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THE POTENTIAL OF *FICUS* SPECIES AS FRUGIVOROUS FEED ON GENTONG HILL, MOUNT UNGARAN, INDONESIA

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Abstract

Ficus plays an essential role in the forest ecosystem and can be used as an indicator of success in the local environment. Its lateral rooting system binds with soil, thereby maintaining soil stability. The fig fruit of *Ficus* is essential food for frugivores. This study aims to determine the species richness and potential as frugivorous feed, focusing on Gentong Hill, Mount Ungaran. Mount Ungaran is a forest ecosystem with a variety of flora and fauna, including various species of *Ficus*, and was selected as a research location due to the habitat it provides for animals and plants. This research was conducted between January and May 2018. Data was selectively sampled based on *Ficus* accessibility and location. Its feed potential was determined using scoring based on fruit dimensions and colour. The research showed 24 species of *Ficus* in six sub-genera. According to our scoring results, these species were divided into four categories based on their frugivorous feed potential: high potential (4 *Ficus* species), potential (11), and less potential (9). This finding implies that Gentong Hill plays an important role in providing food for frugivores, and its maintenance is urgently necessary.

Key words: *Ficus*, frugivore, Mount Ungaran, species richness.

Introduction

Ficus L. (Figs) appears to be a genus that widely spreads throughout Southeast Asia and is considered a keystone resource for sustaining wild animals feed in the tropical forest (Caughlin et al. 2012). Indonesia is home to various species of *Ficus*, including 75 in six sub-genera in Java: *Urostigma*, *Sycidium*, *Sycomorus*, *Pharmacosycea*, *Ficus*, and *Synoecia* (Berg and Corner 2005). *Ficus* vary in morphology and can include trees, epiphytes, hemi-epiphytes, shrubs, creepers, and lianas. The 'fruit', more accurately a pseudo-fruit, is a receptacle that contains a large number of small fruits (achenes) inside (Poonswad 2012). *Ficus* produces a large quantity of fruit throughout the year and provides food for many frugivores (Tweheyo and Lye 2003), making it a major resource in the ecosystem. It is consumed by many frugivores, including 92 species of birds, 12 species of mammals, and 8 species

of insects (Francis et al. 2013). Preliminary studies show that *Treron griseicauda* (Bonaparte, 1855) and *Psilopogon* spp. (Müller, 1836) have consistently been observed to consume *Ficus* in the Gentong Hill region of Mount Ungaran. Strangler figs species are the main resource for other species, as they support ecosystems and are capable of symbiotic mutualism with other species (Lu et al. 2001, Payton et al. 2002).

Gentong Hill is a forest area in the northeastern part of Mount Ungaran, located at 7°12′ S and 110°20′ E in Ngesrepbalong Village, Kendal. Gentong Hill is a habitat for endangered and protected animals, including *Aceros undulatus* (Shaw, 1811), (Rahayuningsih and Kartijono 2013), *Nisaetus bartelsi* (Stresemann, 1924), *Ictinaetus malayensis* (Blyth, 1843), *Loriculus pusillus* (Gray, 1859), *Trachypithecus auratus* (Geoffroy, 1812), and *Hydrornis guajanus* (Statius Müller, 1776). Mount Ungaran is also classified as an Important Bird Area, as it is home to various species of birds which are protected and need to be preserved (Rahayuningsih et al. 2017) and is important for bird conservation due to its adequate resources and habitat (Manu et al. 2010).

However, bird hunting, deforestation, construction of tourist attractions, and settlements have threatened these species in Mount Ungaran. Central Java Province has a relatively high rate of deforestation, averaging 142,560 ha per year between 2000 and 2005. Meanwhile Mount Ungaran had 5413.94 ha of forest area in 1990, this number reduced by 28.43 % to 3874.79 ha in 2000 and decreased yet further to 1335.77 ha in 2006. In the past 16 years, it has lost 4078.17 ha (75.33 %) of forest area (Gunawan et al. 2010).

The forest area on Mount Ungaran is subdivided into natural and secondary forests (Rahayuningsih et al. 2015). Between 1991 and 2009, the natural forest area had a tendency to change. The distribution of natural forests decreased by 53.31 %, while other species of land increased, including secondary forests (63.98 %), plantations (38 %), gardens (82.29 %), and settlements (55.38 %). Various studies are currently being conducted to provide data in support of the protection of Mount Ungaran. The study of its resources is vital in evaluating the actual condition of feed for species inhabiting the area. Studies on *Ficus* diversity are very rarely carried out because the large number of species makes the identification difficult (Harrison 2005). As poor as research about the species of *Ficus* on Gentong Hillis, was limited. Caused those several reasons, we expected to provide profile data on *Ficus* species and protected areas on Gentong Hill, Mount Ungaran. Not only to determine the species richness, but also to evaluate various *Ficus* species that have potential as frugivorous feed and the frugivores attracted the kinds of fruits in this area.

