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Phenological Behavior of *Pericopsis elata* in a Production Forest at Libongo (Southeast Cameroon)

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ABSTRACT

Knowledge of the flowering and fruiting capacity of a species based on the age and/or diameter of the individuals is crucial to define the management methods of exploited populations. Vulnerability of *Pericopsis elata* has shown a deficiency in natural regeneration that may reflect difficulties to sustainability. The objective of this study was to determine the phenological cycle of *P. elata* during one year, as well as its impact on the sustainability of the species. Observations were made in a managing timber exploitation located in southeastern Cameroon, on potential seed trees with diameters greater than 20 cm, at a rate of one passage per month. Biological data were univariate and multivariate and climatic data were obtained using web applications. It appears that the phenological cycle of *P. elata* is annual and modeled on the seasons. Leafing is present throughout the year, flowering peaks during the short rainy season while fruiting dominates in the short dry season. This study showed that 75.3% of individuals were unbloomed, 22.3% had visible flower buds and 2.4% bloomed flowers. Only 1.2% of trees had fruit set, 0.2% with less than half of mature fruits and immature fruit falls were observed on 0.2% individuals. The Minimum Flowering and Fruiting Diameter of *P. elata* was 32 cm found on different individuals. The current Minimum Logging Diameter (90cm) is five times the proposed value (42 cm) to maintain potential seed trees after logging, but not necessarily to ensure the durability of the species, which are based on additional parameters.

INTRODUCTION

Plant phenology is the result of interactions of selective biotic and climatic factors and affects several ecosystem functions such as herbivory, pollination, seed dispersal and the nutrient cycle, among others (Pezzeni, 2014). In the life cycle of a plant, a distinction is made between two major reproductive phenophases, namely flowering and fruiting. The importance of a precise description of phenological models of reproduction for the design of conservation or management strategies and ecological restoration programs has recently been recognized (Morellato *et al*., 2016).

Phenological studies are very important data for understanding the functioning of forest ecosystems (Differt, 2001). They have recently been used to study the response of vegetation to climate change; at the time scale, phenological data are good predictors of the effects of a potential climate change on vegetation, as air temperature and water availability have a significant influence on phenophase start dates (Malom, 2011).

Phenological rhythms of trees are mainly influenced by the intensity of solar radiation and the extent of the dry season. The leafy and leafless phases act on photosynthetic activity, which affects primary and secondary growths, tree survival and productivity. Foliar and reproductive phenology is according to Stahle *et al.* (1999), closely related to variations in local climate at the inter-annual and intra-annual scales, and could prove to be a determining factor in explaining the seasonality of diametric growth (Fétéké *et al.*, 2013).

In the tropics, subtle temperature changes were considered a less important phenological trigger, while seasonal variations in precipitation were generally considered an environmental signal for phenology. However, phenological responses of plants to invariant signals, such as photoperiod, can be important in defining the timing, periodicity and especially timing of plant reproduction, especially in tropical environments with low climatic seasonality (Morellato *et al.,* 2016).

Many studies have been carried out on the phenology of African tropical dense forest tree species (defoliation, flowering, re-flowering and fruiting periods) (Bibani Mbarga *et al.,* 1998, Yalibanda and Lejoly, 1998; Nada *et al*., 2017), but very few studies on tree fruiting diameter, with sufficient samples by diameter class for a species, and even less so on the dispersal distance of the diaspores (Boyemba, 2011).

The size of the reproduction of forest species is essential for the selection of potential seed trees that will ensure the regeneration of the resource after logging. It is also key to the sustainable management of production forests because it's one of the additional conditions for determining the Minimum Logging Diameter (MLD) (Kouadio, 2008). In Central Africa, trees can only be cut if they exceed a MLD. This threshold varies considerably between countries, even for the same species (Bourland *et al.*, 2012b).

Knowledge of the flowering and fruiting ability of a species according to the age and/or diameter of the individuals is crucial to define the management methods of exploited populations (Durrieu de Madron and Daumarie, 2004). According to Sepulcher *et al*. (2008), two parameters can be used to express the stage from which a species is able to regenerate: the Minimum Diameter of Fertility (MDF, the threshold at which flowering and fruiting begin, while producing low levels of diaspores); and the Regular Fruiting Diameter (RFD: threshold at which effective and regular fruiting occurs).

The RFD corresponds to the minimum or median diameter of the class for which 70 to 80% of the trees are breeding (Ouedraogo *et al.*, 2018). The fruiting diameter of an exploited species is fundamental information to the development of sustainable management plans. The vulnerability of a plant species is not only related to its abundance or density in forest; but also based on internal parameters (morphological type, type of habit, type of seed spread, and abundance/density of the species in the forest) and external constraints such as climatic and edaphic conditions, anthropogenic activities (Betti, 2007).

Pericopsis elata big tree with a trunk often tortuous and irregular; smooth and straight over 15 to 20 m which can reach a height of 50 m and a diameter of 80 to 130 cm (Vivien and Faure, 2011) Its distribution is restricted to semi-deciduous moist dense forests extending from Côte d'Ivoire to the Democratic Republic of Congo (DRC). It is a pioneering, anemochoric, heliophilic species that supports changes in soil moisture content, preferring fertile soils rich in magnesium and phosphorus (Fétéké *et al*. 2015).

Its flowers are bisexual, papilionaceous and give pods with between 1 and 5 seeds (Essono *et al*., 2017). The seeds of *P. elata* have 31.25% lipids, 37.41% proteins and 1.93% carbohydrates, their moisture content is 7.5%. They can be dried to reduce it for longer storage at ambient conditions. The drying time lasts between 2 and 19 days depending on the drying agent (Tandoh *et al*., 2018).

