 2011). The low IVI values could also be due to so many different species on the ecosystem type.

Table 1. Important Value Index (IVI) of invasive plant species at Bukit Duabelas plots

| No. | Species | IVI | | | |
|---|---|---|---|---|---|
| | | Forest | Jungle Rubber | Rubber Plantation | Oil Palm Plantation |
| 1 | *Ageratum conyzoides* | 0.00 | 0.00 | 2.63 | 2.75 |
| 2 | *Asystasia gangetica* subsp. *Micrantha* | 0.00 | 0.00 | 2.64 | 11.76 |
| 3 | *Axonopus compressus* | 0.00 | 0.00 | 5.53 | 7.83 |
| 4 | *Borreria alata* | 0.00 | 0.00 | 5.38 | 3.16 |
| 5 | *Borreria laevis* | 0.00 | 0.00 | 2.94 | 0.00 |
| 6 | *Breynia stipitata* | 0.00 | 0.00 | 5.36 | 4.94 |
| 7 | *Bridelia insulana* | 0.00 | 0.00 | 2.65 | 2.48 |
| 8 | *Centhoteca lappacea* | 0.00 | 6.81 | 5.41 | 8.05 |
| 9 | *Chromolaena odorata* | 0.00 | 2.45 | 0.00 | 0.00 |
| 10 | *Clidemia hirta* | 0.00 | 34.23 | 7.30 | 45.76 |
| 11 | *Cyperus difformis* | 0.00 | 0.00 | 2.64 | 0.00 |
| 12 | *Cyrtococcum acrescens* | 0.00 | 0.00 | 2.66 | 0.00 |
| 13 | *Cyrtococcum patens* | 0.00 | 0.00 | 7.47 | 0.00 |
| 14 | *Cyrtococcum trigonum* | 0.00 | 9.94 | 2.65 | 0.00 |
| 15 | *Dianella ensiflora* | 0.00 | 0.00 | 2.65 | 0.00 |
| 16 | *Dicranopteris linearis* | 0.00 | 28.84 | 17.45 | 11.25 |
| 17 | *Fimbristylis dura* | 0.00 | 0.00 | 2.64 | 0.00 |
| 18 | *Imperata cylindrical* | 0.00 | 0.00 | 6.46 | 3.44 |
| 19 | *Lantana camara* | 0.00 | 0.00 | 0.00 | 2.95 |
| 20 | *Lygodium flexuosum* | 0.00 | 6.38 | 0.00 | 5.46 |
| 21 | *Macaranga bancana* | 0.00 | 0.00 | 2.78 | 0.00 |
| 22 | *Melastoma malabathricum* | 0.00 | 12.62 | 5.47 | 6.70 |
| 23 | *Mikania micrantha* | 0.00 | 0.00 | 0.00 | 3.11 |
| 24 | *Mussaenda frondosa* | 0.00 | 0.00 | 2.64 | 2.73 |
| 25 | *Oplismenus compositus* | 0.00 | 6.57 | 0.00 | 0.00 |
| 26 | *Ottochloa nodosa* | 0.00 | 0.00 | 0.00 | 6.69 |
| 27 | *Paspalum conjugatum* | 0.00 | 0.00 | 2.67 | 0.00 |
| 28 | *Paspalum dilatatum* | 0.00 | 0.00 | 5.51 | 5.81 |
| 29 | *Pennisetum polistachyon* | 0.00 | 0.00 | 0.00 | 2.48 |
| 30 | *Polygala paniculata* | 0.00 | 0.00 | 0.00 | 2.45 |
| 31 | *Scleria ciliaris* | 0.00 | 13.18 | 8.23 | 7.35 |
| 32 | *Sporobolus diander* | 0.00 | 0.00 | 0.00 | 2.46 |
| 33 | *Stachytarpheta indica* | 0.00 | 0.00 | 0.00 | 3.00 |
| 34 | *Stachytarpheta jamaicensis* | 0.00 | 0.00 | 0.00 | 5.46 |
| 35 | *Stenochlaena palustris* | 0.00 | 0.00 | 7.78 | 2.45 |
| 36 | *Taenitis blechnoides* | 0.00 | 12.79 | 5.41 | 5.74 |
| 37 | *Tetracera scandens* | 0.00 | 0.00 | 2.77 | 0.00 |
| 38 | *Tetracera indica* | 0.00 | 14.05 | 0.00 | 0.00 |
| 39 | *Uncaria cordata* | 0.00 | 0.00 | 2.70 | 2.56 |
| 40 | *Urena lobata* | 0.00 | 0.00 | 2.65 | 2.58 |
| | Total | 0.00 | 147.85 | 133.08 | 171.40 |

Notes: The species with the highest IVI are highlighted in red. These data has been used on the other paper (Wahyuni *et.al.* in press.).