Materials and Methods

Study area

This research was conducted between January and April 2018 on Gentong Hill, Mount Ungaran (7°12′ S and 110°20′ E), Ngesrepbalong Village, Limbangan District, Kendal, Central Java, Indonesia (Fig. 1).

Area division

The study area was further subdivided into three areas based on dominant vegetation: Area A (*Syzygium* sp. R.Br.

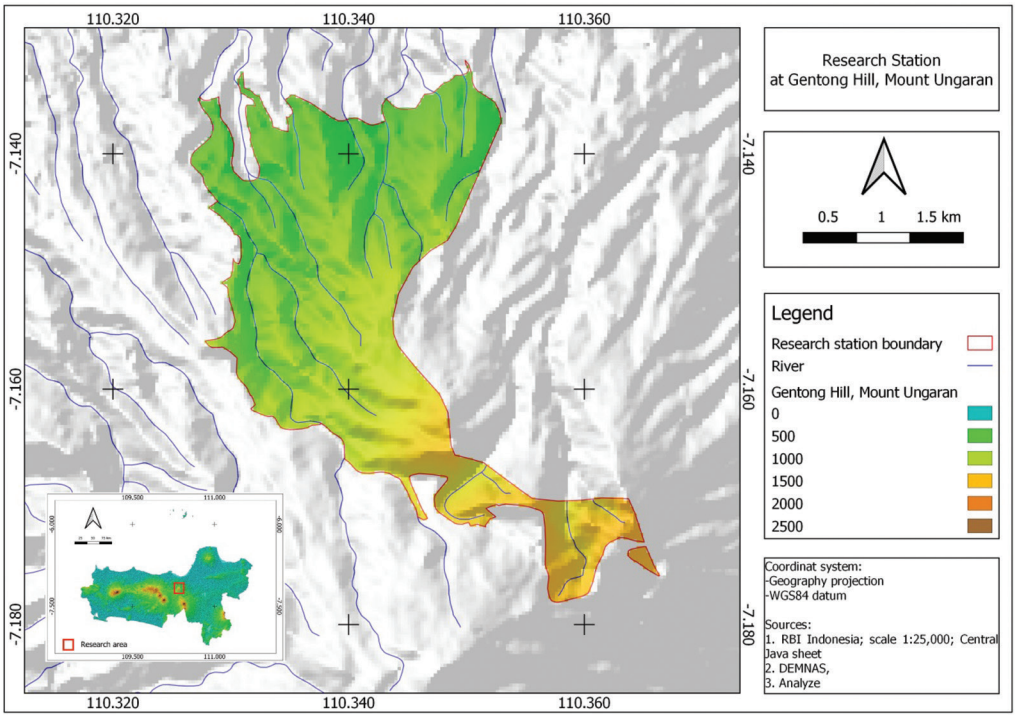

Fig. 1. Research area.

ex Gaertn. 1788); Area B (*Dacrycarpus imbricatus* (Blume) de Laub. 1969, and various species of Lauraceae family); and Area C (*Weinmannia fraxinea* (D. Don) Miq. 1856).

Collection and identification of specimens

Area A was divided into two observation areas, while areas B and C had one observation area. The species of *Ficus* were identified based on morphology, inflorescences, fig size, and scientific identity. The unknown species were carried out to record morphological data in the Biology Laboratory, Faculty of Mathematics and Science, Semarang State University. Identification was performed based on keys provided by Berg and Corner (2005).

Data analysis

Identification was performed descriptively based on the key determinants of *Ficus* Flora Malesiana by Berg and Corner (2005). Its fruits were divided into three groups based on the size in accordance with Lambert and Marshal (1991): small ($d \leq 1.5$ cm); medium (1.5 cm > $d \geq 2.5$ cm); and large ($d > 2.5$cm). The potential of *Ficus* adjusted to the animal's preference in selecting fig was determined via scoring.