Knowledge of the phenology of commercial species in Africa's dense forests is still very patchy. The available data are often scattered in different sites, made with disparate methods; the sampling effort is generally small and the periods of time covered are discontinuous (Malom, 2011). In addition, the triggers for plant reproduction remain poorly understood in the tropics, particularly in highly seasonal ecosystems (Morellato *et al.*, 2016).

Several organizations have expressed concerns about the level of exploitation of *Pericopsis elata*. It was registered on 'Red List' of the IUCN as endangered (criterion A1cd) and was listed in Appendix II of CITES in 1996. The European Union has repeatedly suspended the importation of *P. elata* because of concerns about the sustainability of this species. These suspensions, without any real scientific basis, have all been lifted, without any real knowledge of the risk posed by selective logging for this species timber.

Cameroon adopted strong protection actions in the early 2000s by setting the MLD of this species at 100 cm. Since June 2010, the MLD has been reduced to 90 cm, however still higher than the ones generally used in the producing countries of this wood in the Congo Basin region (Bourland *et al.*, 2012a). Although this reduction of the MLD is important for the forest industry, it does not address the issue of sustainability, which must be based on a silvicultural approach to the species. To begin this process, knowledge of the life cycle of the species appears to be crucial.

The aim of this study is to determine the phenological cycle of *Pericopsis elata*, as well as its impact on the sustainability of the species. Specifically, highlight the correlation between reproductive phenophases and climatic variables and define the flowering and fruiting diameter of *P. elata*. It is therefore necessary to know if the current exploitation system of this species allows seed trees to be kept in place, able to ensuring the supply of seeds for sustainability.

MATERIALS AND METHODS

Study site

The study site straddles the Forest Management Units (FMU) 10010 and 10012 of the SEFAC (Cameroon Forestry and Agricultural Company) separated from each other by the Monguélé River. They are between latitudes 1 ° 30 and 3 ° 30 North and longitudes 15 ° 30 and 16 ° 10 East and cover by evergreen forest with a total area of 126,028 ha, with altitudes between 370 and 500 m.

The study area is limited to the north by the FMU 10009; to the south by Lobéké River, natural separation with the Lobéké National Park; to the east by Mokolabo, a tributary of the Lobéké River which separates forest from agroforestry area around the village Libongo, and then flows into the Sangha River; and to the west by FMUs 10 007 and 10011 (Figure 1).

The soil is a red or yellowish red oxisol with a high content of clay and iron and aluminum oxides (Battipaglia *et al*., 2015). This site was chosen because it is within the extent of occurrence of the species. It is influenced by a Guinean equatorial climate with two rainy seasons and two alternating dry seasons. Rainfall is spread throughout the year, with peaks in April and October. The average rainfall is 1500 mm / year. The average temperature is 25 ° C and the relative humidity fluctuates between 60 and 90% (Noupa and Nkongmeneck, 2008).

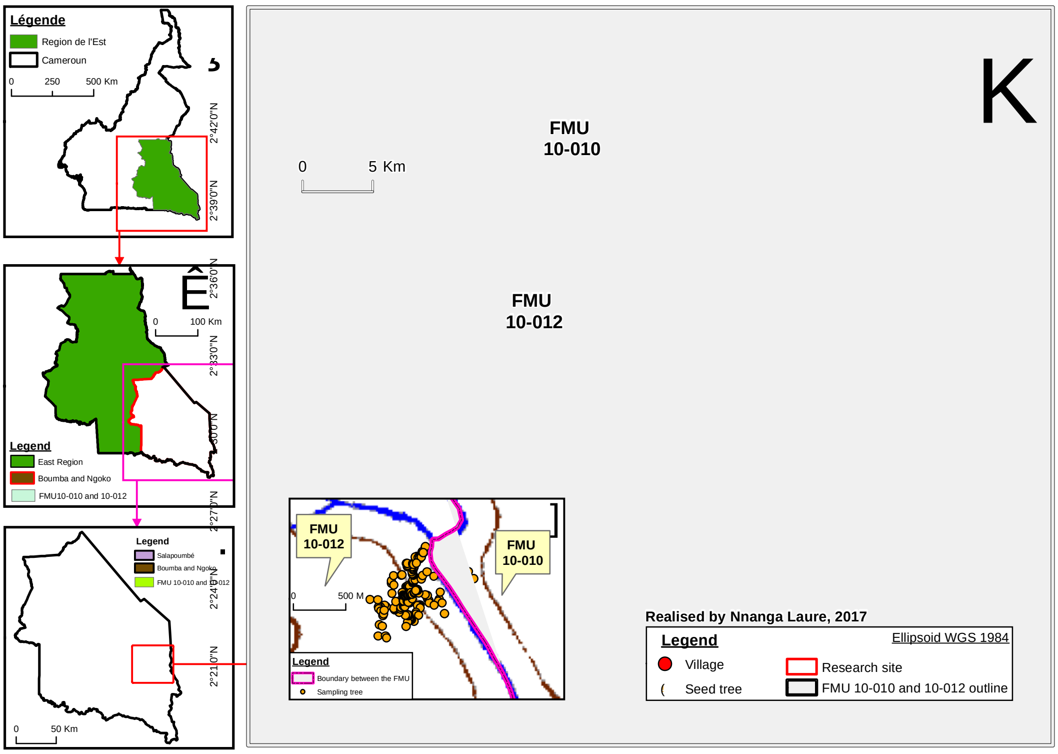

Figure 1: Location of the study area –(Libongo 230 Km from Yokadouma), Cameroon

Methods

Data collection began in June corresponding to the fruiting period of the species. The diameters of all trees (potential seed tree) taken at breast height (approximately 1.30 m from the ground) were then measured, with a circumferential ribbon. Seed tree was considered to be any individual greater than 20 cm in diameter, organized in the following predefined diameter classes (in cm): [20-29], [30-39], [40-49], [50-59], [60-69], [70-79], [80-89], [90-99], ≥100.