Table 2. List of important invasive plant species at Bukit Duabelas plots area, including lowland rain forest of Bukit Duabelas National Park, jungle rubber, rubber and oil palm plantation

| No. | Species | Family | Origin |
|---|---|---|---|
| 1 | *Clidemia hirta* | Melastomataceae | Tropical, Central, and South America |
| 2 | *Dicranopteris linearis* | Gleicheniaceae | Native to Indonesia |
| 3 | *Asystasia gangetica* subspecies *micrantha* | Acanthaceae | Africa and Asia (India, Malaysia) |
| 4 | *Scleria ciliaris* | Poaceae | Native to Indonesia |
| 5 | *Stenochlaena palustris* | Blechnaceae | Native to Indonesia |
| 6 | *Tetracera indica* | Dilleniaceae | Native to Indonesia |

There were six important invasive plant species based on the IVI values (Table 2). *Clidemia hirta* and *Dicranopteris linearis* were the dominant species in the related ecosystem followed by *Asystasia gangetica* subspecies *micrantha*, *Scleria ciliaris, Stenochlaena palustris,* and *Tetracera indica*. Two species among them are recognized as alien species i.e. *Clidemia hirta* and *Asystasia gangetica* subspecies *micrantha*. However, the fourth remaining species are native species. According to Booth *et.al.* (2010), invasive plant species is not always the introduced species but the native species also could become invasive. Colautti and MacIsaac (2004) defined invasive species as a native or non-native species that has colonized natural habitats and has a negative effect on a habitat.

*Clidemia hirta* is an alien species native to humid tropical, central, and South America (Gerlach 2006). This species firstly planted in some botanic garden around the world (Dawson *et.al.* 2008) such as Perediniya-Srilanka in 1894, Amani-Tanzania in 1930, and Wahiana-Hawai in 1941. Backer and Bakhuizen van den Brink (1963) reported that *C. hirta* was widely naturalized in Central and West Java, and then was widely distributed throughout the tropics (Dawson *et.al.* 2008). This species was also included in the list of 100 of the world's worst invasive alien species (Lowe *et.al.* 2000).

Disturbance is a key element in the establishment and invasion of *C. hirta*. In its native environment, the species tends to grow in open areas and only become dominant about twelve months after disturbance, such as in slash-and-burn agricultural areas (Gerlach 2006). The population of *C. hirta* in Bukit Duabelas areas was abundant in the jungle rubber and oil palm plantation plots, along the plantations pathway, and along the trail leading to the forest plots. In addition, it has edible fruit for birds and animals that will aid the dispersal and establishment of *C. hirta* (Dawson 2008).

Another alien plant species, *Asystasia gangetica* subspecies *micrantha* is native to Africa that has been naturalized in several regions of Paleotropics (Luján *et.al*. 2011). It is a major weed in Indonesia, Malaysia, and the Pacific Islands. It infests oil palm and rubber plantations at Bukit Duabelas plots. This species competes for soil nutrients, reduces crops productivity, and increases crop management costs (Anon 2003). It also becomes an agricultural weed in Australia.

*Asystasia gangetica* subspecies *micrantha* as an invasive alien plants species, it smothers other ground plants, and displaces vegetation. Further effect of this species, it reduces the availability of habitat for native plants and animals and therefore reduce biodiversity (Anon 2003). This species forms creeping mat that grows rapidly, up to 0.5 m high alone, but up to 3 m high on supporting vegetation (Anon 2003). In addition, the spread of this species could happen via seed mixing with imported landscape plant seedling (Hsu *et.al.* 2005).

