Floral and Fruiting Phenology in the Lowland Forests of Palanan, Isabela, Philippines

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Abstract

The Palanan lowland forests are being utilized in many ways. It has been a research site for determining ecosystem resiliency. To the communities especially the Agtas, it is an area where they get resources from. Among its ecosystem services is pollination and seed dispersal which can be understood by studying the reproductive phenological development of plant species considering there is little knowledge on biotic interactions involved. The collection of reproductive phenological data was performed in the four sites within the lowland forests of the municipality of Palanan: Brgy. Dipogen, PFDP, and Brgy. Alomanay and Mangrove area in Maharlika. A modified reproductive phenology scoring was utilized. Individual tree count in PFDP is high due to the high recruitment rate brought upon by the frequent freeing up of space in the forest canopy every typhoon, which temporarily removes light limitation for seedlings to grow. The majority of the reproducing species during the study period were categorized as supra-annuals. Of these families, Meliaceae, Euphorbiaceae, Lauraceae, Annonaceae, Lamiaceae, Rubiaceae, Arecaceae, and Dipterocarpaceae, all of which are among the most species-rich families inside the plot with flowering and fruiting occurring during the hot dry conditions. Almost forty percent of the species reproduce sub-annually (≈20%) and annually (≈18%). The less rich group of species reproduces continuously. Current data shows flowering was

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mildly affected by temperature and moderately affected by rainfall. Fruiting was not really affected by temperature and rainfall.

Keywords

Reproductive phenology · Palanan, Isabela · Lowland forests

14.1 Introduction

With the increasing population of the Philippines, more space is needed for agricultural lands to meet the demand and increase food security. Local practices such as Swidden agriculture (kaingin) clear forest patches for the planting of crops on a smaller scale. Timber, on the other hand, is harvested for the building of houses of locals. Housing and infrastructure for the public such as clinics, hospitals, and schools require space. It is common for developing countries to expand land use to these basic services. Inevitably, a lot of green spaces are removed to accommodate these needs. Along with the removal of forest cover is also the loss of habitat for a part of the wildlife population. Additionally, illegal logging is still a big problem, especially in less monitored forests. With the increasing rate of deforestation in the country, it is of primary concern to replenish the lost green spaces wherever needed and possible. Aside from the lowlands and mountains, the mangrove ecosystems also suffer from indiscriminate logging and conversions. In response to this, reforestation programs have been put up by the government, non-government organizations, and the private sector; through laws that required private companies to help in restoring lost habitats, especially for mining companies, as part of corporate social responsibility. All the aforementioned affects the ecosystem services provided by forest ecosystems. One of the most important of which is pollination and seed dispersal. However, in order to evaluate this, one must understand the reproductive phenological development of plant species. It is, therefore, imperative that floral phenology be considered in literature considering there is little knowledge on biotic interactions involved.

Plant reproductive phenology is the study of the periodicity of repeating biological events in plants, in relation to short-term climatic change (Sakai et al. 2005). Long-term disturbances brought about by anthropogenic factors can directly affect floral phenology and ecology as these may cause a decrease in the population and diversity of plant species (Hussein et al. 2021) and plant community structure (Wolf et al. 2017) which in turn cause habitat loss for the fauna. Climatic conditions also directly affect the floral ecology and in return, if reproduction is successful, it affects the microclimatic environment through vegetation enhancement. Conservation and management can be performed when all aspects are considered.

In the Philippines, a long-term research area has been established in Palanan, Isabela. Palanan, Isabela is a first-class municipality whose population in 2021 is at 17,260 and estimated revenue of PhP2,6M (DTI 2021). It is a remote and isolated coastal town, separated by the Sierra Madre Mountains along its western borders from most of the towns of Isabela. As early as 2020, the Ilagan-Divilacan Road was opened to enable travel by land to the remote towns of Divilacan, Maconacon, Palanan, and Dinapigue.

Palanan's forest is the only forest patch in the Philippines whose monitoring or census is mainly supported by the Smithsonian Tropical Research Institute (STRI) through its Forest Global Earth Observatory Network (ForestGEO). A 16-ha area, the Palanan Forest Dynamics Plot (PFDP), was established in 1994 for this endeavor. Since the Palanan Forests is quite vast, several communities of indigenous Agta live in it. However, their culture has been threatened by socio-economic pressures added to the general ecosystem being affected by illegal logging, resource exploitation, and land-use change (ForestGEO 2022).

This chapter shall discuss the reproductive phenology of plant species within selected sites of the Palanan Forest. Methodologies utilized will also be presented. This data assists in describing the area's long-term dynamics as well as in the understanding of how forests respond to continuous disturbances, such as typhoons and human interventions.

14.2 Gathering Reproductive Phenological Data

This is an offshoot study from the larger objective of assessing the bat pollen diet of phytophagous bats in the lowland rainforests of Palanan, Isabela which is a part of a 2.5 years research program (2016–2018) in understanding fruit bats and their interaction with plants in the said area. The underlying criteria for choosing the sites are based on different populations of phytophagous bats determined through the capture and recapture method which this phenological study is supporting.

The collection of reproductive phenological data was performed in the municipality of Palanan. A total of four sites were utilized for the study. The three study sites in the lowland forests were Brgy. Dipogen, Palanan Forest Dynamics Plot (PFDP), and Brgy. Alomanay (Fig. 14.1). PFDP is a reserved area; Brgy. Alomanay site is at a higher elevation and Brgy. Dipogen is at a mid-elevation of the two. The Agta communities are nearest to Brgy. Dipogen site. The fourth site in the lowland forest was later replaced by a mangrove site in Barangay Maligaya due to the similarity of plant assemblages with PFDP. The selection of the mangrove site was to give an array of information regarding the reproductive phenology of mangrove and mangrove-associated species. These sites were visited one after another. The monitoring of the transects was conducted from April 2016 to November 2017.

