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Ficus-frugivore interaction in the forest reserves of Central Mindanao University: its importance to forest restoration

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Abstract. *Ficus* is one of the most important plant groups in the tropical rainforest ecosystems chiefly considered as a major food source for frugivores. *Ficus* is the fifth most speciose genus in the Philippines comprising 104 species. In this paper, we emphasized the trophic relationship of the *Ficus* spp. and frugivores including the observed association with other plant species. The study was conducted in the three forest reserves of Central Mindanao University in Musuan, Bukidnon, Philippines. *Ficus* spp. were surveyed along the established grids. On every *Ficus* spp., a 10-meter circular plot was delineated. All plants within the plot were identified. Mist nets were established on *Ficus* spp. bearing ripe synconia to sample the frugivores. Results revealed twelve (12) species of *Ficus* within the forest reserves. *Ficus balete* was found to be the most abundant and widely distributed while *F. crassiramea* was the most visited by frugivores. Avian species under the family Sturnidae and Pynonotidae were frequently observed feeding on synconia. For volant mammals, only the species under Family Pteropodidae were recorded. The plant species found constantly associated to all surveyed *Ficus* spp. were *Baccaurea tetrandra*, *Senna spectabilis*, *Melanolepis multiglandulosa* and *Myristica glomerata* suggesting trophic preference by frugivores, hence their association and dispersal. In general, the number of frugivore species and *Ficus* spp. diversity is seemingly correlated as observed from the number of caught frugivores and the number of *Ficus* spp. recorded.
Key Words: fig, synconia, natural regeneration, wildlife diversity, forest restoration.

Introduction. *Ficus* is relatively large genus with about 735 species distributed globally, exhibiting numerous growth forms which include shrubs, trees, climbers, epiphytes as well as hemi-epiphytic stranglers, making it the world's most diverse woody plant genus (Frodin 2004; Berg & Corner 2005). According to Berg (1989), *Ficus* is a diverse genus and could be found in all types of forests. In the Philippines, *Ficus* is the fifth most speciose genus consisting of 104 species. It is an important plant resource due to its high economic and nutritional values as well as significant part of biodiversity in the rainforest ecosystem. In addition, it is a source of food for frugivores in tropical areas (Rønsted et al 2005). Globally, a staggering over 1200 vertebrate species feed on figs, which fruit all year round thus are considered critically important to wildlife when other fruits are not available (Shanahan et al 2001).

Most of the published literatures regarding *Ficus* spp. discussed its role as keystone resource for frugivores in many tropical forests (Terborgh 1986; Gautier-Hon & Michaloud 1989). However, correlating the importance of this genus as drivers to plant diversity and species composition deserves investigation to further understand the functional role and importance of *Ficus* spp. in the context of forest succession and restoration. Hence, this study was conducted to determine the influence of *Ficus* spp. on the dispersal, frugivores' feeding preferences and pattern of plant association and how these could influence innatural regeneration and forest restoration. This study focuses on *Ficus* spp. inhabiting the natural forests of Central Mindanao University and their association with avifauna, volant mammals and plants.

Material and Method

Locale of the study. This study was conducted at the lowland evergreen rainforest of Central Mindanao University namely: Mt. Musuan Zoological and Botanical Garden (MMZBG), Taganibong Watershed Forest Reserve, and Faculty Hill Forest Reserve. Mt. Musuan Zoological and Botanical Garden (MMZBG) is found on the northwestern foothills of the famous landmark volcano, the Mt. Musuan, also known as Mt. Kalayo with coordinates 125°4'E longitude and 7°52'N latitude comprising 7.25 hectares at 400 masl. The Taganibong watershed forest reserve is located opposite to MMZBG with geographic coordinates 7°53'2N and 125°2'29E covering 10.89 hectares. The forest reserves at the Faculty Hill is located within the coordinates of 125°04'7E longitude and 7°84'9N latitude with an elevation of 349 masl and approximately 10.84 hectares (Figure 1). The survey of *Ficus* spp. was conducted on the months of September to November 2014 while the sampling of frugivores was done on December 2014 to February 2015.

