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Frugivorous bird characteristic of seed disperser in shrubland tropical forest West Java, Indonesia

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Abstract. *Partasasmita R, Mardiastuti A, Solihin DD, Widjajakusumah R, Prijono SN. 2016. Frugivorous bird characteristic of seed disperser in shrubland tropical forest. Biodiversitas 18: 263-268.* Java has been experiencing a heavy deforestation in the 16th century. Combined with a densely human population, most forests have changed into open land with shrubs and secondary vegetation. For examples Bulbul, flowerpecker and White-eye are three large groups of frugivorous birds and has been known as an effective seed dispersal agent and fostering vegetation recovery. However, variations in the use of fruit by fruit-eating birds very closely linked to the characteristic morphology and feeding behavior. The proportion of fruit in the diet probably varies widely between species, but, for all the best-studied species, fruit it at last seasonally dominant. It is highly frugivorous, particularly in wet season, and consumes the full range of fruit types within it's gave limit, defecating (or, sometimes regurgitating) all seeds intact. According to the some reference that fruit consumers such as Bulbuls, Flowerpeckers, and White-eyes are some time is called seed dispersal. But there is no information on seed fate. So, this paper describes the frugivorous bird characteristic of seed disperser shrubland tropical forest at Panaruban, Subang. West Java, Indonesia. Observation of frugivorous bird's communities was used by capture-recapture method. The frugivorous bird morphology characteristic was measured which consisted of external morphology and digest system morphology. The result shown that frugivorous birds had gape width-height ratio of ≥ 0.90. Frugivorous bird thin-walled gizzard relationship with gizzard weight to determine safety of seed exit with feces in a state of is intact. There was strong interaction between frugivorous bird-fruit by gape width-height and fruit diameter.

Keywords: Frugivorous birds, seed dispersal, guild, Panaruban

INTRODUCTION

Bird species pursuant to eaten food type it can be divided by 7 category that is frugivorous, granivorous, insectivorous, carnivorous, nectarivorous, omnivorous, and piscivorous (Mackinnon et al. 2000). Bird spesies group base on their food have different characteristic one and the other (Jordano 1992, 2000). Characteristic of form and size bill bird determine eaten food type it (Mallarino et al. 2012) Characteristic of bill of frugivorous bird have role to damage and spreading of seed successes. Frugivorous bird having small bill size and robus as *Emberiza* spp. tend to can only eat fleshly fruit, seed away from the parent tree via the gut or dropping them after chewing the pulp (David et al. 2015), or its seed is regurgitated (Jordano 1992).

The generally external factors that affect the intensity of food for fruit-eating birds is the abundance of fruit in habitats such as the availability of feed ripe fruit (Partasasmita 2009, 2015) with attractive fruit color (Galleti et al. 2015), while the body weight of fruit-eating birds are the main factors that determine the intensity of the birds eat fruit. Requirement of amount of fruit food closely related bigly frugivorous bird body (Herrera 1984). Bird as *Acrocephalus* spp. eat medium-size fruit with the composition of the food volume between 30-70%. Small body size is small also eat fruit such as *Sylvia* sp. and *Erithacus* sp. (Jordano 1992, 2000).

Large aperture half showed a close relationship with edible fruit size, the larger the aperture, the greater the size of half of the edible fruit (Wiens 1992; Fukui 1995; Mallarino et al. 2012). Birds that have a small size of the opening half only eat fruit that is small, due to the limited size of the opening beak (Wheelwright 1988; Herrera 1985).

In addition, the fruit-eating birds have a digestive system that is very different than eating other foods. In some birds who have a specialization based on these foods, some parts of the digestive system are modified. Parts of the digestive system is modified, especially in the fruit-eating birds is esophagus (Jordano, 1986, 1992, 2000).

Esophagus can not be widened at Dicaeidae bird groups, whereas in birds Ploceidae and Pycnonotidae can widen (Proctor and Lynch 1993). Modifications also occurring on the proventiculus and ventriculus. In the second part of the muscle gets thinner so that the seeds can pass intact into the small intestine, large intestine and cloaca (Jordano 1987).