The native plants species could also become an invasive species. There are four important invasive plant species which are native to Indonesia i.e. *Dicranopteris linearis, Scleria ciliaris, Stenochlaena palustris,* and *Tetracera indica*. Two species among them are ferns group (*D. linearis* and *S. palustris*) which are problematic weed at the agricultural land (RRIM 1963, Chong and Ismail 2006, Pribadi and Anggraeni 2011). *D. linearis* is a robust fern, forms dense thickets up to 3 m high, and it can survive well in poor soil condition. This species is commonly occurring on disturbed and eroded areas. It is effectively build a large mat so that no seedlings of other species can be established (Farrér and Hertach 2009). They like to grow at the wet habitat, open canopy site on low fertility soil (Russel *et.al.* 1998). This species was reported as an acid soil indicator (Kong 2003). The study area is covered by yellow podzolic soil which contain an acid soil. The presence of *D. linearis* were relatively abundant inside the jungle rubber plots, and along the trails besides the plantation estates at Bukit Duabelas and surrounding area. It was also reported as the dominant species which interfered the Samosir Botanic Garden at North Sumatra (Hartini 2010). In contrast to *D. linearis* which found at almost all the ecosystem types, *S. palustris* was found only inside the rubber and oil palm plantation plots at Bukit Duabelas area. *S. palustris* rarely occurred along the trails. It is reported as an important weed at *Acacia crassicarpa* plantation (Pribadi and Anggraeni 2010) and sago plantation (Rahado and Riry 2012). This is a common fern of open wet grounds but never found in shady forests, and even forming thickets (Wee 2015).

*Scleria ciliaris* is a native species which reported as an important weed at rubber plantations and difficult to control (Tjitrosoedirdjo 1995). This species had been found inside the rubber and oil palm plantation plots at Bukit Duabelas, but its coverage is not significantly high. *S. ciliaris* was found relatively abundant along the trails besides the oil palm plantations. According to Bryson and Carter (2008), Cyperaceae is a large, diverse, cosmopolitan family, and many of its species are distributed by human activities, such as the seeds are transported with vehicles, and it can attach to human cloths and shoes.

One more important native species is *Tetracera indica*. It is reported as weeds at rubber plantation (Supawan & Hariyadi 2014). This species is difficult to control by systemic herbicide because it has trichomes on its leaf and has very strong wooden climber shoot (Supawan & Hariyadi 2014). In Bukit Duabelas, *T. indica* had been found at the jungle rubber area with IVI values of 14.05% which is relatively high compared with the other invasive plant species.

## CONCLUSIONS

Seventy six invasive plant species which belongs to 64 genera and 30 families were identified from four different ecosystem types at Bukit Duabelas and the vicinity of Jambi Province, Sumatra. The most diverse of the families were Poaceae and Asteraceae. High risk of invasive species infestation found at the disturbed areas. Oil palm plantation (28 sp) and rubber plantation (27 sp) had higher number of invasive plant species compared with jungle rubber (10 sp). Invasive plant species was not found in the natural forest plots. The invasive plant species cannot reach the forest interior where the canopy cover is still relatively intact. There are six important invasive plant species based on the IVI values i.e. *C. hirta, D. linearis, A. gangetica* subspecies *micrantha, S. ciliaris, S. palustris,* and *T. indica.* In terms of abundance, *C. hirta* and *D. linearis* were found to be far more invasive.