The score was based on habits, the way how the species showed their fig, syconia size, and fig colour. The type of hemi-epiphytic fig has the highest value based on its fruit production which is abundant throughout the year (Poonswad 2012). Then followed by tree, liana and shrub types. Axillary fruit is very popular with various

types of frugivores. In other hands, fruits on the trunk or branches affect mammals more than birds. Flagelliflorous fertilization is rarely a modification of cauliflorous with very long fruit stalks. Moreover, this is rarely the favor of frugivores (Shanahan and Compton 2001). Black/dark fruit color has the highest score, then the green color has the lowest score (Table 1). According to Shanahan and Compton (2001), the black fruit or dark fruit attracts all of types of frugivores, while the red, yellow, orange or pink were the main attraction for birds, and the green ones only attracts a few mammals, where there are far fewer species than birds. *Syconia* size is also determines the score. Medium fruit has the greatest score, while the large fruit has the lowest score (Table 1). It assumes by that all frugivores of various sizes can consume it, while large fruit can only be consumed by certain species with large body size, whereas such frugivores are very rare (Kinnaird and O'Brien 2007; Tan et al. 2014).

Table 1. List of morphological attributes for scoring of figs potential.

Observed attributes	Categories	Scores
Habits	Hemi-epiphytes	25
	Trees	12.5
	Lianas	6.25
	Shurbs/epiphytes	3.125
The way how the species showed their fig	Axillary	25
	Ramiflorous/cauliflorous	12.5
	Flagelliflorous	6.25
Fig color	Purplish/Black/ Dark red	25
	Orange/yellow/ pinkish	12.5
	Cream/greenish	6.25
	Brown	3.25
Syconia size categories	Large	6.25
	Medium	25
	Small	12.5

The score values were divided into four categories: no potential (≤25); less potential (26–50); potential (51–75); and high potential (≥76). Frugivores attracted by figs fruit were evaluated according to Shanahan and Compton (2001) who divided them into several categories including: canopy birds, arboreal mammals, understory birds, bats only, terrestrial mammals, and primates only.

Results and Discussion

A total of 24 fig species in six sub-genera were found in three areas of Gentong Hill, Mount Ungaran (Fig. 2).

The most common species originates from *Urostigma* sub-genus, followed by *Sycidium*, *Synoecia*, *Sycomorus*, *Ficus*, and *Pharmacosycea*. According to Berg and Corner (2005), Java Island contains 75 species of *Ficus* in six sub-genera. Our results showed that Gentong Hill represents all of *Ficus* sub-genera and 26.67 % of all *Ficus* species in Java. *Urostigma* sub-genus has the largest percentage of floristic constituents (42 %) compared to the other sub-genera. According to Berg and Corner (2005), 32 % of *Ficus* species in Java are of *Urostigma* sub-genus. This result is not surprising, as the genus *Ficus* is a species of cosmopolite (Berg and Corner 2005) and has a very wide tolerance range of environmental factors (Pociecha et al. 2016). In addition, *F. involucrata* is an endemic *Ficus* of Java island, Indonesia (Berg and Corner 2005). However, the reports are very rare to discuss about this species, even though this species is one of high potential types in providing feed for frugivores (Fig. 3).

In accordance with scoring results, 4 species were classified as 'high potential', 11 as 'potential', and 9 as 'less potential'

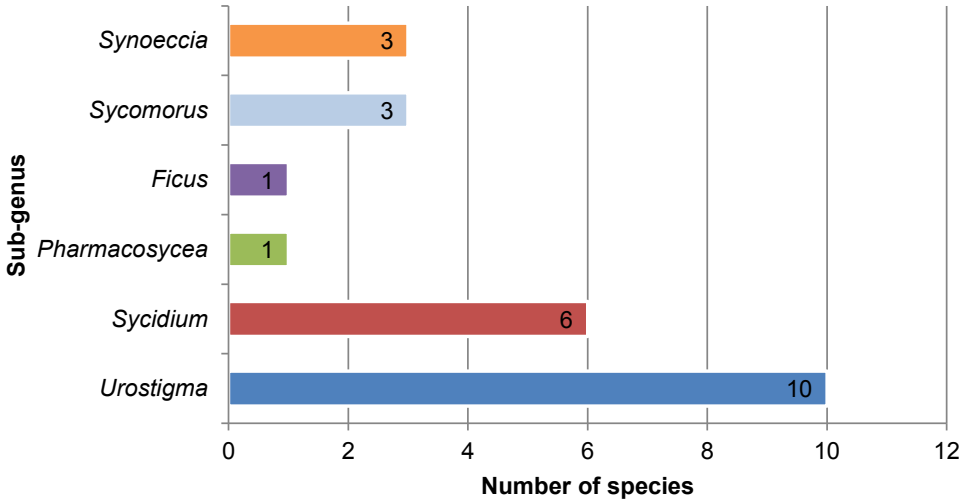

Fig. 2. *Ficus* species richness.