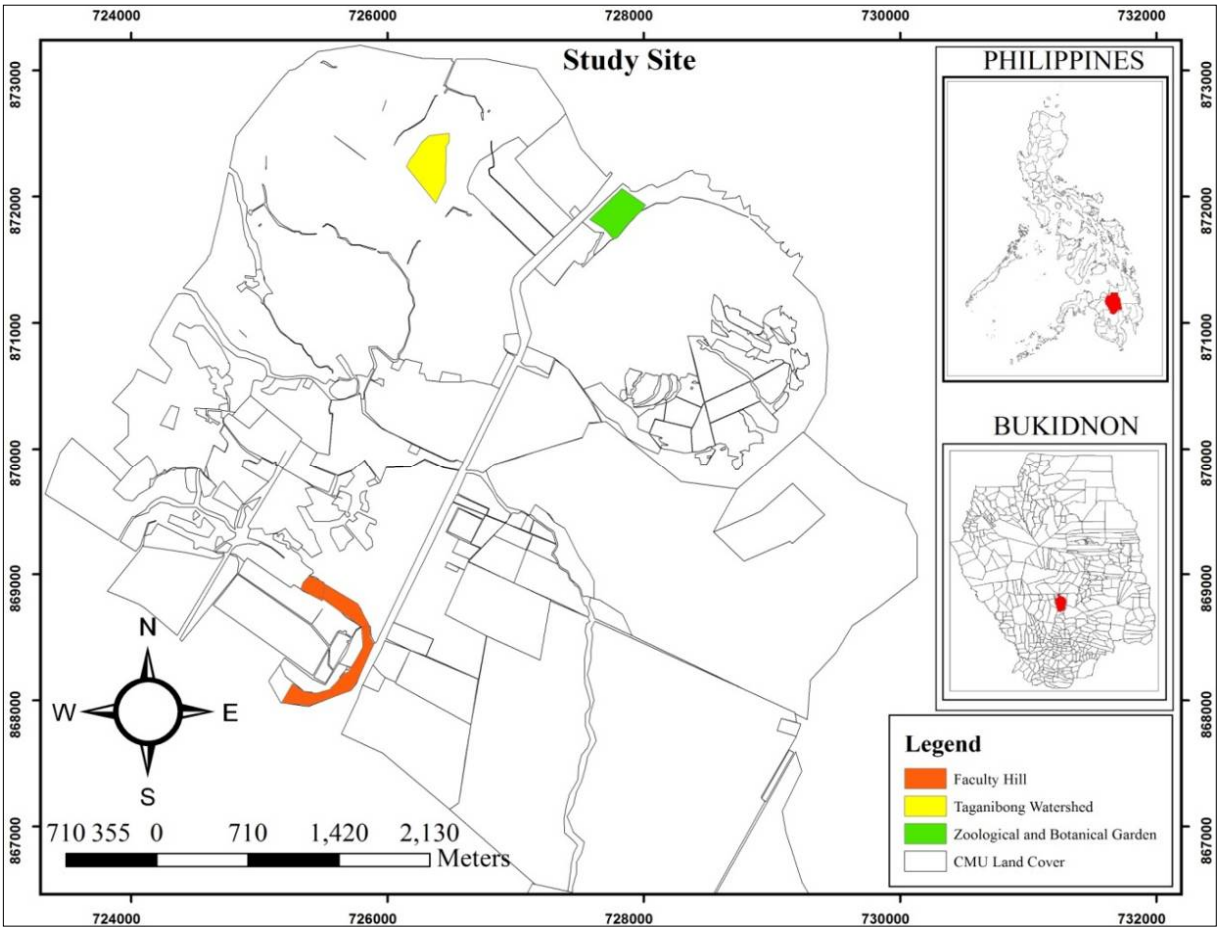

Figure 1. Map of the study site (Source: Villar 2005).

Using Google map the study sites were demarcated with grid lines. These lines were ground-truth using GPS and serve as the route for the inventory of the various *Ficus* spp. (Figure 2). All *Ficus* spp. found within and proximate to the transect line were geotagged using GPS. To determine the associated species, the circular sampling technique was employed wherein all tree species found inside the 10m radius at the point where the *Ficus* was located were recorded. Specimens for both the *Ficus* spp. and the associated species within the sampling points were collected and identified using the Flora Malesiana series and other available taxonomic references such as Merrill (1923-1926); Rojo (1999); Fernando et al (2004, 2008); Co et al (2006); Pancho & Gruezo (2006); La Frankie (2010); and Van Balgooy (1997). Verification of species identification was made

from the information accessed at the www.philippineplants.org as well as the type images of the Philippine National Herbarium.