Each seed tree was spotted by GPS, with white-labeled numbers and phenological status observed with binoculars throughout the year, with one visit per month during the study period from June 2015 to May 2016. The diameter of the seed tree has been noted and the phenological manifestations carefully described as a function of time. Starting on the basis that each phenological phenomenon had its own stages, the characterization of the different stages (Table I) was deduced from the method proposed by Grouzis and Sicot (1980).

Table I: Characterization of phenophases of *Pericopsis elata* (Grouzis & Sicot, 1980)

Stadium	Characteristics
V0	**No leaf** *Complete dessication*
V1	**Leaf buds still visible, between 10% and 50% of mature leaves** *Leaf buds + mature leaves (more than 10% and less than 50% of leaves on the individual)*
V2	**More than 50% of mature leaves** *Leaves mostly blooming, full leaf stage*
V3	**More than 50% dry leaves and observable leaf fall** *Senescence, more than 50% of the individual's twigs have dry leaves, falling leaves*
f0	**No flowers** *Total absence of flowering*
f1	**Floral buds still visible, between 10% and 50% of blooming flowers** *Flower buds + blooming flowers (more than 10% and less than 50%)*
f2	**More than 50% blooming flowers** *More than 50% of the blooming flowers worn by the individual*
f3	**More than 50% dry flowers, falling visible floral pieces** *Mostly dry flowers, falling floral pieces*
F0	**No fruit** *Total absence of fruiting*
F1	**Noodle - Unripe fruits** *Phase of evolution of the fruit until its normal size*
F2	**Less than 50% ripe fruit** *Less than 50% of the ripe fruits worn by the individual*
F3	**More than 50% ripe fruit, observable fruit drop** *Ripe fruit + beginning of spread*

The parameters recorded in the field were consigned on a phenological data sheet. The fixed data taking into account the identification of the tree monitored, the date of the observation and the name of the observer, and the monthly data, on leafing, flowering and fruiting. For each individual, the beginning of each phenophase was determined and located in time period of observation period. The determination of the beginning of a phenophase was made by estimating the total frequencies of this phenophase each month.

Variations in intensity of flowering and fruiting with diameter were determined by calculating the percentage of flowering and fruiting trees by diameter class. The determination of the minimum flowering diameter took into account the proportion of trees having flowered in each diameter class and the determination of the minimum fruiting diameter used the proportion of fruiting trees in each diameter class. The monitoring of the phenology also allowed us to analyze these variations with the diameter.

Statistical analyzes

All calculations, statistical analyzes, programs developed and graphics have been made using the Microsoft XLSTAT software version 2014 and Microsoft EXCEL 2010; Geographic coordinates processing and maps were done with ArcGIS 10.2 software. In this study, the parameters underwent a normality test according to the Shapiro-Wilk tests at the 5% threshold. The presence or absence of leaves, flowers and fruits was studied through descriptive analysis including a univariate and bivariate analysis allowing to view the distribution of the data according to the period of observation.

The climatic data were obtained thanks to the KNMI (Royal Netherlands Meteorological Institute) Climate Explorer which is a web application allowing to analyze climatological data statistically. The Global Climate Climatology Network (GHCN) monthly climate data Set is from the National Oceanic and Atmospheric Administration/ National Climatic Data Center (NOAA / NCDC).

The minimum and maximum daily temperatures and daily precipitation were obtained from the data of the synoptic station of Ouesso in Congo for the period from June 2015 to May 2016. The average temperatures and annual rainfall were compiled to have trend during this period. Sunlight data was obtained from the free Weather Online website.

RESULTS AND DISCUSSION

In this study, 210 individuals have been observed and distributed as shown in fig. 2. The reduced number of individuals in ≥100 cm class can be explained by the fact that a part of the study area was exploited in 2007 with the MLDof 100 cm. In addition, for diameters classes between [80-89] and [90-99], the predefined number of individuals (n = 25 individuals) wasn't reached, probably because of the low recruitment of individuals in upper classes between the period of exploitation and our study.

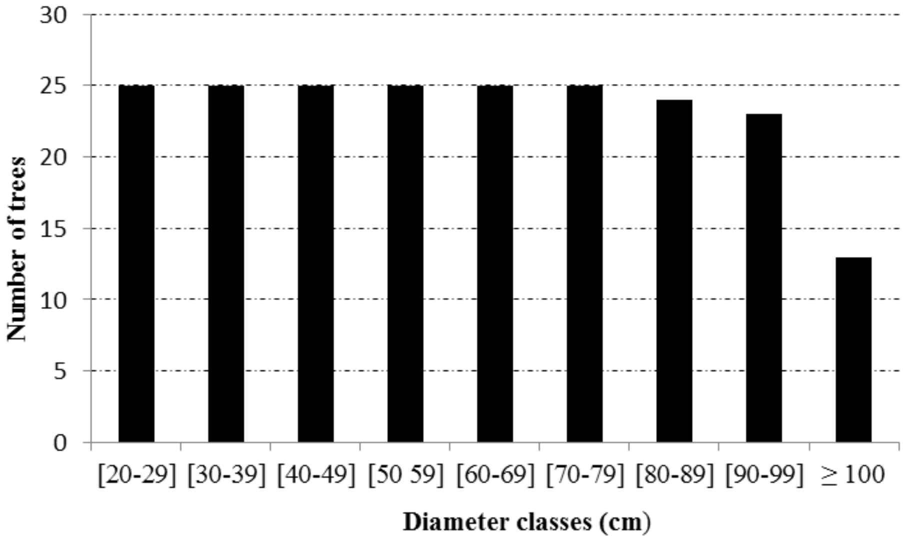

Figure 2: Distribution of *Pericopsis elata*'s seed trees according to diameter classes

Phenophases

The phenological cycle of *Pericopsis elata* is annual type, modeled on seasons, each event taking place once in the year. That is why the duration of the observations spread over one year. Results obtained in this study show that flowering and fruiting are not as constant as leafing (Fig.3).