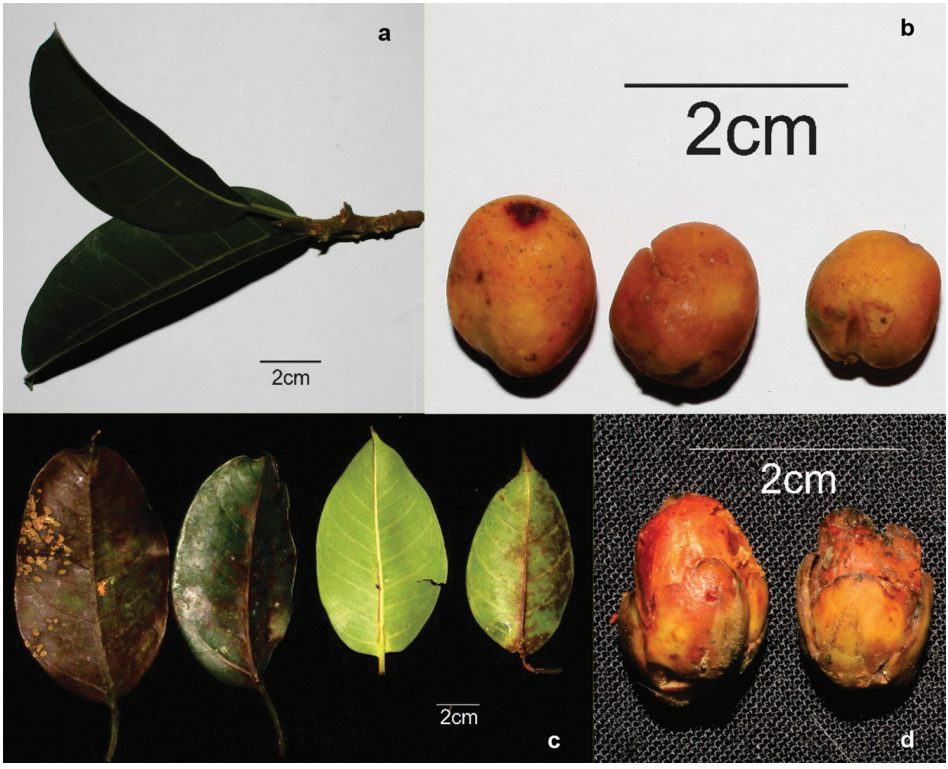

Fig. 3. Common *Ficus* species which has high potential value as frugivores feed at Gentong Hill, Mount Ungaran: *F. kerkhovenii*: a. leaves, b. ripe fruits; *F. involucrata*: c. leaves, d. ripe fruits.

(Table 2). High-potential species were morphologically classified as hemi-epiphytes with a large amount of fruit, medium-sized fruit, and a black or dark red color. The hemi-epiphyte species of *Ficus* generate a great deal of fruit production and were preferred by many frugivores (Naniwadekar et al. 2015). In addition, the species of frugivore has a tendency to select as fruit with a dark or black color.

Table 2. Species richness, characteristics, potential, and frugivores attracted of each *Ficus* species.

Subgenus	Species	Category	Frugivoes attracted[2]
Urostigma	*F. kerkhovenni* Valeton	High potential	CB, AM, UB
Urostigma	*F. benjamina* L.	Potential	CB, AM, UB
Urostigma	*F. binnendijkii* Miq.	Potential	CB, AM, UB
Urostigma	*F. caulocarpa* (Miq.) Miq.	Potential	CB, AM, UB
Urostigma	*F. crassiramea* subsp. *crassiramea* (Miq.) C.C.Berg	High potential	CB, AM, UB
Urostigma	*F. crassiramea* subsp. *stupenda* (Miq.) C.C.Berg	Potential	CB, AM, UB
Urostigma	*F. drupacea* Thunb.	High potential	CB, AM, UB
Urostigma	*F. involucrata* Blume[1]	High potential	CB, AM, UB
Urostigma	*F. microcarpa* L.f.	Potential	CB, AM, UB
Urostigma	*F. virens* Aiton	Potential	CB, AM, UB
Sycomorus	*F. fistulosa* Reinw. ex Blume	Potential	BO
Sycomorus	*F. ribes* Reinw. ex Blume	Less potential	TM
Sycomorus	*F. variegata* Blume	Less potential	PO
Synoecia	*F. lanata* Blume	Potential	CB, AM, UB
Synoecia	*F. punctata* Thunb.	Less potential	PO
Synoecia	*F. villosa* Blume	Less potential	CB, AM, UB
Sycidium	*F. ampelas* Burm.f.	Less potential	BO
Sycidium	*F. cuspidata* Reinw. ex Blume	Less potential	UB
Sycidium	*F. montana* Burm.f.	Less potential	TM
Sycidium	*F. obscura* Blume	Less potential	UB
Sycidium	*F. sinuata* Thunb.	Potential	UB
Sycidium	*F. tinctoria* G.Forst.	Less potential	UB
Ficus	*F. fulva* Reinw. ex Blume	Potential	CB, AM, UB
Pharmacosycea	*F. nervosa* subsp. *pubinervis* (Blume) C.C.Berg	Potential	BO