Diurnal phenological observation and data collection were performed, in between nocturnal nettings. In each site, three 20 m x 80 m transects were set up in the middle of the 20 nets utilized for the bat research. This rendered a sum of 4800 m^2 of surveyed area for each site and 19,200 m^2 for all four sites. The presence of flowers and fruits was recorded using a reproductive phenology scoring (Table 14.1) devised by Yap (2015), which was used in her previous studies in the PFDP. It includes a recording of flowering and fruiting intensity by eye estimation of its percent canopy cover. This phenological scoring is qualitative, simpler, and more practical in field

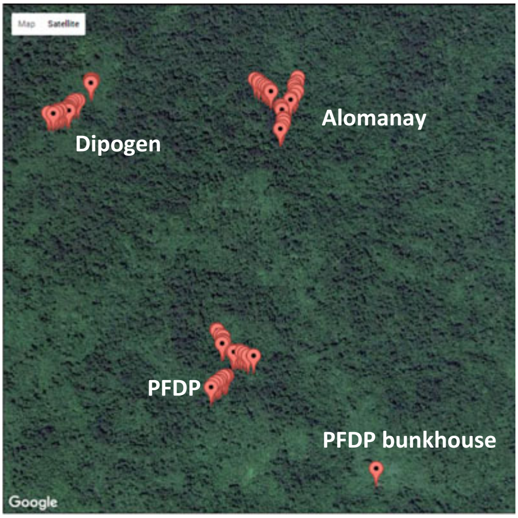

Fig. 14.1 Map of the three study sites. The mangrove site is not represented in the figure. (https://www.darrinward.com/lat-long)

Table 14.1 Modified reproductive phenology scoring (devised by Yap 2015)

Flowering	Intensity	Fruiting
1 if >50% of the buds are closed 2 if >50% of the flowers are opened 3 if >50% of the flowers are in anthesis or dying	0 if ≤25% of the canopy are w/fruits 1 if >25% of the canopy are w/fruits 2 if >50% of the canopy are w/fruits 3 if >75% of the canopy are w/fruits	1 if >50% are unripe and 2 if >50% are ripe

studies without spending long hours gathering absolute counts of flowers and fruits. This was modified from crown estimates of flower and fruit cover within the canopy, methods which were first used in other studies such as Koelmeyer (1959), Sinhaseni (2008), and Elliott et al. (2013). However, the work of Yost et al. (2018) on reproductive phenology scoring using digitized protocol may be utilized later as herbarium specimens have been collected.

Field plant identification was mostly done by long-term field guides and locals. These guides were trained from the previous censuses of the PFDP to identify plants using plant codes representative of the scientific names of the plants in the Palanan plant code guide. Voucher and flower collection were simultaneously done with a gathering of field phenology data (Fig. 14.2). Voucher collections were gathered for identification of individuals that cannot be readily identified in the field, thus were pressed, and brought to the UP Diliman herbarium. Different flora was also utilized for identification and name verification (Pelser et al. 2011; Madulid 2021; Pancho 1983; Pancho and Gruezo 2006; Pancho and Gruezo 2012; Slik 2009). Flower collections were done in conjunction with pollen-type identification.

Data on monthly rainfall and temperature were also gathered through the Davis Weather Station and Vantage Pro™ that was set in the PFDP bunkhouse. This data

Fig. 14.2 Phenology monitoring in the field (**a** and **g**) field guides assist in spotting reproductively active individuals, (**b**) field guides inspecting tag number of trees, (**c** and **d**) climbing trees to get flowers and fruits, (**e**) inspection of buds/fruits, and (**f**) gathering individual flowers/florets for mounting of pollen

was utilized in determining the general conditions in the sites which then is correlated to the reproductive phenology.

14.3 Temperature and Rainfall Readings

Mean temperature together with the total rainfall every month was plotted (Fig. 14.3). Some missing data (e.g., months of February to April 2017) were filled via imputation and interpolation method while data for April 2016 to July 2016 cannot be filled artificially. Examining the timing of reproduction of the species in the lowland forests of Palanan, at least two thirds of the monitored species reproduced during the hot months of April to September. In October 2017, the mean temperature reached 26.06 °C and rainfall hit 500.61 mm from a low of 56.83 mm the preceding month. Almost the same scenario can be seen from the interpolated data for October 2016 (μ temp. = 26.39 °C, total rainfall = 527.03 mm).

14.4 Richness and Diversity of Reproducing Tree Species

Individual tree count in PFDP is high due to the high recruitment rate. The high recruitment in the plot is brought upon by the frequent freeing up of space in the forest canopy every after typhoon, which temporarily removes light limitation for seedlings to grow. This demonstrates good forest resiliency (Yap et al. 2015). The proportion of the reproductive species > and <5.0 cm in DBH from the

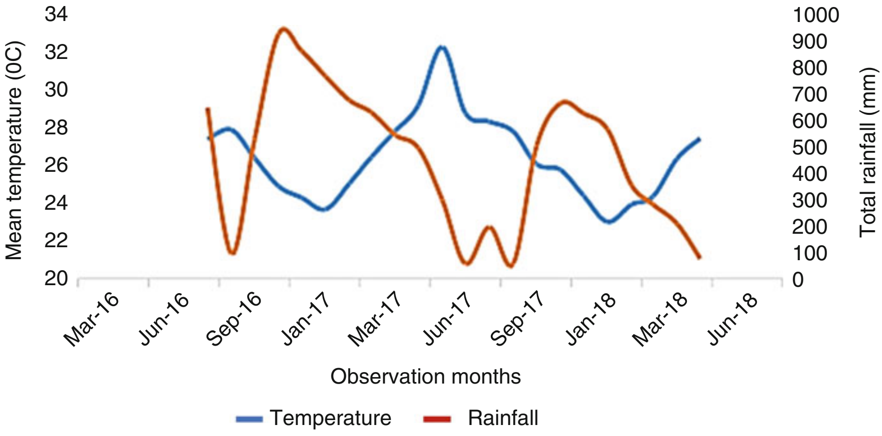

Fig. 14.3 Mean monthly temperature and rainfall in Palanan lowland forest

429 individuals observed to have flowered was examined. This was computed from the data from the first year. It is remarkable that the proportion is 1:1, however even if the individual effort is 1:1, the intensity per individual is greater in bigger conspecifics.

A total of 151 species of fruiting species from 98 genera in 45 families were inside the transect used. Of these, only 107 species from 79 genera in 40 families were observed to have entered at least one episode of reproduction either in the form of flowering, fruiting, or both. Individuals that have been observed to be fruiting but not observed flowering the previous month were considered to have flowered during the 2-week fieldwork break. Of these families, Meliaceae has the most species representation. This was followed by the Euphorbiaceae, Lauraceae, Annonaceae, Lamiaceae, Rubiaceae, Arecaceae, and Dipterocarpaceae, all of which are among the most species-rich families inside the plot. Table 14.2 shows the five most represented families that flowered in PFDP along with their representative species. Their reproductive representation in the phenology data reflect how these families were the most successful and abundant in the lowland forests of Palanan. *Litsea* and *Polyathia* species were observed to be prolific flower producers as they were observed to form flower buds in several months. It is also worth noting that members of Euphorbiaceae such as from the genus *Macaranga* are fast-growing species. Some of them reproduce more than once in a year while members of the family Meliaceae reproduce once or less in a year.

14.5 General Flowering and Fruiting Phenology

The plant species monitored were placed in different phenological classes following the classification system devised by Newstrom et al. (1994). This system standardizes the comparisons on the phenological patterns as tropical plant species

Table 14.2 Five most species represented families that flowered in PFDP

Family	Representative species	
Meliaceae	*Aglaia edulis* (Roxb.) Wall *Aglaia elliptica* (C.DC.) Blume *Aglaia lawii* (Wight) Saldhana & Ramamoorthy *Aglaia oligophylla* Miq. *Chisocheton ceramicus* (Miq.) A. DC. *Chisocheton cumingianus* (C. DC)	*Chisocheton pentandrus* (Blanco) Merr. *Dysoxylum excelsum* Blume *Dysoxylum oppositifolium* F. Muell. *Dysoxylum parasiticum* (Osbeck) Kosterm. *Dysoxylum* sp. 01
Euphorbiaceae	*Endospermum peltatum* Merr. *Macaranga* sp. *Macaranga bicolor* Muell.-Arg. *Macaranga grandifolia* Merr. *Macaranga ovatifolia* Merr.	*Macaranga tanarius* (L.) Muell-Arg. *Omphalea malayana* Merr. *Suregada glomerulata (*Blume) Baill. *Suregada multiflora* (A.Juss.) Baill. *Trigonostemon* sp.
Lauraceae	*Cryptocarya cagayanensis* Merr. *Dehaasia incrassata* (Jack) Kosterm. *Endiandra coriacea* Merr. *Litsea albayana* Vidal *Litsea fulva* (Blume) Fernandez-Villar	*Litsea garciae* Vidal *Litsea tomentosa* Blume *Litsea varians* (Blume) Boerl. *Phoebe sterculioides* (Elmer) Merr.
Annonaceae	*Neouvaria acuminatissima* (Miq.) Airy-Shaw *Haplostichanthus* sp. incert. B *Haplostichanthus lanceolata* (Vidal) Heusden *Goniothalamus elmeri* Merr.	*Enicosanthum grandifolium* (Becc.) airy Shaw *Polyalthia* sp. *Pseuduvaria luzonensis* (Merr.) YCF Su & RMK Saunders
Lamiaceae	*Callicarpa* sp. *Callicarpa* cf. *platyphylla* *Callicarpa cumingiana* Schauer *Callicarpa platyphylla* Merr. *Clerodendrum bracteatum* Wall. ex Walp.	*Clerodendrum macrostegium* Schauer *Clerodendrum mindorense* Merr.

may vary geographically. Of the observed species to have reproduced during the observation period, the majority of the species were categorized as *supra-annuals* meaning that these plants reproduce in a scale greater than a year. Typically, though, the reproductive bouts are less than one per year. Those reproducing yearly and less than a year were labeled as *annual* and *sub-annual*, respectively. Those observed to flowering entirely were labeled *continual*.

However, since the duration of the observation is less than two years, the count of species reproducing supra-annually may indeed still consist of species flowering irregularly or those restricted to flower in general flowering (GF) periods which happens irregularly. Sakai (2000) presented that general flowering is a unique phenomenon occurring in lowland dipterocarp forests in Southeast Asia. In this phenomenon, most dipterocarp species may have profuse flowering in a span of several years in long periods and in synchronicity. Such can contribute to forest diversity because it can disrupt florivory, nectivory, and frugivory due to possible fluctuations in flower and fruit availability. The separation of those reproducing irregularly and strictly in GF events will be made with continuous observation of the species in the lowland forests of Palanan.

Among the monitored species, almost forty percent reproduce sub-annually (≈20%) and annually (≈18%). The less rich group of species reproduce continuously. This includes *Pinanga insignis*, *Musa textilis*, *Ficus congesta*, *F. fistulosa,* and *Caryota cumingii*. *Musa textilis* and its congeners are known to be visited by phytophagous bats for flowers, such as members of the genera *Rousettus, Macroglossus,* and *Eonycteris* (Marshall 1985). A phenology calendar was also constructed out of the data. Table 14.3 shows the full phenophase calendar for the two-year study which shows the timing of bud appearance, floral anthesis, and fruiting.

From April 2016 to March 2017 (Y1), a general trend of decreasing abundance (Fig. 14.4) in flowering and fruiting individuals was observed for the three sites in Palanan, this includes the sites in Brgy. Dipogen, PFDP in Brgy. Villa Robles and another site in Brgy. Alomanay. As in Table 14.3, most of the species monitored produced flowers and fruits during the observed hot dry conditions. Very few were observed during cold wet conditions.

General continuous (except July 2016 and January 2017) phenological data, and climatic condition observation from April 2016 to March 2017 (Y1) in the three sites, reveal quite interesting patterns (Fig. 14.5). Diversity of flowering species was observed to have at least positive weak ($r = 0.190777816$) correlation with average monthly temperature and negative moderate ($r = -0.512106557$) correlation with total monthly rainfall. The effect of temperature in the diversity of flowering species is very minimal but quite detrimental to rainfall. It is understandable the flowers being sink zones will not be produced at very high average monthly temperatures or when average monthly rainfall is high which will destroy the flowers directly. In both cases, plants are under stress. Similar observations were gathered by Ushio et al. (2020) in their study on GF in Bornean lowland rainforest. Using models and time series data from 1993 to 2011, they found out that GF is synergistic and not independent of cool air temperature and drought affecting it. On the other hand, the opposite was observed with the fruiting diversity ($r_{\text{temp}} = -0.30969$, $r_{\text{rain}} = 0.671168$). Since most flowering occurred during hot dry conditions, it is more likely that fruiting will come during cold wet conditions. This is not evident, though, as some species were still with fruiting or with fruits during hot dry conditions. Rainfall may have also not affected the presence of fruits. In the research of Polansky and Boesch (2013), rainfall does not explain fruiting phenology and diversity even with long-term changes. Both flowering and fruiting may also be linked to seasonal patterns, pollination syndromes, and dispersal mechanisms (Mohandass et al. 2018) so long-term monitoring is important.

With these insights even without the integration of the current data with previous data gathered by Yap in 2015, some inferences can be deduced. Considering climate change is a major threat to conservation, organizing long-term and multi-taxa data on

Table 14.3 Reproductive phenology of plant species with their phenological classes in select sites of the Palanan Lowland Forest

		Monitoring year 1			Monitoring year 2				
Scientific name	Family	FB	FO	Fruit	FB	FO	Fruit	Phenological class	General observed conditions
Aglaia edulis (Roxb.) Wall.	Meliaceae	NA	Aug	May, Dec	NA	NA	May	Annual	Hot/cold dry
Aglaia elliptica (C. DC.) Blume	Meliaceae	NA	NA	Aug				Supra-annual	Hot dry
Aglaia lawii (Wight) C.J.Saldanha	Meliaceae	NA	Apr	Apr				Supra-annual	Hot dry
Aglaia oligophylla Miq.	Meliaceae	NA	NA	Dec	May	NA	May, June, Aug, Sep, Oct, Nov	Annual	Hot dry
Albizia butarek sp. nov nom. ined.	Fabaceae-Mimosoideae	NA	NA	Oct, Nov, Dec	NA	NA	Sept, Oct, Nov	Annual	Cold wet
Antherostele banahaensis (Elmer) Bremek.	Rubiaceae	NA	Mar	NA				Supra-annual	Hot dry
Antidesma cumingii Müll.Arg.	Phyllanthaceae	NA	Apr, May	June, Aug, Sep, Oct				Supra-annual	Hot dry
Apocynaceae indet Juss.	Apocynaceae	NA	NA	Apr				Supra-annual	Hot dry
Ardisia sp. Sw.	Myrsinaceae	NA	Mar	NA				Supra-annual	Hot wet
Areca sp. L.	Arecaceae	NA	Apr, Aug, Oct, Feb, Mar	Apr, Dec				Supra-annual	Hot dry
Arecaceae Bercht. & J.Presl, nom. Cons.	Arecaceae	NA	Apr	Apr				Supra-annual	Hot dry
Astronia willamsii Merr. ex C.B. Rob. (unresolved name)	Melastomataceae	NA	NA	June, Mar				Supra-annual	Hot dry

(continued)

Table 14.3 (continued)

Scientific name	Family	Monitoring year 1			Monitoring year 2			Phenological class	General observed conditions
		FB	FO	Fruit	FB	FO	Fruit		
Barringtonia pterita Merr.	Lecythidaceae	NA	NA	June				Supra-annual	Hot dry
Callicarpa L.	Lamiaceae	NA	NA	Oct				Supra-annual	Hot dry
Callicarpa cf. *platyphylla* Merr.	Lamiaceae	Oct	June, Oct	June				Supra-annual	Hot dry
Callicarpa cf. *platyphylla* Merr.	Lamiaceae	Oct	June, Oct	June				Supra-annual	Hot dry
Callicarpa pentandra Roxb.	Lamiaceae	May, Oct	June, Oct	Oct				Supra-annual	Hot dry
Callicarpa platyphylla Merr.	Lamiaceae	June, Aug, Oct	June, Oct					Supra-annual	Hot dry
Camellia lanceolata (Blume) seem.	Theaceae	Feb	NA	NA	NA	NA	Sept	Subannual	Hot wet
Caryota cumingii Lodd. Ex Mart.	Arecaceae	Apr, May, Sept	May, Oct, Mar	Apr, May, June, Aug, Oct, Feb, Mar	June, Sept, Oct	May, June, July, Oct, Nov	May, June, July, Sep, Oct	Continual	All conditions
Caryota rumphiana Mart.	Arecaceae	NA	NA	June, Aug, Sept, Oct, Dec, Feb, Mar				Subannual	All conditions
Chisocheton ceramicus Miq.	Meliaceae	June, Aug	June, Aug, Oct	NA	May	NA	Nov	Annual	Hot dry
Chisocheton cumingianus (C.DC.) harms	Meliaceae	June	NA	NA				Supra-annual	Hot dry

Chisocheton pentandrus (Blanco) Merr.	Meliaceae	Aug	NA	Dec	May, June, July, Oct	July, Aug	Oct, Nov	Annual	Hot dry
Clerodendrum bracteatum wall. Ex Walp.	Lamiaceae	NA	May	June, Aug, Oct				Supra-annual	Hot dry
Clerodendrum macrostegium Schauer	Lamiaceae	Aug, Oct	Aug, Oct	NA				Supra-annual	Hot dry
Clerodendrum mindorense Merr.	Lamiaceae	Feb, Mar	Apr, Dec, Feb, Mar	Apr, May, June, Oct, Dec				Subannual	Hot dry
Cryptocarya cagayanensis Merr.	Lauraceae	NA	NA	May				Supra-annual	Hot dry
Cyrtandra oblongata Merr.	Gesneriaceae	Sept, Dec	Sept, Oct, Dec	Oct	NA	May	May	Subannual	Hot and cold dry
Dalrympelea sphaerocarpa (Hassk.) Nor-Ezzaw.	Tapisciaceae	Feb	Feb	Oct				Supra-annual	Cold wet
Dehaasia incrassata (Jack) Kosterm.	Lauraceae	May	May	June, Aug, Sept, Oct, Nov, Dec				Supra-annual	Hot wet and dry
Dendrocnide subclausa (C.B.rob.) chew	Urticaceae	NA	NA	Aug				Supra-annual	Hot dry
Diospyros discolor Willd.	Ebenaceae	Aug, Oct	Aug, Oct	NA				Supra-annual	Hot dry
Diospyros buxifolia Thouars	Ebenaceae	NA	NA	May				Supra-annual	Hot dry
Diplodiscus paniculatus Turcz.	Malvaceae	June	NA	NA	NA	May	May	Annual	Hot dry

(continued)

Table 14.3 (continued)

Scientific name	Family	Monitoring year 1			Monitoring year 2			Phenological class	General observed conditions
		FB	FO	Fruit	FB	FO	Fruit		
Diplospora fasciculiflora Elmer	Rubiaceae	NA	Apr	NA				Supra-annual	Hot dry
Diplospora tinagaoensis (Elmer) S.J.Ali & Robbr.	Rubiaceae	Apr	Apr, Oct	Apr, May				Annual	Hot dry
Dipterocarpus validus Blume	Dipterocarpaceae	NA	NA	Aug				Supra-annual	Hot dry
Discocalyx insignis Merr.	Myrsinaceae	Sept	NA	NA				Supra-annual	Hot dry
Discocalyx micrantha Merr.	Myrsinaceae	June	June	Aug, Sept				Supra-annual	Hot dry
Drypetes grandifolia (C.B.rob.) pax & K. Hoffm.	Putranjivaceae	NA	NA	Apr, May, June, Aug, Nov, Dec, Feb	NA	Apr, July	Apr, May, July, Oct	Annual	Hot wet and dry
Dysoxylum excelsum Blume	Meliaceae	Feb	NA	NA				Supra-annual	Cold wet
Dysoxylum oppositifolium F. Muell.	Meliaceae	NA	NA	Apr, May, Aug, Oct	NA	NA	May	Annual	Hot dry
Dysoxylum parasiticum (Osbeck) Kosterm.	Meliaceae				Mar	NA	May, June, July	Supra-annual	Hot dry
Dysoxylum sp. 01 Blume	Meliaceae	NA	NA	Apr, Aug, Oct, Nov				Supra-annual	Hot dry
Endiandra coriacea Merr.	Lauraceae				NA	Apr, Oct	Apr, Oct	Supra-annual	Hot dry

Endospermum peltatum Merr.	Euphorbiaceae	NA	NA	Dec	May, Sept	May	NA	Annual	Hot dry
Monoon grandiflorum (Becc.) B.Xue & R.M.K. Saunders	Annonaceae	Aug	Apr	Apr				Supra-annual	Hot dry
Ficus congesta (H. Lév. & Vaniot) H. Lév.	Moraceae	Apr, Aug, Nov, Dec	Apr, Dec, Feb, Mar	Apr, May, June, Aug, Sept, Oct, Dec, Feb, Mar	NA	May	Apr, May, June, July, Sept, Oct, Nov	Continual	All conditions
Ficus fistulosa Reinw. Ex Blume	Moraceae	May, Aug, Dec, Feb	Apr, May, Aug, Dec, Feb	Apr, May, June, Aug, Sep, Oct, Nov, Dec, Feb, Mar	May	May, July	Apr, May, June, July, Aug, Sep, Oct, Nov	Continual	All conditions
Garcinia macgregorii Merr.	Clusiaceae	May	NA	NA				Supra-annual	Hot dry
Phyllanthus albus (Blanco) Müll.Arg.	Phyllanthaceae	NA	NA	Mar				Supra-annual	Hot dry
*Phyllanthus lutescens (*Blume) Müll.Arg.	Phyllanthaceae	NA	NA	Mar				Supra-annual	Hot dry
Glycosmis greenei Elmer	Rutaceae	Sept, Oct, Feb	Oct	Dec	June, Oct	NA	NA	Subannual	Warm and cold wet
Gomphandra cumingiana (Miers) Fern.-Vill.	Stemonuraceae	Sept, Oct, Dec, Feb	Feb	May, Sept, Oct, Dec	Oct, Nov	Oct, Nov	Oct	Annual	Cold wet
Gomphandra luzoniensis (Merr.) Merr.	Stemonuraceae	Apr	Apr	Apr, May, June, Aug, Sept, Oct, Feb, Mar				Subannual	Hot dry

(continued)

Table 14.3 (continued)

Scientific name	Family	Monitoring year 1			Monitoring year 2			Phenological class	General observed conditions
		FB	FO	Fruit	FB	FO	Fruit		
Goniothalamus elmeri Merr.	Annonaceae	Dec	Dec	Dec, Mar	Nov	NA	NA	Annual	Cold wet
Gonocaryum calleryanum (Baill.) Becc.	Cardiopteridaceae	Na	Feb	Na				Supra-annual	Cold wet
Gynotroches axillaris Blume	Rhizophoraceae	Sept, Dec, Feb	May, Dec, Feb	May, Oct, Nov, Mar				Subannual	Warm and cold wet
Polyalthia lanceolata S.Vidal	Annonaceae	Apr	Oct	Oct	Na	Apr, Sep	Apr, Sept	Subannual	Hot dry
Polyalthia sp. incert. B. Blume	Annonaceae	Oct, Feb	Sept	May, Aug, Sept, Oct, Dec, Feb, Mar				Subannual	Warm and cold dry
Knema glomerata Merr.	Myristicaceae	May	NA	NA	NA	NA	June, July	Annual	Hot dry
Knema sp. lour.	Myristicaceae	Aug	NA	May, June, Aug				Supra-annual	Warm/ cold dry
Leea congesta Elmer	Vitaceae	Apr, Mar	Apr, May	May, Oct				Subannual	Hot dry
Leea guineensis G. Don	Vitaceae	Aug, Sep, Oct, Nov	Sept, Oct	Nov, Dec, Feb, Mar				Subannual	All conditions
Leea "hairy" D. Royen ex L.	Vitaceae	Oct	Oct	NA				Supra-annual	Hot dry
Leea indica (Burm. f.) Merr.	Vitaceae	Oct	Oct	NA				Supra-annual	Hot dry
Leea philippinensis Merr.	Vitaceae	NA	June	June				Supra-annual	Hot dry

Lepisanthes tetraphylla Radlk.	Sapindaceae	Apr	May	May, Oct				Annual	Hot dry
Leptonychia banahaensis (Elmer) Merr.	Malvaceae	NA	Apr, May, Feb, Mar	Apr, Mar	NA	Apr	Apr	Subannual	Hot dry
Litsea albayana S. Vidal	Lauraceae	May	NA	June, Feb, Mar	NA	Apr	Sept, Oct, Nov	Subannual	Hot dry
Litsea fulva Fern.-Vill.	Lauraceae	Apr, May, June, Sept	Apr, May, June, Sept	Oct, Nov, Dec, Feb, Mar				Subannual	Warm wet and dry
Litsea garciae S. Vidal	Lauraceae	Apr, Aug, Dec, Mar	NA	Apr, Aug				Subannual	Hot dry
Litsea tomentosa Blume	Lauraceae	Apr	Apr	Apr, Mar				Supra-annual	Hot dry
Litsea varians Boerl.	Lauraceae				Oct	NA	NA	Supra-annual	Hot dry
Macaranga Thouars	Euphorbiaceae	Aug	Apr, May	June, Sept, Oct, Mar				Subannual	Hot dry
Macaranga bicolor Müll.Arg.	Euphorbiaceae				May	May	June	Supra-annual	Hot dry
Macaranga grandifolia Merr.	Euphorbiaceae	Feb	Feb	NA	May, June, July	May, June, July	June	Annual	Hot dry
Macaranga ovatifolia Merr.	Euphorbiaceae	May, June, Sept	May, June	May, June, Aug				Subannual	Hot dry
Macaranga tanarius Müll.Arg.	Euphorbiaceae	Apr, May, Sept, Feb, Mar	Apr, Sept, Oct, Feb, Mar	Apr, Oct, Mar	NA	NA	May, Oct	Subannual	Hot dry
Magnolia acuminata (L.) L.	Magnoliaceae				NA	NA	July	Supra-annual	Hot dry

(continued)

Table 14.3 (continued)

Scientific name	Family	Monitoring year 1			Monitoring year 2			Phenological class	General observed conditions
		FB	FO	Fruit	FB	FO	Fruit		
Matthaea heterophylla Quisumb. & Merr.	Monimiaceae	NA	Apr	Apr				Supra-annual	Hot dry
Melastoma malabathricum L.	Melastomataceae	May	May	June, Feb				Supra-annual	Hot dry
Melicope confusa (Merr.) T.S.Liu	Rutaceae	Dec	Dec	Na				Supra-annual	Cold wet
Memecylon ramosii Merr.	Melastomataceae	May	NA	Oct				Supra-annual	Hot dry
Microcos triflora (Blanco) R.C.K. Chung	Malvaceae	NA	NA	Apr, may				Annual	Hot dry
Morinda sp. L.	Rutaceae	NA	NA	May, June				Supra-annual	Hot dry
Musa textilis Née	Musaceae	Apr, May, Aug, Sept, Oct	Apr, May, June, Aug, Oct	Apr, May, June, Aug, Sept, Oct, Nov, Dec				Continual	All conditions
Mussaenda anisophylla S. Vidal	Rubiaceae	May, Aug, Sept, Dec, Feb, Mar	May, Aug, Oct, Dec, Feb, Mar	May, June, Aug, Oct, Nov				Subannual	All conditions
Myristica philippensis lam.	Myristicaceae	Aug	NA	May, June, Aug				Subannual	Hot dry
Neo-uvaria acuminatissima (Miq.) airy Shaw	Annonaceae				May, Sept, Oct, Nov	NA	NA	Supra-annual	Hot dry

Nephelium ramboutan-ake (Labill.) Leenh.	Sapindaceae	NA	Apr	Oct	May	May	May	Annual	Hot dry
Octomeles sumatrana Miq.	Tetramelaceae	NA	Oct	NA				Supra-annual	Hot dry
Omphalea malayana Merr.	Euphorbiaceae	Apr, June, Oct, Feb	May, June, Oct Feb	NA				Supra-annual	Hot dry
Palaquium bataanense Merr.	Sapindaceae	NA	NA	Sept				Supra-annual	Hot dry
Palaquium tenuipetiolatum Merr.	Sapotaceae	NA	NA	Sept				Supra-annual	Hot dry
Phoebe sterculioides Merr.	Lauraceae	NA	Apr	May, Oct				Subannual	Hot dry
Phyllanthus ramosii Quisumb. & Merr.	Phyllanthaceae	NA	NA	Dec				Supra-annual	Cold wet
Pinanga insignis Becc.	Arecaceae	Continuous			Continuous			Continual	All conditions
Pinanga maculata Porte ex Lem.	Arecaceae	Continuous			NA	Jun	Apr, June, July, Sept, Oct	Subannual	Warm and cold dry
Pipturus asper Wedd.	Urticaceae	NA	NA	Sept				Supra-annual	Hot dry
Planchonia spectabilis Merr.	Lecythidaceae	Oct, Dec	Aug, Sept	Aug				Supra-annual	Hot dry
Polyalthia lanceolata S. Vidal	Annonaceae	Apr	NA	Apr				Supra-annual	Hot dry
Polyalthia sp. Blume	Annonaceae	Apr, May, Aug, Dec, Feb, Mar	June, Sept, Mar	Apr, May, June, Aug, Sept, Oct, Mar				Supra-annual	Hot dry

(continued)

Table 14.3 (continued)

Scientific name	Family	Monitoring year 1			Monitoring year 2			Phenological class	General observed conditions
		FB	FO	Fruit	FB	FO	Fruit		
Praravinia sablanensis (Elmer) Bremek.	Rubiaceae	Apr, Aug, Mar	Feb	Sept, Oct, Nov				Subannual	Hot dry
Pseuduvaria luzoniensis (Merr.) Y. C.F.Su & R.M.K. Saunders	Annonaceae				NA	NA	May	Supra-annual	Hot dry
Psychotria pallidifolia Merr.	Rubiaceae	Dec	NA	Apr, Oct, Nov, Dec	Apr	Apr, July	Apr, July, Aug, Oct	Subannual	Hot dry
Psychotria sp. L.	Rubiaceae	NA	NA	June				Supra-annual	Hot dry
Pterocarpus indicus Willd.	Fabaceae - Papilionoideae	NA	NA	Feb				Supra-annual	Warm and cold wet
Saurauia klemmei Merr.	Actinidiaceae	Mar–June	Mar–June	Mar–June, Aug–Feb	Apr, May, June	Apr, May, June	Apr, June, July, Sept, Oct	Annual	Hot dry
Semecarpus sp. big leaf L.f.	Urticaceae	Oct	Oct	NA				Supra-annual	Hot dry
Atalantia racemosa Wight & Arn.	Rutaceae	NA	Aug	Apr, Dec				Supra-annual	Hot dry
Shorea assamica dyer	Dipterocarpaceae	NA	May	May				Supra-annual	Hot dry
Shorea contorta S. Vidal	Dipterocarpaceae				NA	Aug	NA	Supra-annual	Hot dry
Shorea palosapis Merr.	Dipterocarpaceae	Mar	Mar	NA				Supra-annual	Hot dry
Shorea polysperma Merr.	Dipterocarpaceae	Mar	NA	NA				Supra-annual	Hot dry

Strombosia philippinensis S. Vidal	Erythropalaceae	Aug	Apr, Aug	Apr, June, Aug	NA	NA	Oct	Annual	Hot dry
Suregada glomerulata Baill.	Euphorbiaceae	Feb	Feb	NA				Supra-annual	Hot dry
Suregada multiflora Baill.	Euphorbiaceae	Nov	NA	Apr				Subannual	Cold wet
Syzygium cf. *longisimum* P. Browne ex Gaertn.	Myrtaceae	NA	NA	May, Sept, Oct				Annual	Hot dry
Syzygium everettii (C.B.rob.) Merr.	Myrtaceae				NA	May	May	Supra-annual	Hot dry
Syzygium nitidum Benth.	Myrtaceae	Feb	NA	NA	NA	NA	June, Oct	Annual	Hot dry
Syzygium sp. P. Browne ex Gaertn.	Myrtaceae				NA	July	Oct	Annual	Hot dry
Tabernaemontana pandacaqui lam.	Apocynaceae	Dec	May	May, Aug, Sept, Feb, Mar				Supra-annual	All conditions
Trigonostemon sp. Blume	Euphorbiaceae	Feb	NA	Na				Supra-annual	Cold wet
Voacanga globosa Merr.	Apocynaceae	Sept, Nov	Apr, Aug, Oct, Feb	Apr, Aug, Oct, Feb, Mar				Subannual	All conditions
Xanthophyllum palawanense Elmer	Polygalaceae	Apr, May	May	May				Annual	Hot dry

FB floral bud; *FO* flower open

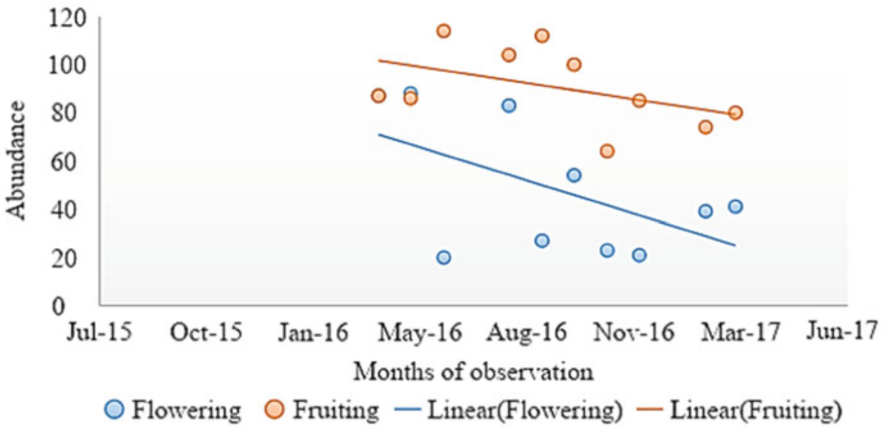

Fig. 14.4 Abundance of flowering/fruiting individuals per month from April 2016 to March 2017 in Palanan, Isabela

phenology is important to developing proper conservation strategies (Rosemartin et al. 2014), especially on reproductive phenology data as it will give information for seedling recruitment. Borghi et al. (2019) further presented that disruptions in plant–pollinator interactions reduce crop yields when drastic environmental conditions occur during flowering periods. Additionally, close monitoring may provide useful information on the behavior of Palanan lowland forests in phenomena such as general flowering.

14.6 Summary and Conclusion

Individual tree count in PFDP is high due to the high recruitment rate. A total of 151 species of fruiting species from 98 genera in 45 families were inside the transect used. Of these, only 107 species from 79 genera in 40 families were observed to have entered at least one episode of reproduction either in the form of flowering, fruiting, or both. The most reproductively active families were Meliaceae, Euphorbiaceae, and Lauraceae. The integration of previous phenological data with what has been gathered in this study is needed. The current information generated can be amended to the phenological schedules generated from February 2014 to March 2015. In general, the majority of the species reproduce during the relatively hot period of the year from April to September. The phenophase calendar constructed has shown that most of the plant species are supra-annuals with flowering and fruiting occurring during the hot dry conditions. This calendar can be continuously revised with previous and new incoming data.

The tropical lowland forests of the Philippines are indeed one of the most diverse in the region. The population of species, dynamics, and resiliency of these forests are well documented for some designated areas, but most are still under the pressure of

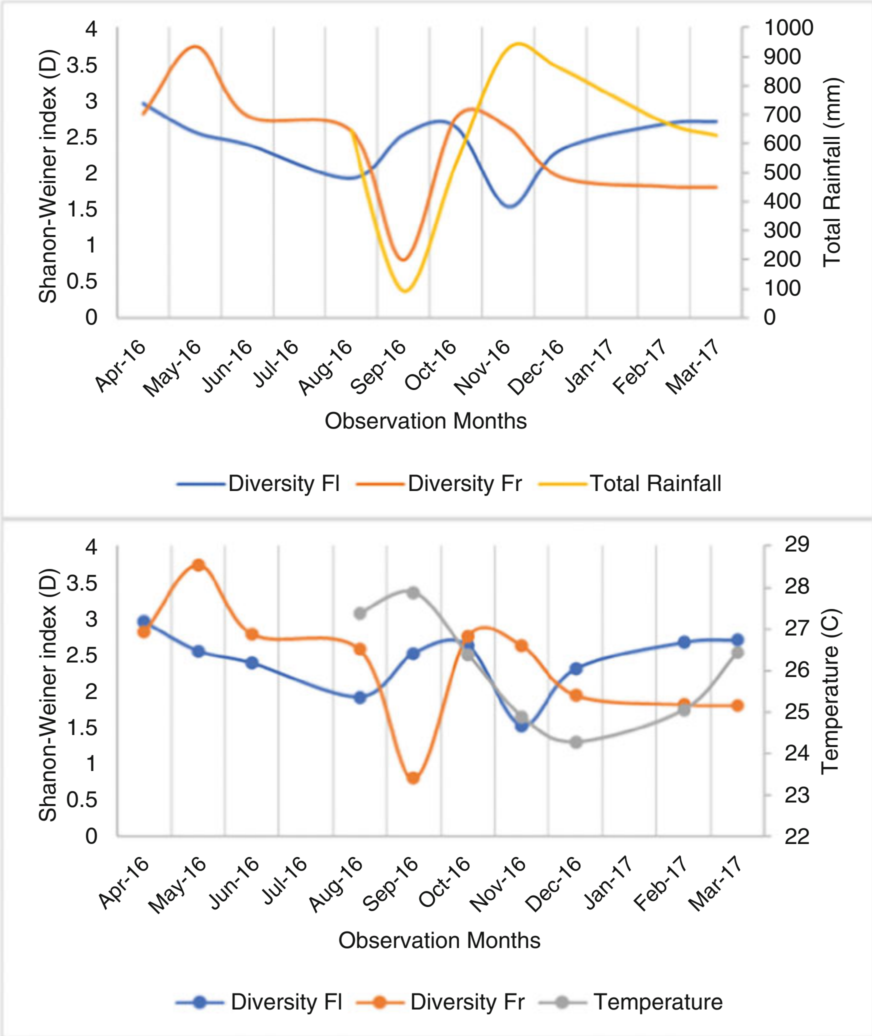

Fig. 14.5 Patterns of flowering and fruiting in the lowland forests of Palanan, Isabela with respect to mean monthly temperature and total monthly rainfall

conversion for human use. Furthermore, little is known of its reproductive phenology (Co et al. 2006), from species to community levels. With the ever-changing climate, gradual change in global temperatures, and increased fluctuations from established climatic patterns, it is imperative to study the responses and adaptability of these species. Palanan, a unique lowland forest, a frontier in the Philippines, diverse and resilient, may enable us to understand how to not replace but to "restore forests" (Ong 2017).

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