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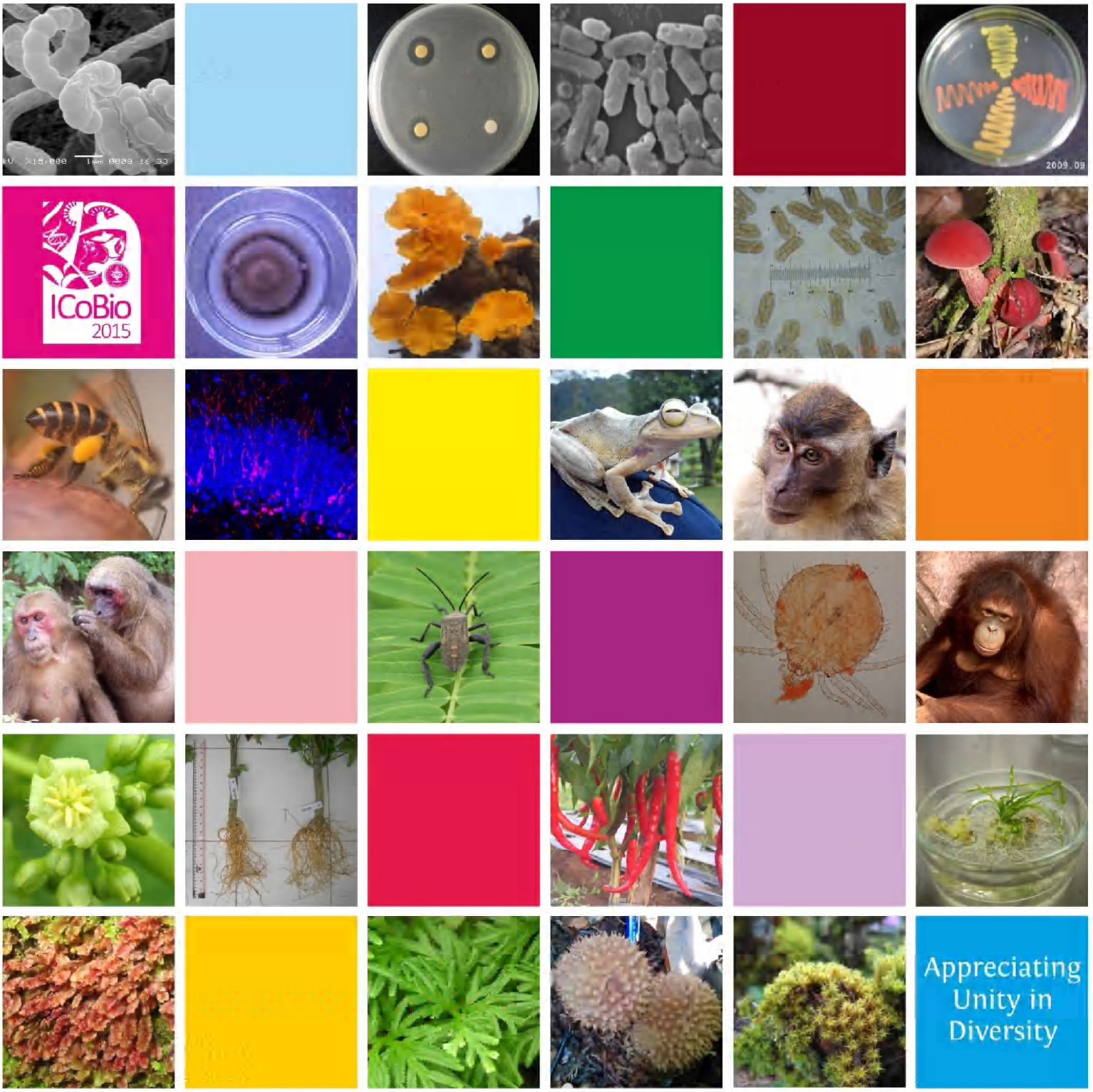


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# Foreword

International Conference on Biosciences, ICoBio 2015, took place in Bogor, Indonesia, on August 5-7, 2015. The ICoBio 2015 have the theme of "Appreciating Unity in Diversity". This conference is intended to gain insight into current trends in research and teaching related to biology, such as interdisciplinary approaches that are important for understanding the biology and its applications. Moreover, to encourage the formation of networks between biologists and relevant stakeholders to accelerate our efforts to understand the biological phenomena and their applications.

The ICoBio 2015 is attended by more than 200 participants from several countries including Japan, Malaysia, India, Pakistan, Germany, Thailand, and Indonesia. The conference is the first international conference organized by the Department of Biology, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, Indonesia and is expected to serve as an initial step to be held continuously every two years (bianually). This activity is also the first step in the framework of collaboration between the Faculty of Mathematics and Natural Sciences (especially Department of Biology) Bogor Agricultural University, Indonesia with the Faculty of Science, Kasetsart University, Thailand.

One of the activities in this conference is the preparation of the proceeding. We received 9 keynote papers and more than hundred papers from oral presentations, workshops, and poster presentations. To collect paper we communicate with the authors and reviewers. One paper was reviewed by a competent reviewer. Reviewers provide comments and further authors revise his/her paper and return it to the editor of this proceeding. Therefore we highly indebted and appreciated to the reviewers who have taken the time, energy, and experience to review the papers.

Finally, there are the 16 accepted papers from oral presentations published in this book. Their topics cover a wide range of biosciences. In the conference, they presented the papers in the main four groups focusing on Biodiversity, ecology, and evolution (group 1); physiological, developmental, and behavioral sciences (group 2); Molecular biology, biotechnology, and omic technology (group 3); and Applied and interdisciplinary biology (group 4).

We do hope that this proceeding will provide you, the reader, the opportunity to get acquainted in greater detail with the ideas and results of the conference participants and also, perhaps, to recall some of the friendly and inspiring atmosphere of ICoBio 2015.

Bogor-Indonesia, August 24, 2015

Prof. Aris Tri Wahyudi
Conference Chairperson

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The International Conference on Biosciences (ICoBio) 2015

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