Common characteristic modification digestive system fruit-eating birds include: (i) oesopagus reduced and proventriculus simple, (ii) there is a wall of the ventricles thin, or have no muscular ventricle (gizzard), (iii) the lateral position of the ventricles and almost directly from the esophagus to the small intestine, and (iv) the length of the small intestine is relatively short (Jordano, 1992, 2000).

The birds are specialized as an insect eater, had a muscular ventricle is thicker than fruit eaters. Fruit-eating birds have a mechanism that destroys the digestive process is done in the ventricles rind simple and seeds passed through the small intestine (Jordano, 1992, 2000). Some seeds are found in the feces of birds destroyed, because when handling the fruit in its beak.

This paper empirically prove that fruit-eating birds as seed dispersers or predators seed based on morphological characteristics beak and digestive system, and the number of intact seeds in the feces of birds.

MATERIALS AND METHODS

Study site

The study was conducted in a Panuruban tea plantation and secondary forest, in Cicadas Village, Sagalaherang Sub-district, Subang District, West Java, Indonesia (Figure 1). The study site 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 dan ten years, and the area developed into bush and secondary forest.

The procedures

Observations on the characteristics of birds caught mist nets intended to determine the characteristics of the external morphology of birds. Installation of mist nets to capture birds sampled in each vegetation type (the abandoned tea plantation 5 years and 10 years, and secondary forest) is 5 days per month, for 9 months. Mist nets used have the following specifications: black, made of nylon thread, length 12 m, width 2.6 m, mesh size 30 mm

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

mesh, has 4 pockets (Schemnitz 1980). Birds are categorized as eating fruit, in addition to the measured external morphological characteristics are also the morphological characteristics of the digestive system (Corlett 1996; Jordano 1987), by category of food, namely dried fruit and fleshy, determined nine species of birds that measured the morphological characteristics of the external part to define groups of fruit-eating birds, the one species of family Dicaeidea, Timaliidae, and Zosteropidae namely Orange-billied flowerpecker, Screscent-chested Babbler, and Oriental White-eye; three species of family Pycnonotidae, i.e. Orange-spotted bulbul, Sooty-headed bulbul, and Yellow-vented bulbul; three species of family Estrildidae, i.e. Javan Munia, Scaly-breasted Munia, and Tawny-breasted Parrotfinch. Steps being taken as follows: arrest, external morphometric measurement, tagging and release back (Corlett 1998; Partasasmita 2009). Some individuals are fruit-eating birds caught in mist nets after identified the species name and its external morphology characteristics were measured, and then measured the morphological characteristics of the digestive system. Each species of fruit-eating birds taken as many as five samples. The birds were used as samples taken from catching up with mist nets, especially birds injured due to thrashing netted mist nets. It is intended to reduce the decline in bird populations due to observer error. Samples of the bird species dissected and measured morphological characters digestive system (Schieck and Millar 1985; Jordano 1987)

Bird morphology measurements carried out on the wide aperture half commissure measured starting from the left side to the right side and high-aperture part measured from the top end of the top half of the commissure point until the lower end of the lower half of the commissure point. The parts that are measured include the length of the gastrointestinal tract (throat until proventriculus and intestine length), length and thickness of the ventricles and the ventricles wet weight after food is removed. Some individuals known fruit-eating birds in their faeces contain many seeds measured morphological characteristics of the digestive system, the one species of family Dicaeidea and Zosteropidae namely Orange-billied flowerpecker, and Oriental White-eye; three species of family Pycnonotidae, i.e. Orange-spotted bulbul, Sooty-headed bulbul, and Yellow-vented bulbul.

RESULTS AND DISCUSSION

External morphology frugivorous bird

Fruit-eating birds can be classified based on the state of the fruit is dried fruit and fleshy fruits. Dried fruit-eating birds suspected to have potentials can propagate seeds and help the succession of plants (Partasasmita 2009). Some dried fruit-eating birds such as fruit grass is family Estrildidae example Javan and Tawny-breasted Munia Parrotfinch. According to MacKinnon et al (2000) birds Estrildidae groups included in the seed eaters because it has a more robust beak shape. External morphological parameters were very supportive of the grouping by the guild are gape-width and gape-height. Jordano (1987) states that the index frugivory associated with bill-shape, and gape-width.

Granivorous bird can be distinguished from avian frugivores as beak shape a more solid and thick. But on morphometric ratio to the length of the long half head inconspicuous. According to Mackinnon et al (2000) and King et al (1992) the species of Estrildidae often included in a group of birds granivorous, but in this study group was added frugivores in hopes of finding a clear ratio between the two groups of birds by type of food.

Based on the eating habits, the morphometric ratio to the length of the long half bird's head Dicaeidae (0.30), Pycnonotidae (0.33 to 0.45), Zosteropidae (0.28), Ploceidae (0.34 to 0.39) and Timalidae (0.38) (Table 1). This is far different from honey-eating birds is 0.52 (Partasasmita et al. 2004).

In addition, the long half-life was instrumental in reaching the food, such as bird honeyeater. Height ratio and wide aperture half shows the amount, form and manner of handling of food eaten. According Moermond and Denslow (1985) variation in the handling of food for birds frugivores are intimately associated with limitations in ecology and behavior. In this study been as many as nine species of 5 family, because the bird feces were found seeds (Table 2).

Some bird species of Ploceidae such as birds Tawny-breasted Parrotfinch, Javan munia, and Scaly-breasted Munia often takes a special dry fruit from plants family Graminae, so it is considered as a fruit eater. In the feeding behavior of bird species of family Ploceidae how to handle food bitten between the top half and the bottom half, then liquid fruit out of grain swallowed up, if the ears of young fruit such as fruit grains. However, if birds eat the grain above the old grass, eating behavior seem peck grain grass then swallowed directly.

The hypothesis as the basis Ploceidae put some bird species to groups of bird frugivores. But based on Table 2 shows that birds are not eating fruit Ploceidae but seed predators. Screscent-chested babbler bird inclusion in the frugivores, as some researchers found that the birds often consume fruits (Corlett 1998). It is often found when the *Stachyris melanothorax* bird pecking fruits perch near the place and found the seeds in feces (Tabel 2).

Table 3 shows that bird species family Ploceidae have a high ratio with wide aperture half smaller than 4 family others. Size openings narrower half indicating swallowed food tend to have a rounded shape. The food was not proportional to the big openings must peck beak and strong pressed between upper and lower beak so as to be flat. Behavior handle such foods cause most fruit seeds ingested to be broken even yet be destroyed. The group of birds that eat the fruit but do not help spread the seeds because the seeds tend to be issued with feces broken-called predatory fruit (Herrera 1984). Thereby indicating that Ploceidae as fruit predators, while *Stachyris melanothorax* as seed dispersers but voluntary.

In birds that have openings sized beak almost equally between the height and width of the openings (ratio ≥ 0.9) are easier to swallow fruit that is proportional to opening its beak such as a bird of Orange-billied flowerpecker, Oriental White-eye, Sooty-headed bulbul, Orange-spotted bulbul, and Yellow-vented bulbul (Table 4). Width opening

Table 1. Characteristics half length, head length and weight of the bird that has potential as a fruit eater

English name	Species name	n	Bill length (mm)	Head lenght (mm)	Weight (g)	Category *feeding guild*
Orange-billied flowerpecker	*Dicaeum trigonostigma*	5	7.10±0.34	24.05±0.44	7.40±0.89	F
Tawny-breasted Parrotfinch	*Erythrura hyperythra*	5	10.11±0.55	25.96±0.83	15.60±0.64	G
Javan munia	*Lonchura leucogastroides*	16	8.08±0.60	23.47±0.25	10.00±1.69	G
Scaly-breasted munia	*Lonchura punctulata*	10	8.17±0.95	22.25±0.98	10.88±1.73	G
Sooty-headed bulbul	*Pycnonotus aurigaster*	14	14.25±0.85	37.17±1.26	31.93±1.98	F
Orange-spotted bulbul	*Pycnonotus bimaculatus*	9	16.43±0.51	37.28±1.24	32.04±1.79	F
Yellow-vented bulbul	*Pycnonotus goiavier*	34	12.75±1.66	38.44±1.41	31.50±2.61	F
Screscent-chested babbler	*Stachyris melanothorax*	44	12.21±1.50	32.15±1.18	12.97±0.92	I
Oriental White-eye	*Zosterops palpebrosus*	128	7.14±0.98	25.66±1.23	8.11±1.00	F

Note: F: frugivorous, G: granivorous, I: insectivorous

Table 2. The composition of the seeds intact and non-intact (item) in the feces of birds that have the potential as a fruit eater

Species name	be caught /seed total	∑ seed intact	∑ non-intact	Category
Dicaeum trigonostigma	5/5	363	0	ab
Erythrura hyperythra	5/1	1	6	c
Lonchura leucogastroides	16/1	3	32	c
Lonchura punctulata	10/2	4	17	c
Pycnonotus aurigaster	14/12	1519	3	ab
Pycnonotus bimaculatus	9/7	254	2	ab
Pycnonotus goiavier	34/28	6488	23	ab
Stachyris melanothorax	44/20	1267	43	b
Zosterops palpebrosus	128/107	4234	14	ab

Note: a: frugivorous ≥ 50% individual samples of birds are the remaining fruit and seeds in the feces; b: seed dispersal ≥50% There are intact seeds in the feces; c: seed predator ≤ 50% was found intact seeds in feces

Tabel 3. The large size of fruit-eating bird beak openings

Family	Species name	n	BOH	BOW	ROB
Dicaeidae	*Dicaeum trigonostigma*	5	5.88±0.58	5.57±0.21	1.06
Ploceidae	*Erythrura hyperythra*	5	3.59±0.26	8.00±0.92	0.45
Ploceidae	*Lonchura leucogastroides*	16	5.55±0.53	6.85±0.58	0.74
Ploceidae	*Lonchura punctulata*	10	5.13±0.68	7.02±0.89	0.73
Pycnonotidae	*Pycnonotus aurigaster*	14	10.38±0.95	10.94±0.96	0.95
Pycnonotidae	*Pycnonotus bimaculatus*	9	10.24±0.76	10.96±0.48	0.93
Pycnonotidae	*Pycnonotus goiavier*	34	9.40±1.23	10.43±0.98	0.90
Sylviidae	*Stachyris melanothorax*	44	6.00±0.90	6.91±0.86	0.87
Zosteropidae	*Zosterops palpebrosus*	128	6.25±0.63	5.96±0.63	1.05

Note: n: the number of samples of birds, BOH: beak opening height, BOW: beak opening wide, ROB: ratio of opening beak is comparison between (BOH/BOW)

Table 4. Morphometric characters digestive system fruit-eating birds and seed dispersers (n=5 individu sample /species)

Species name	t-pv (cm)	Intestinal length (cm)	Ventriculus		
			Length (mm)	Thick (mm)	Weight (g)
Dicaeum trigonostigma	4.16±0.06	11.36±0.60	6.45±0.50	3.35±0.36	<0.10
Pycnonotus aurigaster	7.64±0.15	13.72±0.41	14.47±0.25	6.87±0.51	0.58±0.08
Pycnonotus bimaculatus	6.34±0.17	14.57±0.08	14.63±0.87	7.66±0.16	0.64±0.06
Pycnonotus goiavier	5.79±0.03	14.66±1.36	15.12±0.64	6.59±0.33	0.52±0.08
Zosterops palpebrosus	3.71±0.50	11.98±1.61	8.88±0.70	5.46±0.40	0.22±0.05

Note: t: throat, pv: proventiculus

half family Pycnonotidae range 10-11 mm in the study site, shows a smaller size than the same family in Hong Kong (Corlett 2002). According to Wheelwright (1988), the ability of birds to handle and swallow pieces of efficient depends on the size of the fruit, the bird's body size and large-size opening half. Frugivores bird groups have width and height openings beak almost balanced, making it easy to swallow the fruit, and the seeds are inedible likely intact (Herrera 1985; Levey 1987).

In addition, variations in the size of the opening half, relate to the size of the weight of the bird itself. Tables 1, 2 and 3, the greater the weight, the greater openings bird beak, with a very high correlation is r = 0.99. Similarly, fruit-eating birds in the area Hato Raton Spain Donana National Park has a very significant correlation between weight and the width of the opening half (Jordano 1987). The body weight of fruit-eating birds are the main factors that determine the intensity of eating the fruit. The amount of food needs are closely related to large pieces of fruit-eating birds body (Herrera, 1984). The greater the weight and fruit-eating birds, the more fruit that can be eaten. Therefore, smaller body size small fruit eating birds as well as Orange-billied flowerpecker (*Dicaeum trigosnostiga*) and Oriental White-eye (*Zosterop palpebrosus*). It is almost as common Jordano (2000), a large bird like Acrocephalus spp. eating the fruit of medium size with a composition of feed volume between 30-70%.

Large aperture size is determined by the half higher than the opening width of the beak, so that the higher the opening half, the wider range of fruit sizes that can be swallowed whole (Tables 2 and 3). Birds that have a large aperture size small part only eat fruit that is small, due to the limited size of the opening beak (Wheelwright 1988; Herrera 1985). Therefore, the fruit is eaten by birds family Dicaeidae, Zosteropidae, and Pycnonotidae will be found the seeds in the feces the bird. Nevertheless, the passage of the ingestion of seeds in the bird's beak does not directly be found in the feces, because the seeds must also survive the digestion process in the esophagus, and in the intestines of bird ventriculus.

Bird morphology digestive system

Morphological characters digestive system fruit-eating birds showed that the large size of the body related to the length of the gastrointestinal tract. Bird Dicaeum trigonostigma and Zosterops palpebrosus whose weight is smaller than Pycnonotidae bird species have morphological characteristics of the system is shorter and lighter (Tabel 4).

Length of the digestive tract system and thick ventriculus further demonstrate the effectiveness of the birds in spreading the seeds. For example, *Zosterops palpebrosus* birds have a shorter size gastrointestinal system and ventriculus thin (Table 4). Therefore, the feces often found many small seeds such as *Melastoma affine* and *Clidemia hirta*, also medium-sized seeds like *Lantana camara*. Size short digestive tract and especially the thin layer of the ventricles is very possible that swallowed the fruit, the seeds may come out intact with feces of the bird. In the digestive tract of birds that have longer and thicker muscular ventricle is very possible the edible fruit, seeds removed with feces in a state intact, unless the seed has exocarp thick and strong. This is evident in birds *Stachyris melanothorax*, although several times observed eating fruit but very rarely found in the feces seed (Tabel 2).

In addition, a shorter size thin ventricle of the digestive tract and fruit-eating birds is a modified form and morphological adaptations of birds of the types of food they consume (Jordano 1987, 2000). Thus, the birds are making dietary changes by consuming fruits more often. Although the fruit is consumed has a high nutrient content such as fat, protein, and carbohydrates. But these nutrients are not absorbed a lot, because most of the nutrients stored in the seed, and the birds just digest more flesh alone (Corlett 1996; Ko et al. 1998; Cipollini 2000).

In short digestive tract on a fruit-eating birds accelerate the retention time of digestion, so the shorter the digestive tract faster seeds also issued with feces of fruit eaten. The length of the digestive tract and weight bird seed dispersers which have a strong correlation coefficient of determination $R^2 = 0.99$ (Table 4), it indicates that a small bird that always has a length shorter digestive tract. Thus frugivores birds is unlikely to have retention times faster than larger birds. Therefore, the retention time of food in the digestive tract is determined by large birds, but also the length of the gastrointestinal tract, seed size and type of fruit. However Jordano (1986) found five species of the genus Sylvia with a growing weight ranges from 11.1-19.0 g, 12.2-15.6 cm length of intestine ranges have average retention time for 32.3 to 44.6 minutes. While Fukui (2003) found the average length of retention times faster (20.8 minutes) in birds *Hypsipetes amourotis* (Pycnonotidae) with a growing weight ranges 29-32 g.

Thick heavy ventriculus closely related to the ventricles. In birds that have less thick ventricles tend to have a lighter weight. This is shown in the bird Orange-billied flowerpecker (*Dicaeum trigonostigma*) with thick ventriculus 3: 35 ± 0: 36 mm has a wet weight of <0.10 g (Table 5). Therefore, the thinner ventriculus then chances are intact seeds out with feces from the edible fruit growing. Jordano (1986) stated on fruit-eating birds modification of the digestive system in the proventriculus and thinner ventricle muscle.

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