Note: [1]Java endemic species; [2]Frugivores attracted according to Shanahan and Compton (2001): CB=Canopy birds, AM=Arboreal mammals, UB=Understory birds, BO=Bats only, TM=-Terrestrial mammals, PO=Primates only.

Urostigma species is characterized as a high-potential (4 species) and potential (6 species). *Urostigma* is generally a hemi-epiphyte and known as strangler figs (Sastrapradja and Afriastini 1984). They have a large canopy (Harrison et al. 2003), and provide fruit throughout the year (Dew and Boubli 2005). The primary colors of this sub-genus are yellow, red, and black, which are highly favored by various species of frugivores (Kinnaird and O'Brien 2007). This explained why fig

species from this sub-genus are frequently visited by various types of frugivores at fruiting in the study area. The types of frugivores that most frequently visit fruiting figs were the yellow-throated hanging parrot (*Lorichulus pusillus* Gray 1859), black-banded barbet (*Psilopogon javensis* (Horsfield, 1821)), and grey-cheeked green pigeon (*Treron griseicauda* Wallace, 1863). There is one additional piece of evidence which demonstrates that *Ficus* can support frugivores all year round, implying keystone status. It is the only known plant taxon upon which frugivorous birds in South-east Asia have specialized. *Treron* spp. (forest green pigeons) and probably some *Megalaima* (*Psilopogon*) sp. (barbets) are fig-eating specialists (Leighton and Leighton 1983).

On the other hand, the less potent species come from *Sycomorus* sub-genus (2 species), *Synoecia* (2 species) and most of *Sycidium* (5 species). The species of *Sycidium* generally are shrubs with low number of fruits. *Sycomorus* sub-genus such as *F. variegata* and *F. ribes*. *F. variegata* has a large fruit character which is only attractive to certain primate species, while *F. ribes* with flagelliflorous fruit type is only attracted by land mammals (Shanahan and Compton 2001).

Various morphological combinations of fig species at the study site showed the feed availability for all frugivore categories. Especially for medium sized fruit, it could be consumed by various frugivores with various sizes (Tan et al. 2014). Meanwhile, primates prefer large fruit with a size of more than 5 cm such as *F. variegata*. This is an evolutionary form of fig species forming a strategy for seed dispersal by developing the shape and fruit color in such a way as to attract the different types of frugivores that consume them.

Ficus on Mount Ungaran has potential as feed for frugivore groups, such as birds and mammals. They provide habitats for them (Rahayuningsih et al. 2017) and large trees for nesting (Rahayuningsih and Kartijono 2013). This study was able to explain that the various characteristics of fig from various categories could provide food for various types of frugivores. Even for the less potent species, figs still have a particular role to play for frugivores with special characteristics. This confirmed that the forest condition in Bukit Gentong, Gunung Ungaran, has good food availability, especially for frugivores. Forest areas with large trees and abundant feed have high potential as habitats for frugivores (Gomes et al. 2008).

A total of 24 *Ficus* with various fruit sizes have been identified, including 4 high-potential species, 11 potential species, and 9 less potential species. Strangler figs species are major resources (Kinnaird and O'Brien 2007), and losing them can lead to mass extinction (Watson and Herring 2012). Over all, *Ficus* protection is therefore essential to providing feed resources on Mount Ungaran to protect balance the ecosystem. However, less potential species does not mean that they do not have an ecological function, such as *F. variegata* which provides food for primates, where almost all species are scarce.

Conclusion

The research showed 24 species of *Ficus* species in six sub-genera recorded in Gentong Hill of Mount Ungaran. Those which has high potential value were *F. kerkhovenni, F. crassiramea* ssp. *crassiramea, F. drupacea, F. involucrate*. The various characteristics of figs from different categories were able to provide food

for different frugivore groups. Even for the less potent species, figs on Mount Ungaran still have a certain role for the frugivore species with special characters.

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