Mistnetting method was employed to sample the avifauna and volant mammals. Mist nets were established on every *Ficus* spp. bearing ripe synconia. Two mist nets with at least 1 meter above the ground were established to sample the low-flying frugivores while 1 mist net was set up within the canopy level as high as > 10 meters above the ground. Sampling was done on 10 mistnet days. Caught avifauna were photographed and were marked by cutting the outer tail feather and were released afterwards. For bats, data on morphometrics were collected prior to marking and release. Identification of birds was done using Kennedy et al (2000) while bats were identified using Ingle & Heaney (1992).

Results and Discussion

Ficus-frugivore relationship. Only four (4) *Ficus* spp. bear ripe synconia during the conduct of the study. These include *F. variegata* Blume, *F. forstenii* Miq., *F. callosa* Willd., and *F. crassiramea* (Miq.) Miq. These *Ficus* spp. were monitored for four consecutive weeks to determine the feeding preferences of frugivores. Six (6) species of bats and four (4) species of avifauna were recorded during the entire observation. Avifauna captured belong to families Pycnonotidae, Columbidae, Vireonidae, and Sturnidae while only Pteropodidae was observed among the volant mammals (Table 1). The avian families observed in this study has similarity with the study of Shanahan et al (2001) wherein species under Columbidae, Psittacidae, Pycnonotidae, Bucerotidae, Sturnidae, and Lybiidae were observed foraging on figs. While among the mammals, the major fig-eating families observed by Shanahan et al (2001) include Pteropodidae, Cercopithecidae, Sciuridae, Phyllostomidae, and Cebidae. Relox et al (2014) observed the same in Mt. Apo in Mindanao, Philippines and reported that the only volant mammals foraging on figs include *Cynopterus brachyotis* Müller, *Haplonycteris fisheri* Lawrence, *Ptenochirus minor* Yoshiyuki, *Macroglossus minimus* É. Geoffroy, and *Ptenochirus jagori* Peters. Most of these volant mammals are Philippine endemics and are considered seed dispersers of various species of forest trees (Relox et al 2014). Further, Achondo et al (2014) obtained comparable results in terms of volant mammals sampled in Kidapawan, Cotabato and Balabag Natural Reserve in Mt. Apo both in Mindanao, Philippines.

Results of this study in Table 1 also revealed that the most eaten and frequently visited fig was *F. crassiramea* with two species of birds i.e. *Sturnus vulgaris* L. and *Pycnonotus goiavier* Scopoli and six species of bats i.e *Harpyionycteris whiteheadi*, *H. fischeri*, *M. minimus*, *P. minor*, and *P. jagori*. Contrastingly, the less visited is *F. variegata* with only two species of birds, i.e. *Chalcophaps indica* L. and *Vireo gilvus* Vieillot and two species of bats i.e. *C. brachyotes* Müller and *P. minor* were recorded.

Table 1

Observed frugivores feeding synconia on four *Ficus* spp.

Species	*Number of individuals*				*Total*
	Ficus callosa	*Ficus crassiramea*	*Ficus forstenii*	*Ficus variegata*	
VOLANT MAMMALS					
Ptenochirus minor	5	24	16	10	55
Haplonycteris fischeri	11	17	8	0	36
Ptenochirus jagori	8	11	9	0	28
Haplonycteris whiteheadi	15	4	5	0	24
Macroglossus minimus	0	2	0	0	2
Cynopterus brachyotis	0	0	3	3	6
AVIFAUNA					
Chalcophaps indica	0	0	0	3	3
Vireo gilvus	0	0	0	4	4
Pycnonotus goiavier	0	8	10	0	18
Sturnus vulgaris	0	12	11	0	23

Based on the results, the frugivores could be classified via feeding preferences, i.e. generalist (feed on all figs species) and specialist (feed on specific figs). In the case of volant mammals, the endemic species consisting of *P. minor*, *H. fischeri*, *P. jagori* and *H. whiteheadi* appears to be generalist having recorded on almost all of the fruiting *Ficus* spp. On the other hand, the non-endemic species *C. brachyotis* and *M. minimus* have been observed in one or two *Ficus* spp. only. According to Shanahan et al (2001), *Ficus* species are not equally suitable for all frugivores in a given area. Further, different patterns of frugivore attraction were associated with differences in fruit characters. Specifically, green or brown figs tend not to attract avian frugivores and such figs are rarely as small as the smallest bird-dispersed figs. However, fig-eating animals can be considered in three broad groups such as specialists, generalists and casual consumers of figs (Shanahan et al 2001). Lambert & Marshall (1991) reported that almost all of the pigeons of family Columbidae in the tropical forest are generalist with *Ficus* spp. as the major food source. The same was observed for Pteropodidae especially *Cynopterus* sp., *P. minor*, *P. jagori* and *H. fischeri*. Shanahan et al (2001) concluded that a forest with numerous *Ficus* species are often visited by many frugivores which corroborate with the findings of this study as observed in the Faculty Hill forest reserve wherein the occurrence of various species of *Ficus* seemingly correlates with the number of caught frugivores in the area.

Diversity of Ficus species. Figure 2 shows the number of *Ficus* spp. recorded in the three forest reserves of CMU. Twelve (12) *Ficus* spp. comprising 242 individuals were identified out of the 104 species recorded in the Philippines. The identified species consist only of *Ficus* with trees or shrub as their habit, stranglers and hemi-epiphytes were not included. The species include *F. balete*, *F. callosa*, *F. variegata*, *F. septica*, *F. calophylla*, *F. cordatula*, *F. ampelas*, *F. forstenii*, *F. crassiramea*, *F. pseudopalma*, *F. banahaensis* and an unknown *Ficus* spp. Among these, *F. balete* Merr. was the most abundant followed by *F. callosa* Willd., *F. variegata* Blume, and *F. ampelas* Burm.f. while the least abundant was *F. crassiramea* (Miq.) Miq. Amoroso et al (2014) have similar observations in Mt. Musuan Zoological and Botanical Garden as well as in the Faculty Hill forest reserve with *F. balete* obtaining the highest dominance. Relox et al (2014) reported that *F. balete* is the most widely distributed species and with the highest dominance among other plants in Mount Apo in Mindanao. Similar observation was reported by Orlanes (2002) in Tabunan forest in Cebu in the Visayas region.

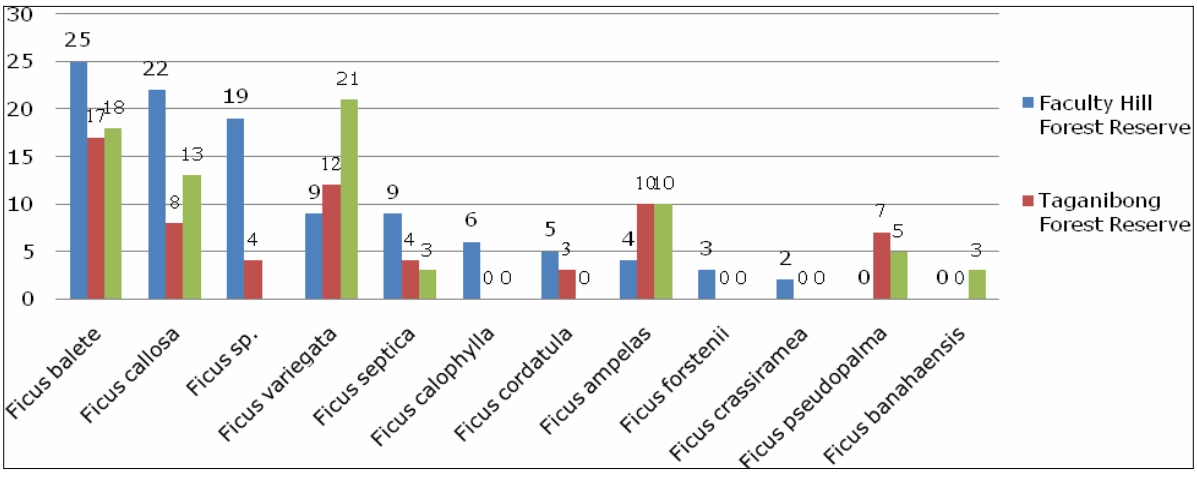

Figure 2. *Ficus* spp. in the forest reserves of CMU.

Results also revealed that the Faculty Hill forest reserve had the highest number of *Ficus* species recorded among the three forest reserves of CMU with 10 species, followed by Taganibong watershed forest reserve with 8 species while the least is the Mt. Musuan Zoological and Botanical Garden with only 7 species recorded. This observed abundance of *Ficus* spp. in the Faculty Hill forest reserve is that this area has relatively less disturbance to wildlife species. The presence of wildlife aid in a relatively effective

dispersal. In the case of Taganibong, the trails of this forest are used as routes of residents at the periphery. The forest is also mixed with plantation species such as *Sweitenia macrophylla* King, *Gmelina arborea* Roxb. and giant bamboos which are used for wood production of CMU's income generation project. On the other hand, the Mt. Musuan is an area that is frequently visited by students and tourists who do laboratory activities and for recreation, respectively.

Ficus spp. - plant species association. The frequency of plant species associated with the twelve (12) *Ficus* spp. was graphed to determine their association (Figure 3). The data were derived from the 188 circular sampling points comprising approximately 5.29 hectares. In general, four plant species found to have the highest frequency of association with *Ficus* spp. These include *Baccaurea tetrandra* (Baill.) Müll. Arg., *Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll., *Senna spectabilis* (DC.) H.S. Irwin & Bar. and *Myristica glomerata* Kudo and Masam (= *Knema glomerata*). Based on the result, this study confirms the reports of Amoroso et al (2014) and Olpenda et al (2013) that *M. multiglandulosa* and *S. spectabilis* were the species with highest species importance value (SIV) in Mt. Musuan Zoological and Botanical Garden and *M. glomerata* and *S. spectabilis* in Taganibong watershed forest reserve, respectively. Marsden & Pilgrim (2003) stressed that *M. multiglandulosa* is one of the most favored food plants of avian species. Meanwhile, *B. tetrandra* and *M. glomerata* have edible fruits, the latter is being foraged by rodents. However, the widespread occurrence and distribution of *S. spectabilis* may not be directly attributed to trophic relationship with frugivores but probably due to the invasiveness of the species being considered as among the most invasive alien species (IAS) in the world (Obiri 2011; Richardson & Rejmánek 2011; Semenya et al 2012).

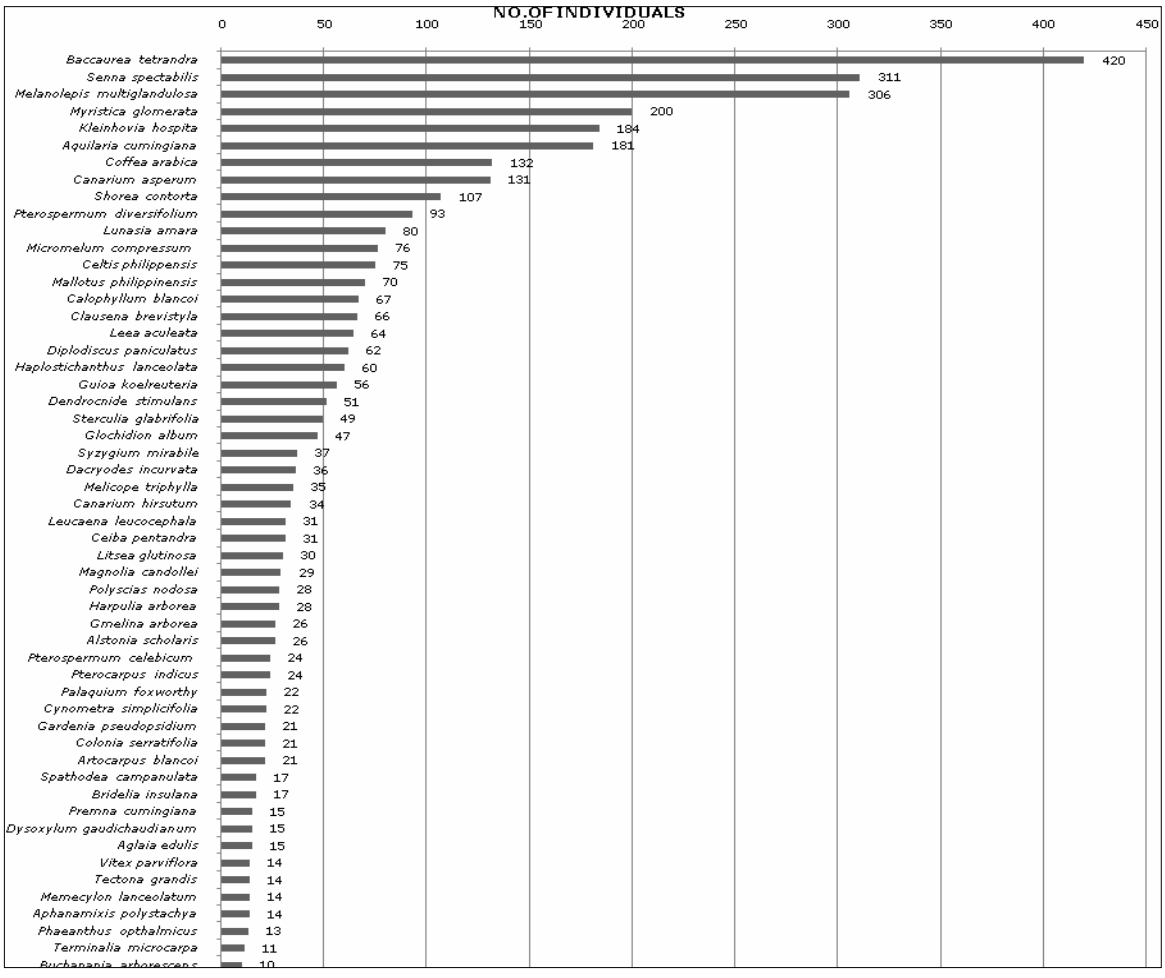

Figure 3. Frequency of associated plant species of *Ficus* spp.

The observed association of other plants to various *Ficus* spp. strongly indicates foraging preferences of the frugivores hence, clearly exhibiting the trophic relationship. This association also exemplified the effective seed dispersal ability of frugivores. Thus the idea that *Ficus* diversity eventually influences the plant alpha-diversity (α-diversity) of the area via frugivores is seemingly overwhelming in the absence of anthropogenic-induced habitat fragmentation and destruction. Further, relationship between *Ficus* spp.-frugivore has an eventual influence on forest restoration and natural regeneration. Recent concepts on framework species approach (FSA) to forest restoration recommend the use of *Ficus* spp. as drivers of diversity by providing food sources to wildlife and eventually facilitating seed dispersal and forest succession to occur thus facilitating wildlife habitat regeneration and restoration.

Conclusions. Forests within CMU campus still harbors 12 species of *Ficus* that enhances diversity of wildlife. This study emphasizes the paramount importance of the trophic relationship between *Ficus* spp. and frugivores. The data suggest that *Ficus* spp. and frugivores co-exist, each with specific niche that mutually influences their survival. Findings reveal that endemic volant mammals, such as *P. minor, H. fischeri, P. jagori* and *H. whiteheadi* were recorded on fruiting *Ficus* spp. *Pycnonotus goiavier* and *Sturnus vulgaris* were also the observed frugivores. Results of the study further reveal that *Ficus* spp. are also associated with other plants such as *M. multiglandulosa*, which is a preferred food of avifauna, and *B. tetrandra* and *M. glomerata* which are food sources of rodents. This *Ficus*-fauna-plant association promotes natural seed dispersal that will account for natural regeneration and forest restoration. Thus, this implies that *Ficus* is a keystone species in forest ecosystems. By attracting and sustaining animals which also feed on and disperse seeds of diverse range of other fruits, *Ficus* guilds (dispersers) may have further roles in maintaining diversity of other plant species and in facilitating regeneration of disturbed habitats. However, abundance of flora may not be directly attributed to wildlife but may also an indication of the extent of human influence or due to its invasive nature such as *S. spectabilis* dominantly found in the study site. Thus, it is important to know what to prioritize in forest regeneration or restoration initiatives, i.e. for production of forest resources for income generation or for protection of forest for wildlife.

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