The leafing was present throughout the year. However, it increased between the periods of during the great rainy seasons and dropped at the end of the long dry season. This corroborates with the work of Bourland (2013) who found that the peak of defoliation was during dry season in Mindourou, Cameroon. These results are also in line with the work of Boyemba (2011) who described defoliation between January and February, a period corresponding to the long dry season in Kisangani in the DRC. According to Richardson *et* *al.* (2013), the fall of old leaves, and the production of new leaves, tend to coincide with the beginning and the end of the dry season. On the individual level, leaf maturation was discontinuous from one season to another. This result in the fact that an individual with leaf buds visible this season could have half of his leaves the following season at the same date.

The fall of the leaves wasn't simultaneous from one branch to another, and some individuals were not subjected to defoliation. Trees completely defoliated were not observed but just a partial defoliating of the crown. Bourland (2013) observed complete defoliation of *Pericopsis elata* 2 to 3 weeks after the peak of leaf fall in the Mindourou area. The leaf buds were visible between March and July.

Flowering occurred at the small rainy season, following the defoliation, with a peak at March, it decreased gradually between March and May simultaneous with fruiting. Essono *et al.* (2017) found that flowering was triggered preferentially in the second half of February, and occurred twice a year in Bidou in the Atlantic forest in South region of Cameroon. However, for Bourland (2013) flowering occurred between March and April, after the fall of the leaves.

Fruiting curve seems to show that this event took place twice in the year but it's just because of the beginning of the observations which coincided with the period of fructification which seems between February and September, with a peak of fruiting in August. This is consistent with the results of Essono *et al.* (2017) who observed the beginning of fruiting in March, while Bourland (2013), postponed it between April and December, and Boyemba (2011) observed a peak of fruiting in August. During this study of the 210 individuals observed, only 33 were found carrying fruit, the majority being fruitless. Essono *et al.* (2017) also reported that most of their individuals did not produce fruit, current year 2015.

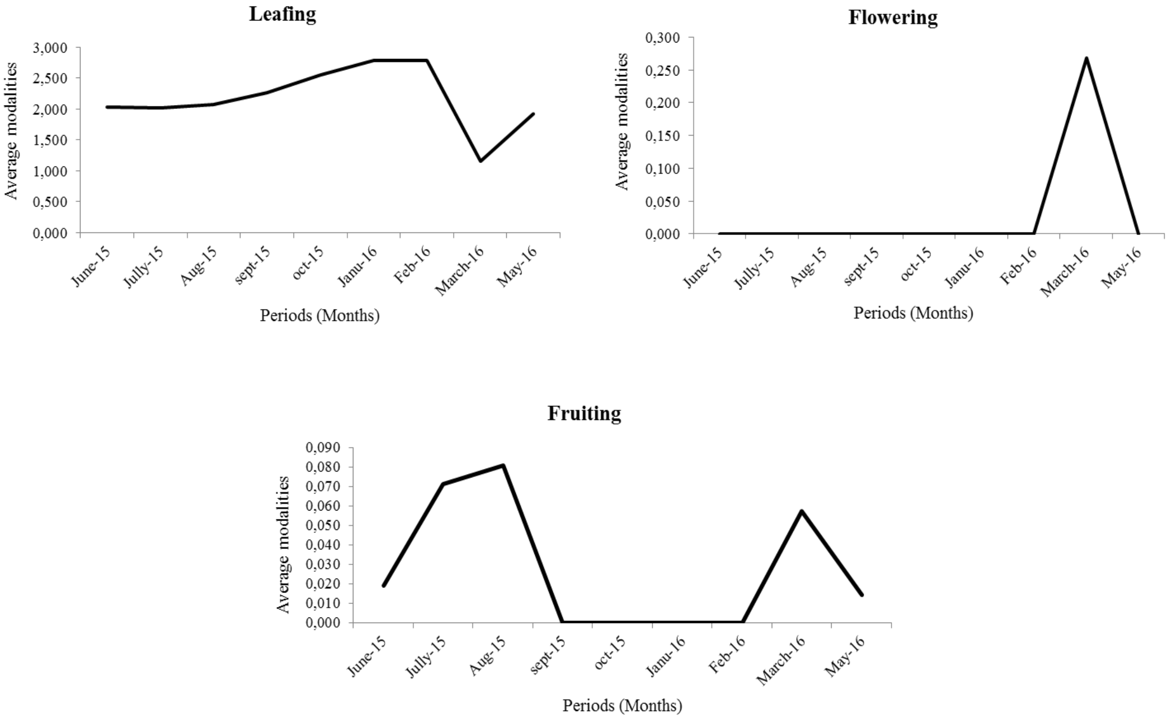

Figure 3. Distribution curves of leafing, flowering and fruiting of *Pericopsis elata* during the observation period

Reproductive phenology and climate

The study site is influenced by a Guinean equatorial climate with two rainy seasons and two alternating dry seasons. The rainfall regime is bimodal characterized by a small and a large long rainy season, spreading respectively from March to June and from August to November. They alternated with a long dry season (from November to March) and a short dry season (in July-August). However, the latter is not a true dry season because it corresponds to a simple drop in rainfall (Fig. 4).

The mean annual precipitation is 148.08±73.44 mm/year with a peak in September (294 mm) and a minimum value in February (47 mm). The average annual temperature is 25.90±1.27° C with peaks in January and May. *Pericopsis elata* is to very fond of depressed soils and stream banks, so it is usually found in flood areas. Abundant and irregular rains can affect reproductive phenology by promoting flower abortion and early fruit dispersal. Floods can also cause seed trees fallen. Field observations identified a fallen seed tree because of its low rooting in the soil.

Generally, the duration of the day is 12 hours in the study area. The sunshine was between 3 and 6hours with a mean of 4.79±0.61 hours. The sunniest months are February, April and May and the least sunny months are June, July and August. The phenological rhythms of trees are mainly influenced by the intensity of solar radiation and the extent of the dry season (Fetéké *et al.,* 2016).

Flowering heralds the end of the rainy season and the beginning of the dry season, which leads to an increase in temperature and optimal sunshine. Echereme *et al*. (2018) show that day length variation is important in manipulating bud-break or flowering in tropical trees. In regions near the equator where day length variation is small across the year, times of sunrise or sunset explain synchronous flowering.

Generally, flowering is negatively correlated with rainfall (Bawa *et al*., 2003). Nada *et al*., (2017) showed that the flowering period of the Kemmanugundi Forest runs from January to March. Solar radiation is also considered a major element of phenology in tropical forests (Richardson *et al*., 2013).

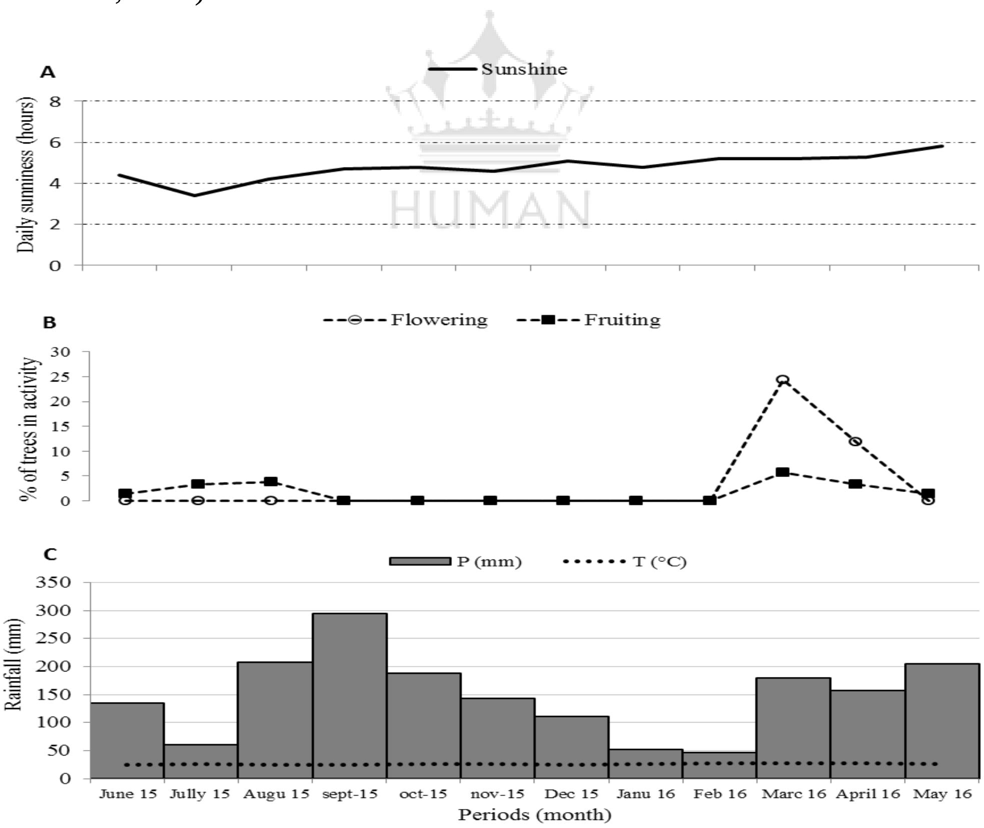

Figure 4. Climatic variable values and reproductive phenophases of *Pericopsis elata*. A) Daily sunniness throughout the year. B Percentage of trees with flowers and fruits throughout the year. C) Meteorological data of the study site.

This study showed that although 75.3% of individuals were found without a flower, 22% of individuals with visible flower buds and 2.4% with blooming flowers were observed; which underlies a weak flowering during the study period. Flowering was synchronous with the appearance of the new fruits.

The study started during the fruiting period, which explains the absence of flowers but the presence of fruits. Fruiting took place between February and September (period from the short rainy season to the large rainy season), with a peak of fruiting in August. This is inconsistent with the results of Boyemba (2011), who observed that 98.9% of the trees were in fruit in dry season in the Yoko Forest Reserve in Kisangani (DRC). On the other hand, Essono *et al.* (2017) observed in plantations in Zoulabot and Bidou in Cameroon, that the beginning of fructification took place in March, with a peak of fruiting in April; while Bourland (2013), postponed the fruiting period between April and December.

A proportion of 1.2% was fruit set, 0.2% with less than half of the mature fruit, and immature fruit was also observed on 0.2% of the individuals. This reflects weak fruiting of Assamela during our observation period. Essono *et al.* (2017) also reported that most of their individuals did not produce fruit in the current year of 2015. Most individuals had no fruit at all stages of flowering, even more when the individual did not show any fruit, no flowers. This association shows a significant impact of lack of flowers on the absence of fruit ($p<0,05$).

The month of March has also shown that flowering and fruiting are observed at the same time. While some individuals are in bloom (24.40%) with 21.90% having less than 10% of flowers and 2.38% having between 10 and 50% of blooming flowers; others (about 6.25%) have fruit set corresponding to less than 10% of ripe fruit. Essono *et al*. (2017) found during the same year 2015, the beginning of flowering and the triggering of remaking in the dry season and fruiting with the return of rains.

Diameters of flowering and fruiting

In this study, no flowering individuals were observed in class [20-29]; classes [30-39] and [40-49] each have an individual, classes [50-59] and ≥100 each have 07 individuals, while classes [60-69] and [70-79] count respectively 08 and 05 individuals. Finally, classes [80-89] and [90-99] each have 12 individuals. This represented a flowering rate of 25.23%. Classes [20-29] and [40-49] didn't present any fruiting individual. class [30-39] had a fruited individual, while classes [50-59] and [60-69] each had two individuals, classes [70-79] and [80-89] each had 4 individuals; and finally classes [90-99] and ≥100 had 10 and 06 individuals respectively. The fruiting rate during this study period was very low, 13.8% (Fig. 5).

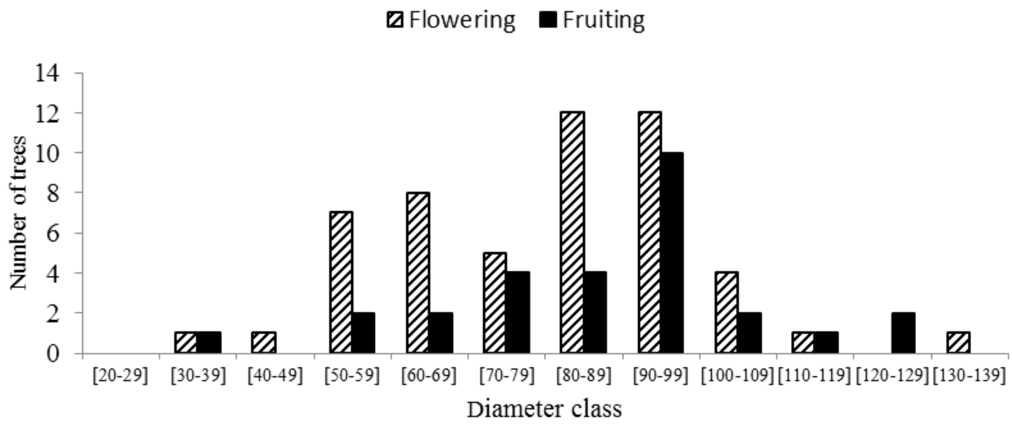

Figure 5: Distribution of flowering and fruiting of *Pericosis elata* as a function of diameter class

The frequency curve of flowering (A) and fruiting (B), as a function of diameter class (Fig.6) generally shows weak flowering during this study. The highest frequencies of flowering were in the high diameter classes. Appearance of flower buds is denser in individuals with diameter classes between [130-139] and appear early. Caron *et al.* (2004), show that during low flowering years, the percentage and diameter of the smallest flowering tree are found in the high diameter classes. In addition, a clear relationship between the regularity of flowering and diameter can be observed in the data set as larger trees flower most often.

More than 50% of blooming flowers are recorded in *P. elata* individuals of diameter class between [80 - 89] and [100 - 109] centimeters; while 98% individuals of the class [40-49] were mostly met without flower. All individuals of *P. elata* between [130 - 139] diameters were recorded flowering and less than 20% with flower buds in the class [30-39].

Ripe fruits were observed on *P. elata* individuals of diameter [60-69], [80-89] and [90-99] representing respectively 4%, 4% and 8%. We also observed that the trees of [120-129] centimeters in diameter were mainly in fruit although they are not mature. According to Boyemba (2011), fruiting of *P elata* is regular annual (each year) and discontinuous (it takes place only from June to December). He also points out that it varies from year to year and the periods of "mast fruitings" (mass fructifications) can occur one year out of three. It can also vary from one individual to another.

The frequency of fruiting during our study period remains very low. The appearance of the fruit set was observed mainly in the diameter class [120 - 129]. Ripe fruits were observed in *P. elata* individuals between [90 - 99] centimeters in diameter and only 2% of individuals; it was also noted that 60 - 80% of *Pericopsis elata* individuals were fruitless and no ripe fruit drop was observed during this period. On the other hand, Boyemba (2011) found that trees of the class [80 - 89] were the most fruiting (95%). It would seem, therefore, that adult trees (large diameters) start fruiting sooner than individuals of smaller diameter.

During this work, the *P. elata*'s minimum diameter of flowering and fruiting was 32 cm (corresponding to class [30-39] cm) and were found on different individuals. According to Sepulchre (2008), this value can be considered as the Minimum Diameter of Fertility (DMF), threshold at which flowering and fruiting begin while translating into low seeds production. This precocity of reproduction would guarantee the maintenance of the species and its capacity to perpetuate itself. Indeed, the species has a very high juvenile mortality rate, and for Malom, (2011) this early fructification is of extreme necessity to compensate for this mortality and its sustainability in the forest environment.

The phenological observations made it possible to define a minimum diameter of fruiting of 32 cm. Bourland (2013) in a production forest in South-East (Cameroon), found minimum fertility and effective fruiting diameters of 32 and 37 cm respectively. In contrast, Boyemba (2011) found a minimum fruiting diameter of less than 30 cm in Kisangani, DRC; the amount of fruit carried by the seed trees was also very low, and the number of fruits produced increased significantly with the diameter of the trees.

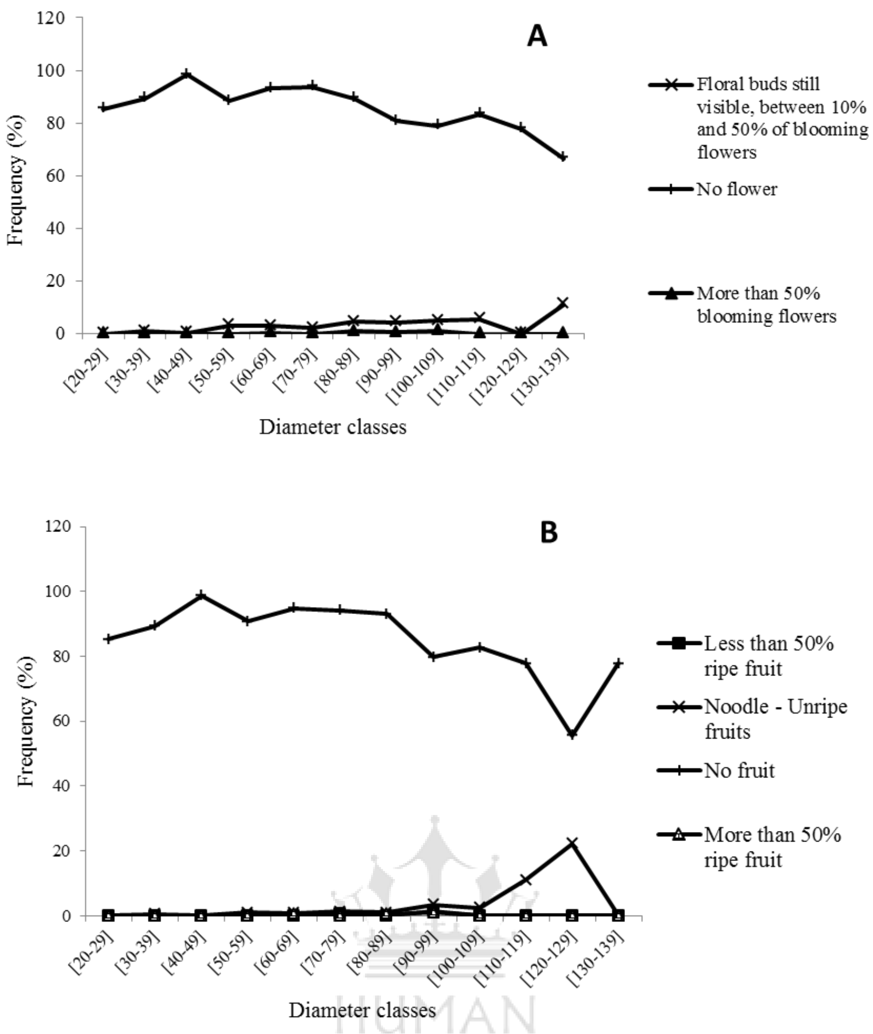

Figure 6: Frequency curve of flowering (A) and fruiting (B) stages as a function of *P. elata* diameter class.

According to Sepulchre *et al* (2008), *Pericopsis elata* has shown a deficiency in natural regeneration that may reflect a difficulty to maintain in the long term. This study was based on 3 parameters: the ability to regenerate (diameter curves), the geographical area of the species and the Minimum Logging Diameter (MLD) against the Fruiting Regular Diameter (FRD). Menga *et al.*, (2012) admit that to ensure the maintenance of potential seed trees after the passage of logging and thus ensure the regeneration of the exploited species, the MLD must be higher than the FRD. They propose to fix the value of the MLD of at least 10 cm (corresponds to a class of diameter) higher than that of the FRD.

In Cameroon, the MLD set by the administration since June 2010 is 90 cm, which is five times the value proposed by Menga *et al.*, (2012) if we take into account the DMF obtained in this study; this MLD, therefore, helps keep seed tree on their feet. It can be tentatively inferred that the regeneration of *P. elata* is not threatened. But Ouedraogo *et al.* (2018) states that the presence of seed trees in the stand doesn't necessarily ensure effective natural regeneration.

CONCLUSION

The study showed that the phenological cycle of *Pericopsis elat*a is annual type, modeled on the seasons. Flowering and fruiting were very low during this study. The fertility diameter was 32 cm with a regular fruiting diameter proposed in the same class. The current Minimum Logging Diameter (MLD) set by the administration since June 2010 (90 cm), is five times the value proposed (42 cm)according to the DMF of this study. The MLD helps to ensure the maintenance of potential seed trees after the logging and thus ensure the natural regeneration of *P. elata*. It can therefore be concluded that *P. elata*'s mode of exploitation (MLD) makes it possible to keep seed trees alive, but not necessarily to ensure the sustainability of the species, which depends on other parameters.

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REFERENCES

1. Battipaglia G, Zalloni E, Castaldi S, Marzaioli F, Cazzolla- Gatti R, Lasserre B, Tognetti R, Marchetti M Valentini R. Long tree-ring chronologies provide evidence of recent tree growth decrease in a Central African tropical forest. PLOS One. 2015:10(3): e0120962. https://doi.org/10.1371/journal.pone.0120962.
2. BawaKS, KangH,Grayum MH. Relationships among time, frequency, and duration of flowering in tropical rain forest trees. Am JBot.2003:90(6): 877–887.
3. Betti, JL. Exploitation and exportation of *Pericopsiselata*(Fabacea) in Cameroon. Rapport d'étude; 2007
4. BibaniMbarga R, Jonkers WBJ,EssamaEtoudi J. Phénologie de 86 essences productrices de bois d'œuvre de la forêt dense humide sempervirente du Sud-Cameroun. Rapport Séminaire Forafri de Libreville, Gabon; 1998..
5. Bourland N. Dynamique d'une espèce ligneuse héliophile longévive dans un monde changeant: le cas de Pericopsiselata (Harms) Meeuwen (Fabaceae) au sud-est du Cameroun. Essai présenté en vue de l'obtention du grade de Docteur en Sciences agronomiques et Ingénierie biologique; 2013.
6. Bourland N, Kouadio YL, Lejeune P, Sonke B, Philippart J, Daïnou K, Fétéké F,Doucet J-L. Ecology of Pericopsiselata (Fabaceae), an Endangered Timber Species in Southeastern Cameroon. Biotropica.2012a:44(6): 840-847.
7. Bourland N, Kouadio YL, Fétéké F, Lejeune P,Doucet J-L. Ecology and management of Pericopsiselata (Harms) Meeuwen (Fabaceae) populations: a review. Biotechnol. Agron. Soc. Environ. 2012 (b):16(4): 486-498.
8. Boyemba, FB. Écologie de *Pericopsiselata* (Harms) Van Meeuwen (Fabaceae), arbre de forêt tropicale africaine à répartition agrégée. Thèse de Doctorat, Université Libre de Bruxelles, Belgique; 2011.

9. Caron H, Dutech C,Bandou, E. Reproductive phenology and mating system of six tree species in Paracou stands. Part III: Genetic diversity of forest tree species in French Guiana (Chapter 1). Ecology and Management of NeotropicalRainforest;2004:149-159.

10. Differt D. Phénologie des espèces arborées - Synthèse bibliographique et Analyse des données du Réseau national de Suivi à long terme des Écosystèmes forestiers (RENECOFOR). Rapport scientifique. Nancy: UMR ENGREF-INRA – LERFOB;2001.

11. Durrieu de Madron, L andDaumerie, A. Diamètre de fructification de quelques essences en forêt naturelle centrafricaine. BOIS FORTROP. 2004: 281 (3): 87-95.

12. Echereme CB,Igboabuchi NA,Ekwealor KU. Phenology in plants: Concepts and Uses. Ijsrm.Human.2018: 11 (1): 8-24.

13. Essono D, Nwaga D,Kono L. D. Phénologie fruitière de Pericopsiselata dans la forêt dense humide de Zoulabot et Bidou (Cameroun). WWJMRD.2017:3(2): 74-88.

14. Fétéké F,Perin J, Fayolle A,Dainou K,Bourland N, Kouadio YL,Moneye SJJ,Bekono C-C,Liboum BY, Doucet J-L, Lejeune P. Modéliser la croissance de quatre essences pour améliorer la gestion forestière au Cameroun. BOIS FOR TROP. 2015, 325 (3): 5-20.

15. Fétéké F, Fayolle A, Dainou K, Bourland N, Dié A, Lejeune P, Doucet J-L, Beeckman H. Variations saisonnières de la croissance diamétrique et des phénologies foliaire et reproductive de trois espèces ligneuses commerciales d'Afrique centrale. BOIS FOR TROP.2013, 330(4): 3-21.

16. Grouzis M. andSicot M. Une méthode d'étude phénologique de population d'espèces ligneuses sahéliennes: influence de quelques facteurs écologiques. Paris: ORSTOM, 2-15p. multigr. Symposium sur les fourrages ligneux en Afrique, AddisAbeba; 1980.

17. Kouadio YL. Mesures sylvicoles en vue d'améliorer la gestion des populations d'essences forestières commerciales de l'Est du Cameroun. Thèse, FUSAGx, Gembloux;2008.

18. MalomDebence A. Phénologie et diamètre de fructification de Millettialaurentii de Wild"(Wenge) dans la région de Bolobo et Kinshasa en RDC. Mémoire, Université de Kinshasa;2011.

19. Menga P, Bayol N, Nasi R, Fayolle A. Phénologie et diamètre de fructification du Wengé, *Millettialaurentii* De Wild.: implications pour la gestion. BOIS FOR TROP.2012:312 (2): 31-41.

20. Morellato LPC, Alberton B Alvarado ST, Borges B, Buisson E, Camargo MGG, Cancian, LF, Carstensen DW, Escobar DFE, Leite PTP, Mendoza I, Rocha NMWB, Soares NC, Silva TSF, Staggemeier, VG, Streher AS, Vargas BC, Peres CA. Linking plant phenology to conservation biology.Biol Cons.2016:195: 60-72.

21. Nanda A, Suresh HS, Krishnamurthy YL. Phenology of tree species in a tropical Evergreen forest of southern India. JOGEE. 2017:6(1): 1-12.

22. NgodoMelingui J-B, Mvogo C,Kono LD. Management of High Conservation Value in Forest Management Units of Cameroon: Case of 1025 Forest Concession. JPRSS ISSN 2395-6283.2018:7(2): 33-549.

23. Nnanga MRL, Mala AW,Ndongo Din. Early growth stages structure and distribution of Pericopsiselata (Harms) van Meeuven in a logging concession of South-East Cameroon. JBES.2014: 5(3): 354-363.

24. Noupa P,Nkongmeneck BA. Influence des clairières forestières sur la répartition spatiale des grands mammifères dans la forêt dense du Bassin du Congo: cas du Parc National de Boumba-Bek (Sud-Est Cameroun). Int. J. Biol. Chem. Sci.2008: .2(2): 185-195.

25. Ouedraogo D-Y, Fayolle A, Dainou K, Demaret C, Bourland N, Lagoute P, Doucet J-L. Enrichment of Logging Gaps with a High conservation Value Species (Pericopsiselata) in a Central African Moist Forest. Forests.2014:5: 3031-3047.

26. