The Occurrence of Fault Bars in Birds in the Harapan Rainforest and Bukit Duabelas National Park Landscapes, Jambi, Indonesia

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ABSTRACT

Birds react differently to adapt to land-use changes. One of the reactions is the formation of fault bars, which is a malformation during feather growth. Fault bars in birds' feathers may be used as indicator of environmental quality. This study examines the occurrence of fault bars in four different land uses in Jambi Province, Sumatra: secondary forest, jungle rubber, rubber plantation and oil palm plantation. Mistnetting was conducted during April-June 2014 in regions near to the Harapan Rainforest Landscape and the Bukit Duabelas National Park. A total of 90 and 145 birds were caught and examined for fault bars in Harapan Rainforest Landscape and Bukit Duabelas National Park Landscape, respectively. In the Harapan Rainforest Landscape, the highest occurrence of fault bars (score 3) was found in the secondary forest (53.5%) and oil palm (50%), whereas in Bukit Duabelas National Park Landscape, the highest occurrence of fault bars (score 3) was found in rubber plantation (43.8%) and oil palm (39.2%). There was no significant difference in the number of fault bars score between Harapan Rainforest Landscape and Bukit Duabelas National Park landscape ($df= 30$; $t = - 1.398$; $p>0.05$), however there is difference between the numbers fault bars in birds in four habitat in Bukit Duabelas National Park Landscape ($F = 2.67$, $p>0.05$. Further research about the fault bars along with habitat analysis is needed to determine the effect of habitat to the birds in depth.

Key words: birds, fault bars, land-use change, Jambi

INTRODUCTION

Sumatra Island is one picture of the wealth of tropical areas of Asia with the lush rainforest that support biodiversity, but the population growth over the years resulting in increased demand for land for agriculture, housing, recreational facilities, timber extraction and conversion to oil palm and pulp-wood plantations (Holmes and Rombang 2001; de Kok 2015). Destruction and fragmentation of habitats are major factors in the global decline of populations and species (Bennett and Saunders 2010). The species richness of understorey insectivores often declines rapidly following logging as birds move away into more favourable habitat. Recolonization can be fairly rapid however under some conditions it may take considerable lengths of time (Johns 1997).

About 70% of the mammal and bird species found in the Sunda Region are dependent on more or less intact primary lowland forest, and the effects of disturbance by forest clearance affected in several ways: the noise and shock of disturbance may cause immediate change in behavior; the removal of parts of the forest canopy alters ranging patterns and diet, which may in turn affect

social behavior and population dynamics; finally the slow regeneration rate may cause permanent changes in population density (Whitten *et al* 1987).

Birds have the ability to serve as bio-indicators, because they detect changes in the environment that cannot be observed or predicted (physical or chemical parameters) and they can be used to monitor biological parameters (Koskimies 1989; Crick 2004). The condition of bird feathers can serve as an indicator of their health and feather damage can be seen directly, such as dry, scaly skin, broken feathers, and the occurrence of fault bars, the feather color, and the presence of parasites such as ticks, bacteria or fungi (Friend and Franson 1999; Gill 2007).

The study of birds can reveal the quality of their habitat, such as the environmental factors that influence the populations and behavior. Bird species vary considerably in their breadth of response to food or needs for nest sites or cover. As a basic requirement for survival, forest birds use a variety of spatial to select habitats for nesting, foraging, and cover, even in the patch types. (Kaputska *et al* 2004; Sutherland and Green 2005).

The proportion of the local avifauna using degraded areas may depend on factors such as the disturbance history in addition to the quality and quantity of the remaining forest habitat. Further, the long-term viability of forest bird populations remains uncertain, as it is unclear whether they are able to maintain reproductive and viable populations in degraded areas. With devastating deforestation now unfolding in most tropical regions, it is becoming increasingly important to understand what proportion of forest biota are retained in different deforested areas, and how these species adapt to disturbance and fragmentation (Sodhi, *et al* 2005).

Fragmentation of forest ecosystems without complete removal – as occurs through selective logging or when shifting cultivation encroaches on a rainforest remnant – also creates stress for the animals which are removed or displaced. Habitat loss means a declining geographical range for each species, as well as an increased competition for food and other resources in the remaining suitable areas (Park 1992).

Fault bars are an abnormality in feathers which is common in birds (Riddle 1908). Fault bars are narrow lines and are translucent, situated almost perpendicularly to the main stem feathers. They are produced by some barbules as a result of a time variation in the deposition of keratin during feather growth (Murphy et al 1989). Fault bars are found in the line of feather growth and development and their existence can be the result of stressors that can occur within seconds (escape from predators), minutes (territorial fights), hours (intense storm), days (parasite infection) or more (Jovani and Real 2012).

Food-related stress has been evoked commonly as the probable cause of fault bars. The others stressor that can induce fault bars in growing feathers are starvation, poor nutrition, environmental changes, dehydration, overheating, escapes from predators, territorial fight, storm, parasite (Bortolotti *et al* 2002; Sodhi *et al* 2005; Serrano and Jovani 2005; Møller *et al* 2009; Jovani *et al* 2014)

Individual birds may be caught and marked in capture-recapture method in order to estimate species composition, to investigate habitat selection, relative abundance, population size, to calculate survival rates, and to measure the reproductive success of individual birds using mist nets. In addition to these data, information about the physiological and biological condition can be obtained (Bibby *et al* 1992; Dunn and Ralph 2004). The occurrence of fault bars can serve as one environmental indicator that shows changes in habitat and indicates how these changes affect the bird communities in it.

The purpose of this study was to determine the bird community composition and whether there are any differences in the occurrence of fault bars between four habitats: secondary forest, jungle rubber, rubber plantations and oil palm plantations.

MATERIALS AND METHODS

Mist netting was conducted in the Harapan Rainforest landscape from 24April 2014 to 20 May 2014 and in Bukit Dua belas National Park landscape from 26 May 2014 to 21 June 2014 (Figure 1). We used mist nets with 19 mm and 30 mm mesh size to capture small to medium-sized understory birds. These nets have a height of 3.0 – 3.2 m and were set up 0.1 – 1.0 m above the ground, depending on the site conditions (slope, ground vegetation). The two 6 m nets with 19 mm mesh size, two 18 m-nets with 30 mm mesh size and five 12 m-nets with either 19 mm or 30 mm mesh size (in total 108 m net length) were combined. We opened the mist nets at sunrise (approximately 6 AM) and closed them before sunset (approximately 5 PM), to avoid nocturnal birds or bats. During daytime, we closed the nets during rainfall or when temperatures were too high during the middle of the day to avoid bird mortality.

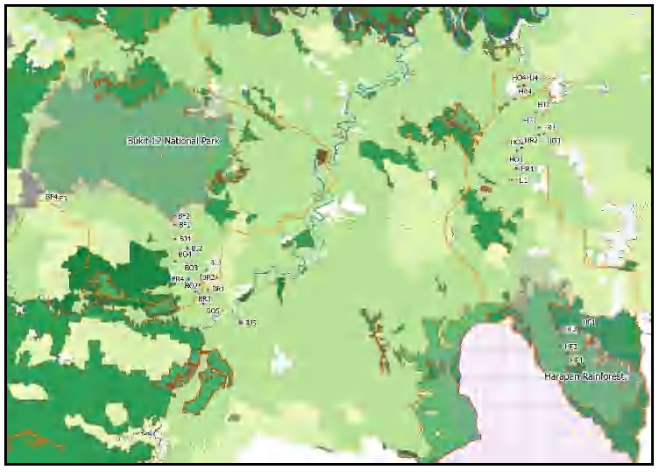

Figure 1. Map of data collection in Harapan Rainforest Landscapes and Bukit Duabelas National Park Landscapes

Data collection at each plot took place over a two-day period. Nets were checked every hour to reduce stress for the birds and to avoid birds becoming more entangled with time. We extracted the birds from the nets and put them into clean paper bags before we started our measurements. The first step was to identify the species (Robson 2002; MacKinnon and Phillipps 2010) and to measure the bird's tarsus diameter to apply a fitting bird ring with its individual ID number (bird rings provided by LIPI, the Indonesian Institute of Sciences). Next, we measured body mass to the nearest 0.5g using pesola spring balance, beak length to the nearest 0.1 mm using calipers, wing length, tail length and total length to the nearest 1 mm using ruler. . The occurrence of fault bars was determined by examining the 12 tail feathers. The presence of fault bars was scored 0 (no feathers in group have fault bars), 1 (one feather has fault bar), 2 (2-4 feathers have fault bars) and 3 (>4 feathers have fault bars) (Machmer *et al* 1991).

Shannon - Wiener diversity index (H') was calculated to assess bird diversity in each habitat. The difference between fault bar score of both landscapes was tested using a t-test and the difference between fault bar numbers in birds and habitat was tested using anova.

RESULTS

Bird Diversity

A total of 257 individuals of 57 species from 18 families were captured during the sampling at Harapan Rainforest and Bukit Duabelas landscapes. Nine (16 %) of the species we captured are considered as "Near Threatened" by IUCN and are legally protected by Indonesian Law (Peraturan Pemerintah 7 Tahun 1999). In Harapan Rainforest landscape we caught 101 individuals (in the net, escaped from the net and processed) from 39 species. In Bukit Duabelas National Park landscape we caught 156 individuals (in the net, escaped in the net and processed) from 40 species.

The capture rate was 12 individuals/1000 net hours with a recapture rate of 4.95% in Harapan Rainforest landscape and the capture rate in Bukit Duabelas National Park landscape was 18 individuals/1000 net hours with a recapture rate of 5.13%. The number of birds caught per net per day was 0.01 in Harapan Rainforest landscape and 0.02 in Bukit Duabelas National Park landscape. The most common species netted in Harapan Rainforest landscape were Emerald Dove *Chalcophaps indica* (14.9%), Little Spiderhunter *Arachnothera longirostra* (7.92%), Yellow-bellied Bulbul *Alophoixus phaeocephalus* (7.92%) and Crimson-breasted Flowerpecker *Prionochilus percussus* (5.94%) and in Bukit Duabelas National Park landscape were Emerald Dove *Chalcophaps indica* (21.29%), Little Spiderhunter *Arachnothera longirostra* (11.61%), Olive-winged Bulbul *Pycnonotus plumosus* (10.97%), and Yellow-vented Bulbul *Pycnonotus goiavier* (7.10%) . The least diverse families were Campephagidae and Cuculidae, each represented by a single species and individual. Shannon- Wiener (H') index showed in Harapan Rainforest landscape and Bukit Duabelas National Park landscape were medium (1≤H≤3) (Table 1).

Table 1. Shannon Wienner Index (H') in four transformation habitats in two landscapes

Landscape/Habitat	Secondary forest	Jungle Rubber	Rubber Plantation	Oil Palm Plantation
Harapan Rainforest	2.77	2.67	1.83	1.35
Bukit Dua Belas National Park	2.19	2.51	2.45	2.27

Bird's Fault Bars

A total of 409 fault bars were observed on the 90 individuals in Harapan Rainforest landscape and in Bukit Duabelas National Park landscape, 639 fault bars were observed on 145.

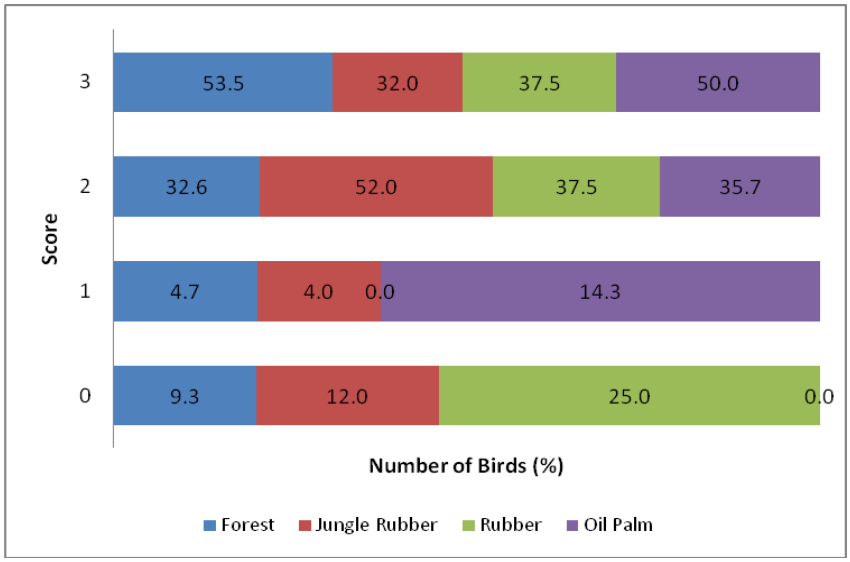

Figure 2. The proportion score of fault bars in four transformation habitats in Harapan RainForest Landscape

In Harapan Rainforest landscape, the fault bar score 3 (>4 feathers have fault bars) in secondary forest was the highest score (53,5%) followed in oil palm plantation habitat was 50% (Figure 2). The most common birds with the highest number of fault bars score in secondary forest was Little Spiderhunter *Arachnothera longirostra* and in oil palm plantation was Emerald Dove *Chalcophaps indica.* In Bukit Duabelas National Park landscape, the fault bar score 3 (>4 feathers have fault bars) was found in rubber plantation (43.8%) followed by oil palm plantation was 39.2% (Figure 3). The most common birds with the highest number of fault bars score in rubber plantation was Olive-winged Bulbul *Pycnonotus plumosus* and in oil palm plantation was Emerald Dove *Chalcophaps indica.*

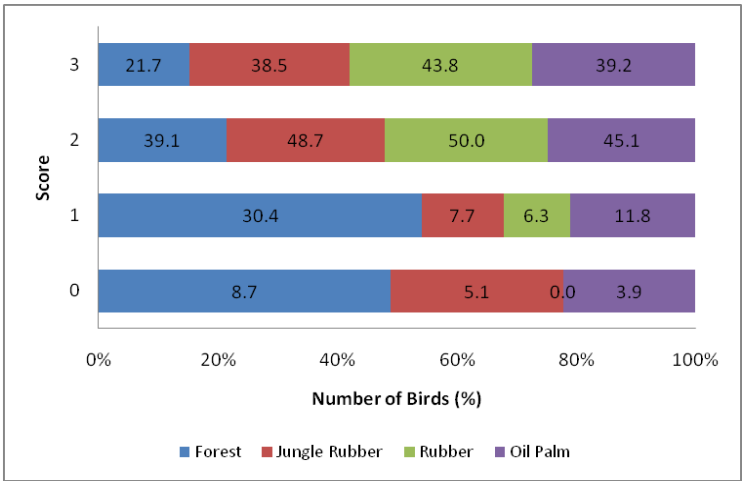

Figure 3. The proportion score of fault bars in four transformation habitats in Bukit Dua Belas National Park Landscape

The t-tested the difference between the fault bars score within Harapan Rainforest and Bukit Dua Belas National Park landscape (DF= 30; t = - 1.398; p>0.05) and concluded that there is no

significant difference between fault bars scores in the two landscapes. The anova tested showed no difference significance between the numbers of fault bars in birds and four habitat in Harapan Rainforest landscapes (F1.92 = 2.71, p>0.05), but there is difference between the numbers fault bars in four habitat in Bukit Duabelas National Park landscapes (F3.04 = 2.67, p>0.05). Continued test in Bukit Duabelas National Park showed the differences are between secondary forest with rubber plantation and secondary forest with oil palm plantation.

DISCUSSION

Bird Diversity

The species caught by mist netting were species that are adapted to flying in low or medium strata at height of only 3-4 meters. Mist netting is often a less efficient measure of species inventory than other methods like point counts and tends to under-sample or completely miss some species, such as aerial foraging swallows, raptors or hornbills (and all species dwelling up in the canopy). Nevertheless, it is a tool to determine what species are present in a study area and the composition of bird populations, because it detects more cryptic and ground-foraging (Dunn and Ralph 2004).

Table 1 shows that the diversity indices in Harapan Rainforest landscape and Bukit Duabelas National Park landscape wereThe high value of diversity in Harapan Rainforest was in secondary forest habitat (H'= 2.77) with 22 species and 45 individuals, while on Bukit Duabelas National Park was in jungle rubber habitat (H' = 2.51) with 16 species of 38 individuals. The species dominated in two landscapes was Emerald Dove. Recapture studies by Wells (1999 in Lin 2009), indicated that Emerald Dove usually makes local movements depending on availability of fallen fruit and competition from conspecifics but occasionally flies long distances of up to 800 km. A study by Lin (2009) in a semi-forested landscape in Singapore showed that the home ranges of the male and female from Emerald Dove were 24.1 ha and 23.1 ha.

Secondary forest in Harapan Rainforest landscape has the higher diversity index than other habitats; this habitat classified as a dry lowland dipterocarp forest with approximately 40% of this forest is high secondary forest, 25% medium secondary forest and 25% low secondary forest and 10% scrub and open ground (www.forestlandscaperestoration.org). This habitat still has a place for forest-interior birds for find the food, nest site or cover. Some forest-interior birds that we caught, White-rumped Shama *Copsychus pyrropygus*, Rufous-winged Philentoma *Philentoma pyrhopterum,* Asian paradise-flycatcher *Terpsiphone paradisi* are still needs the secondary habitat for their habitat.

In the Bukit Duabelas National Park landscape, the diversity index in jungle rubber and rubber plantation is higher than in secondary forest, presumably because the frequency of hunting activities in this area. Based on interviews with one of the national park staff, people from outside or from the surrounding national parks often enter to hunt animals and as the ranger office is too far, there is a lack of supervision from the national park staff. If species have a critical function, such as fruit-eating bats, birds and hornbills dispersing seeds, their reduction in number because of hunting may ultimately result in many extinctions (Robinson and Bennett 1999).

Bird's Fault Bars

Figure 1 showed that the score of 3 (> 4 feather have fault bars) found in secondary forest habitat by 53.5 % individuals and most species of fault bars was found on Little Spiderhunter. This species

is found in secondary forest and plantations, sips nectar from banana and ginger flowers and eats small invertebrates (MacKinnon and Phillipps 1993; Strange 2001). In the field, there were not many flowering trees or ginger flowers, so possibly there were no nectar resources for these birds and they had to compete with other birds. Hildebrandt's (2014) research showed that the food resource of the Little Spiderhunter was *Poales* sp from Poaceae, for example grass or bamboo in secondary habitat on Harapan Rainforest and Bukit Duabelas National Park landscape. But de Kok *et al. (*2015) explained that Poaceae are not dominant in Harapan Rainforest. Sodhi *et al* (2005) found that the adult Little Spiderhunter in secondary forests in Central Java had more fault bars, indicating that secondary forest habitat may have been lower in quality and resource availability, like lowest abundance of small-sized arthropods and the number of flowering tress for this species. Graph 2 showed that the score of 3 (> 4 feather have fault bars) found in rubber plantation habitat by 43.8 % individuals and most species of fault bars was found on Olive-winged Bulbul *Pycnonotus plumosus.* This species frequented forest edge, plantation, and secondary growth. The majority of Pycnonotids are essentially frugivores, eating berries, figs and a certain amount of arthropods, including beetles, orthopterans and even freshwater crabs (MacKinnon and Phillipps 1993; Strange 2001; del Hoyo *et al* 2005). This species consumes more fruits, during the sampling fruit trees were absent from rubber plantations, but some Harendong plant *Melastoma candidum could* be found.

In Bukit Duabelas National Park showed that there were differences between secondary forest with rubber plantation and secondary forest with oil palm plantation to the occurrence of fault bars. The numbers of feathers have fault bars in secondary forest were 64 feathers, in rubber plantation were 162 feathers and in oil palm plantation were 250 feathers. If we seen the numbers of feathers have fault bars showed that secondary forest in Bukit Duabelas National Park still give the canopy cover, greater small-sized arthropod, fruit compared with the others habitat. However, hunting activity has made this site inhospitable for some forest species. In rubber plantation the vegetation in ground not so many. Researched by Beukema *et al* (2007) showed terrestrial pteridophytes decrease in rubber plantation, epiphytic orchids were not found in any of the rubber plantation and epiphytic pteridophytes lower in rubber plantations. In oil palm plantation, the harvesting of oil palm plantation disturb the only place where animal could set up a permanent base and when disturbed, this species will fly to other trees (Whitten *et al* 1987). Researched by Bobo and Waltert (2011), the proportion of environmentally stressed birds might be higher in agricultural land, judged from the occurrence of fault bars and body weight. The fault bar parameter gradually increased with increasing habitat modification. Researched by Ross *et al* (2015), showed that there were fault bars in juvenile Grasshopper Sparrows's tail feathers when the storm hit.

CONCLUSION

The frequency of fault bars varied among species, habitat and landscapes. This result provide additional information in bird biology and conservation, but further research about the fault bars with habitat analysis is needed to determine the effect of habitat to the birds in depth.

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Index

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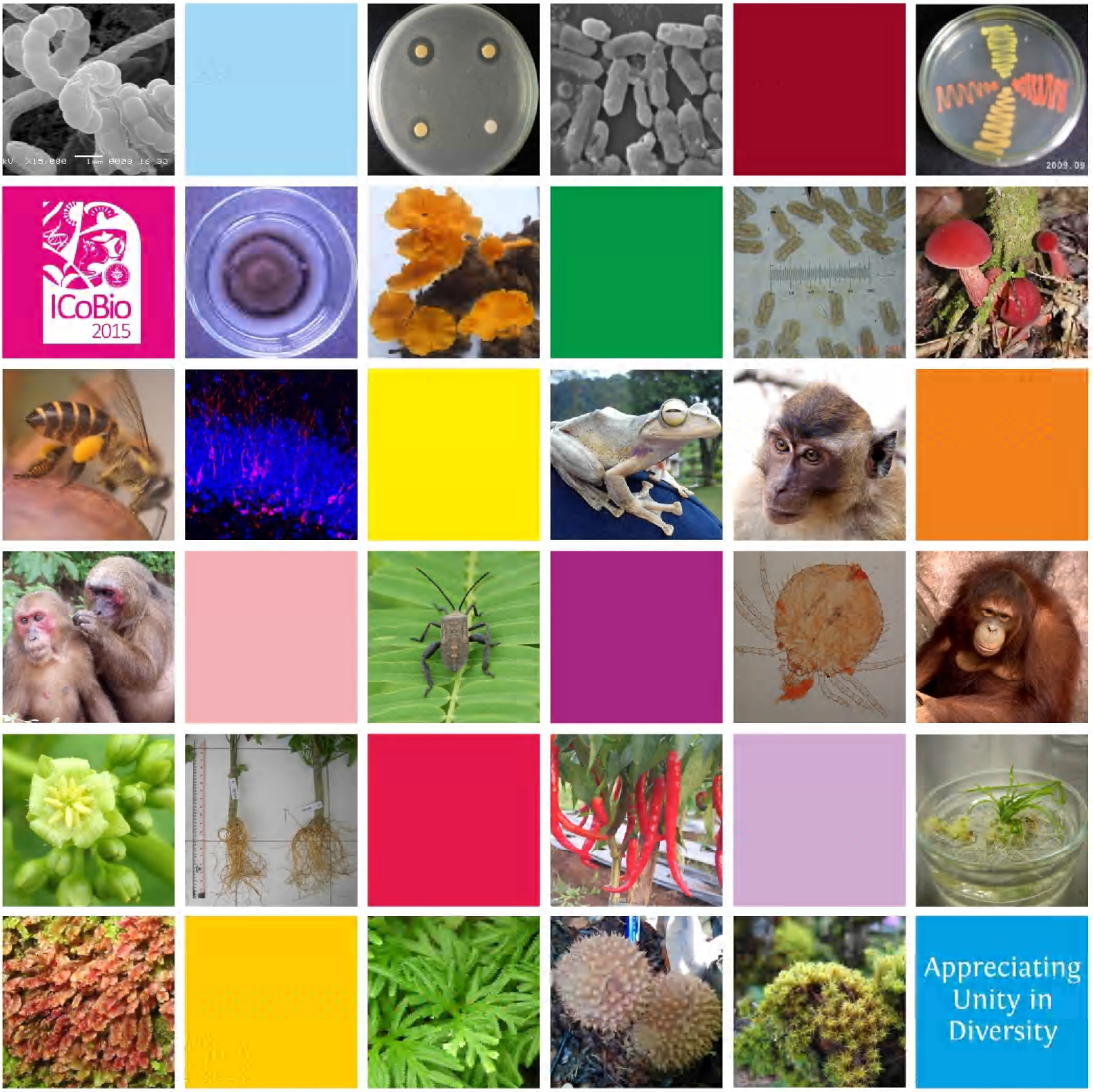

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Foreword

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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Table of Contents