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The role of frugivorous birds in the dispersal of shrubs in submontane zone of tropical forest, West Java, Indonesia

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Abstract. *Partasasmita R. 2015. The role of frugivorous birds in the dispersal of shrubs in submontane tropical forest, West Java, Indonesia. Nusantara Bioscience 7: 144-148*. Shrubs are widely distributed, from lowland to mountainous area. Submontane forest zone is one of many ecosystem types rich in many species of shrub. The success of plant growth and establishment depends on the role of the seed dispersal agents. This study of shrub seed dispersal by frugivorous birds has been conducted in tea plantation area of Panaruban, Subang, West Java. To get seeds trapped in feces, samples of feces were collected from birds trapped in mist nets and from fecal dropped count method. The study sites were tea plantation which had been neglected for five years and bush in a secondary forest nearby. The results showed that seeds of 7 species of shrub were found in the feces of six species of frugivorous birds trapped in mist nets and one species of bird from fecal dropped count method. Based on feces analysis, of the seven shrub species, *Clidemia hirta* was dispersed mostly by *Dicaeum trigonostigma*, and then by *Pycnonotus aurigaster*. *Sambucus javanica* was mostly dispersed by *Pycnonotus goiavier* and *Scissirostrum dubium*. The germination rate of seeds collected from feces was 1.43-5.71% higher than that of seeds which had not passed through the bird's digestive tract.

Keywords: birds, feces, seed dispersion, shrub

INTRODUCTION

Shrubs are widely distributed in various geographical areas, from lowland to mountainous land. Submontane is one of many ecosystem types rich in many species of shrub. The dispersal agents play significant roles in the success of dispersal and establishment of shrubs. Birds are important agent for shrub dispersal, especially those which have fruit and seed which cannot be dispersed by wind or water (Iskandar 2015; Fitriawan et al. 2015). The role of frugivorous birds in dispersing seeds is important in maintaining the stability and sustainability of nature (Partasasmita 2015). The frugivorous birds and fruit-bearing plants develop mutualism (Jordano 2000; Partasasmita 2009; 2011; Jarulis et al. 2015). In endozoochory, the success of seed dispersal is determined by three substantial processes, namely fruit production, dispersal by animals and germination rate of the dispersed seeds (Fukui 1995; Partasasmita 2009). The seed dispersal is done by frugivorous birds. In the secondary forest in Hongkong, 89% of shrub seed dispersal is done by birds (Corlett 1996).

In secondary tropical forest and subtropical shrubland, 85% of almost 200 species of flowering plants have their seeds dispersed by birds (Corlett 1996). Examples of the plants are *Lantana camara, Sapium discolor, Litsea* sp., *Ficus* spp., and *Dendrophthoe* spp. (Reid 1990). The families of birds which play role in pollination and seed dispersal of those plants are, among others, Nectariniidae, Anatidae, Columbidae, Turdidae, Corvidae, Sittidae (Welty and Baptista 1988), and Pycnonotidae (Fukui 1995). According to Jordano (1995), the seed-dispersing birds can be detected from feces analysis of frugivorous birds. The composition of feces shows the types of the birds' diet because the feces contain undigested materials which can be identified (Corlett 1996). Most of the undigested materials are seeds, and most shrub seeds are not digested by bird digestive system (Partasasmita 2009).

Some species of plants have indirect association with birds because some birds have preference of fruits, so they eat only certain fruits they like (Wiens 1989; Jordano 2000). As a result, some species of plants dominate an ecosystem which is undergoing succession. During succession, the success of plant regeneration is determined by the germination rate of its seeds. Seed dormancy can impede germination, so there must be some mechanisms of dormancy breaking (Barnea et al. 1990, 1991, 1992; Widajati et al. 2008). Bird digestive systems increase germination rate significantly (Traveset et al. 2001). The objectives of this study were to know the correlation between the diversity of bird species and the diversity of plant species whose fruits are eaten by birds and to know the role of birds in seed dispersal and vegetation succession.

MATERIALS AND METHODS

Site of study

The study was conducted in a Panuruban tea plantation, in Cicadas Village, Sagalaherang Sub-district, Subang District, West Java, Indonesia (Figure 1). The study site

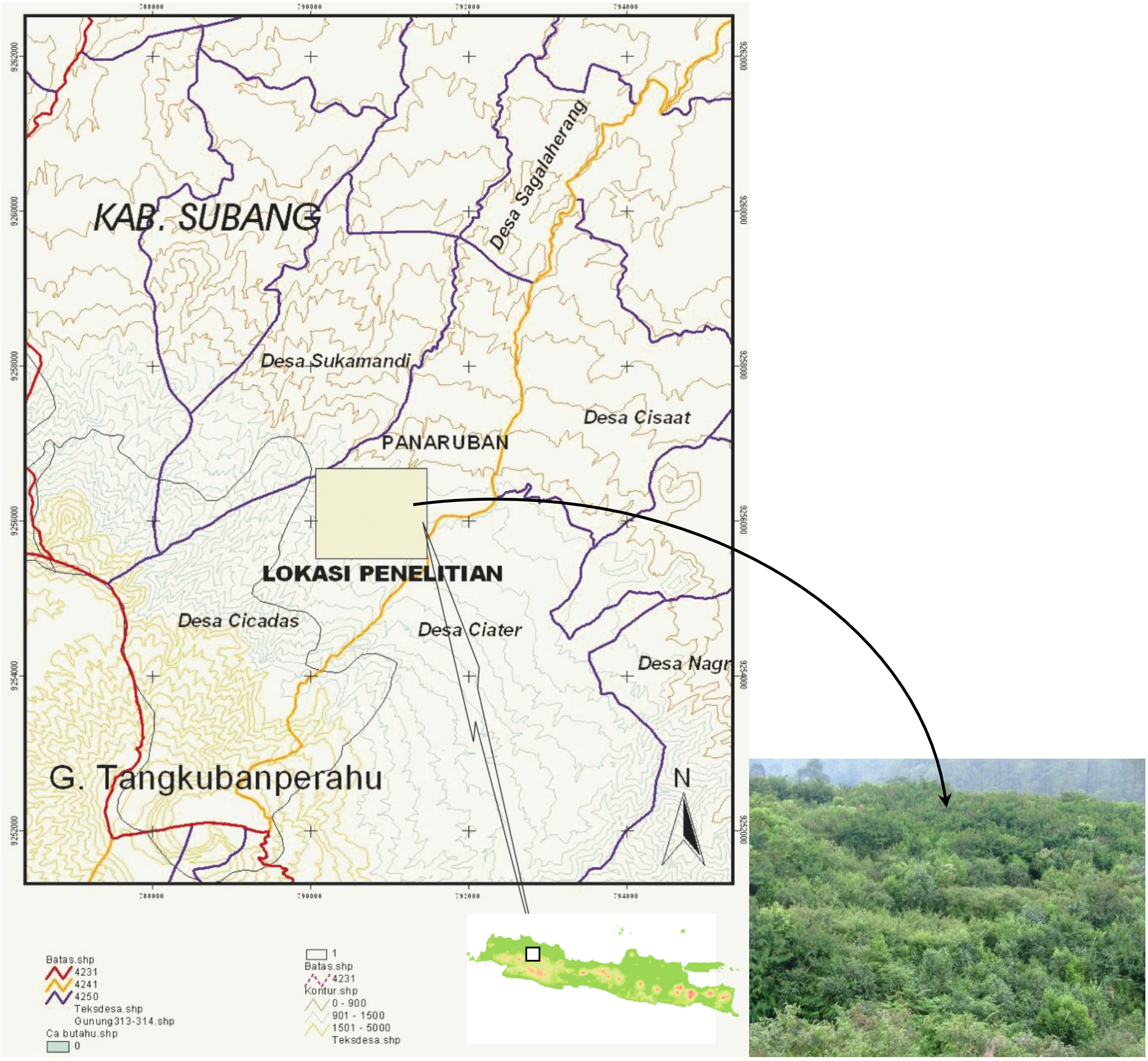

Figure 1. The location of study in Panaruban tea plantation, Cicadas Village, Sagalaherang Sub-district, Subang District, West Java, Indonesia

was ± 29 km from the town of Subang and ± 38 km from the city of Bandung. Geographically, the study site is located at $6^0$11’- $6^0$49’S and $107^0$31’ - $107^0$54’ E, at an altitude of 880-1100 m above sea level (categorized as submontane zone). This area was selected because the tea plants had not been harvested or trimmed in the last five years, and the area developed into bush and secondary forest.

The procedures

Sampling of feces to determine the composition of seeds in the feces

Feces of birds trapped in mist nets were sampled to know the composition of seeds in the feces. The trapped birds were put inside bags for 60 minutes. According to the research of Corlett (1998), when the trapped birds were put in cloth bags for 15-60 minutes, they defecated. After 60 minutes, the birds were identified and released. The feces inside the bags were collected in filter paper and then were put inside envelopes with label to be analyzed in laboratory.

To get seeds from the feces samples, the samples were put on sieves lined with filter paper. Then they were spread with a brush and rinsed with running water slowly. The materials left on the filter were separated based on shape, color, and size. The materials assumed to seed were washed again thoroughly. The intact seeds, pieces of seeds and fruits were moved into Petri dishes lined with filter paper. The dried seeds and fruits were put in tubes which had been labeled. Identification of seeds was done in two ways: matching them with references from Steenis (1972) and matching them with collection of fruits and seeds specimen collected from the location of study which had been identified. The observation of seeds and fruits was done using stereo microscopes. The seeds characters compared were shape, size, color and other important characters (Jordano 1995; Corlett 1998). The number of fruit or seeds for each species was recorded for each sample. The diameter of fruits and seeds was measured with digital caliper at 0.1 mm precision. The weight of fruits and seeds was determined with digital scale at 0.1 g precision.

Germination rate

The quality of seeds in feces samples were determined using seed germination rate test (Fukui 1995). Seed germination test was done for seven species of plants mostly eaten by birds. The seeds and fruits were divided into three groups such as done by Fukui (1995). The first group was seeds from feces of frugivorous birds. The second group was seeds from the same species but they had not passed through the bird's digestive tract. The third group was seeds still covered with mesocarp (fruit flesh) from the same species. For each of the second and third groups, 10 intact seeds or fruits were selected from each species of plant. For the first group, 10 seeds were selected from each plant species from each species of frugivorous birds.

The seeds and fruits were placed inside sand and cotton, because the good media for germination rate testing were sand, paper, and cotton (Widajati et al. 2008). Then, the media were watered and kept at room temperature (27^{o}C). Watering of media was done every other day to keep the media moist. The observation of seed germination was done every week for three weeks, and the percentage of germination was determined. The germination test was aimed to determine whether frugivorous birds help disperse seeds and play direct role in vegetation succession.

RESULTS AND DISCUSSION

Composition of seeds in feces of fruit-eating birds

The number and composition of seeds in feces of frugivorous birds varied for each bird species (Table 1). The number of *Clidemia hirta* seeds was found highest in feces of *Dicaeum trigonostigma*.

Many seeds were found in feces, indicating that there was interaction between shrubs and birds which eat their fruits (Table 1). The shrubs benefit from the interaction, because their seeds get dispersed widely, far from the parental plants to reduce competition, while the birds benefit from the abundant food available in their habitat. This interaction is mutualism. The plants have better chance for regeneration because seed dispersal is the most important factor for future plant distribution. The success of some shrubs in invading wide area and in having high importance values is likely due to the role of frugivorous birds.

The high number of seeds in feces does not always mean that the birds eat many fruits, because fruit of shrub may have many seeds, such as the fruit of *Clidemia hirta* and *Melastoma affine* (Partasasmita 2009). If a bird eats fruit of these species, then there will be many seeds in the bird's feces. A fruit of family Melastomataceae has an average of ≥ 100 seeds (Gerlach 1993; Binggeli et al. 1997; Pizo and Morellato 2002).

The difference in seed abundance in feces of each species of bird is influenced by the availability of food in the bird's habitat (Partasasmita 2009). The bird species *D. trigonostigma* was found mostly in bush of secondary forest where its food source, *C. hirta*, was abundant. Another shrub species, *M. Affine*, found in tea plantation was having ripe fruits and this plant had relatively high frequency and abundance. Therefore, the fruit of this species became the diet for several frugivorous birds, namely *Pycnonotus goiavier*, *P. bimaculatus*, *P. aurigaster* and *Zosterops palpebrosus* as indicated by the presence of the many seeds in the birds' feces. In some tropical forest, this plant species invades open space and its seed dispersal is helped by birds (Binggeli et al. 1997).

Polygonum chinensis was found abundant in feces of *P. aurigaster* (Table 1) because this plant is abundant in all types of vegetation and its fruit has attractive color and a lot of water, and the size fits the bird's beak opening. The seeds of *Sambucus javanica* and *L. camara* were found in the feces of birds of the families Pycnonotidae and Zosteropidae. The seeds of these plants were potentially dispersed by birds because they have high nutrition such as fat and protein and their color is purple-black which is

Table 1. The average number of seeds in bird feces

Species of birds	N/n	Arb	Br	Cr	Hbr	Hbl	Kpt	Sl
Dicaeum trigonostigma	5/5	0,00	2,40±2,65	0,00	0,00	70,20±26,83	0,00	0,00
Pycnonotus aurigaster	14/12	1,00±1,83	4,67 ±2,74	0,83 ±0,46	76,08 ±64,08	40,42 ±16,42	1,50 ±2,07	1,82 ±2,05
P. bimaculatus	9/7	1,89±2,63	0,00	6,29±8,98	24,57±26,87	0,00	1,43±2,08	1,86±1,26
P. goiavier	34/28	0,82±2,16	0,71±1,00	1,75±1,61	189,75±331,74	28,89±67,26	7,57±9,92	2,21±5,18
Zosterops palpebrosus	128/107	2,43±2,63	0,00	3,18±3,72	27,65±114,31	7,17±84,17	0,95±1,87	0,19±1,23
Scissirostrum dubium	3/3	0,00	0,00	0,00	0,00	0,00	6,33±6,08	0,00

Note (abbreviation of local plant names): Arb: Redberry (*Rubus chrysophyllus*), Br: Chinese knotweed (*Polygonum chinensis*), Cr: Breynia (*Breynia microphylla*), Hbr: Blue tongue (*Melastoma affine*), Hbl: Koster's curse (*Clidemia hirta*), Kpt: Javanese elder (*Sambucus javanica*), Sl: West indian lantana (*Lantana camara*), N: the number of trapped birds, n: the number of feces of trapped birds in which seeds were found

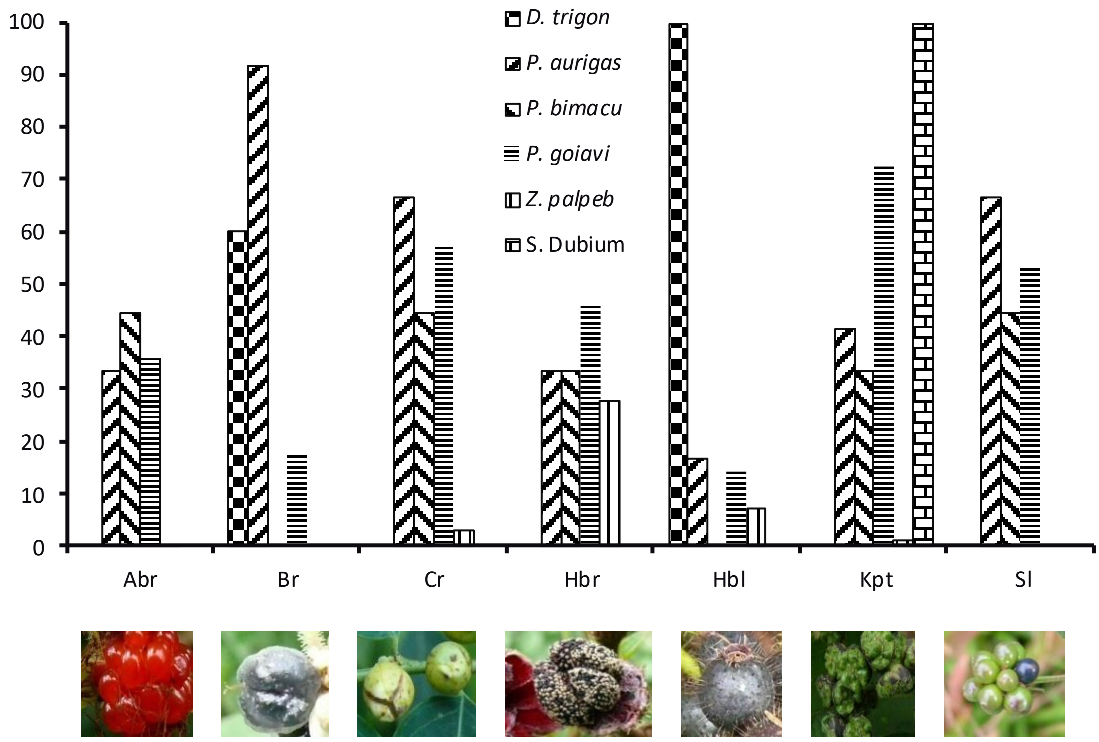

Figure 1. Proportion of seed dispersed by bird as seed dispersal agents. Note (abbreviation of local plant names): Arb: Arben (*Rubus chrysophyllus*), Br: Bungbrum (*Polygonum chinensis*), Cr: Cecerenean (*Breynia microphylla*), Hbr: Harendong beureum (*Melastoma affine*), Hbl: Harendong bulu (*Clidemia hirta*), Kpt: Kipapatong (*Sambucus javanicus*), Sl: Saliara (*Lantana camara*)

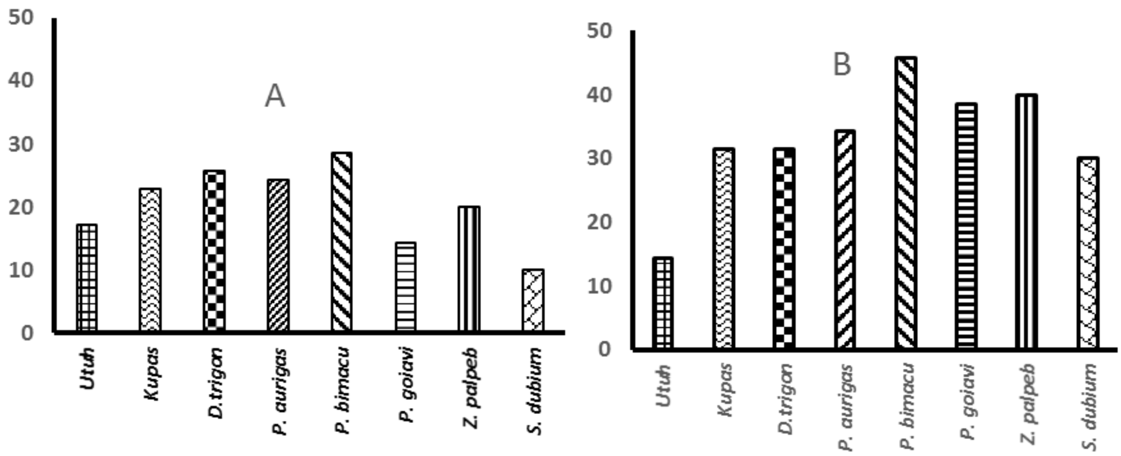

Figure 2. The germination rate of seeds after passing through the bird digestive system. A. Sand medium, B. Cotton medium

preferred by *Pycnonotus* and *Zosterops* (Partasasmita 2009). Gosper (2004) found that the invasion of *L. camara* in national parks of Australia was helped by birds for its seed dispersal. The selection of fruits by birds is not only determined by the bird preference but also the plant abundance. This is the case in the feces of *S. dubium* which contain only the seeds of *S. javanica* because *S. javanica* is dominant in the bird's habitat (Partasasmita 2010a, b).

The seeds of *C. hirta* were found most frequently in the feces of *D. trigonostigma* (Figure 1). The difference in the frequency of seeds in feces is determined by the availability of fruit in the location, the weight of seeds which can be swallowed by birds and the birds' preference (Partasasmita 2009). The composition of seed in feces is not a result of random selection of diet from the available fruit, but it indicates the presence of consistent selection patterns (Herrera 1984; Jordano 2000).

Germination rate

There was no significant difference in germination rate among treatments in cotton and sand growth media (χ^2=8.55; df=6). But the average germination rates of seeds which had been peeled (22.86-31.43%) or passed through the bird's digestive tract (31.43-45.71%) tended to be higher than that of control (14.29-17.29%) (Figure 2).

The seed dormancy breaking physiologically requires a lot of water. The humidity in cotton medium was assumed to be high, so more seeds germinated in cotton medium than in sand medium (Figure 2). Not all seeds of plants as source of bird food can germinate in sand or cotton medium (Partasasmita 2009). The presence of mesocarp is assumed to impede germination, especially the start of germination. The amount of water in fruit flesh does not guarantee quick germination. The fruits of *Rubus chrysophyllus* and *Polygonum chinensis* have higher moisture content than the fruits of *M. affine* and *C. hirta* (Partasasmita 2009), but they are slower in germination than *M. affine* and *C. hirta*. Both seeds can germinate after eight weeks. The appearance of shoot occurs after the mesocarp and exocarp decompose. Fukui (1995) states that mesocarp can impede germination of seeds. The removal of mesocarp means reducing impediment of germination, so the seeds can germinate faster. Barnea et al. (1992) found that the seeds of *Morus nigra* which are difficult to germinate could have higher germination rate after passing through the digestive tract of *Pycnonotus xanthopygos* and *Turdus merula* than the control seeds.

In conclusion, frugivorous birds, especially the bird species of families Dicaeidae, Pycnonotidae, and Zosteropidae showed close association with shrubs bearing the fruit the birds eat and helped establish the vegetation during succession. The bird digestion process resulted in better germination rate than removal of mesocarp and keeping the fruit intact.

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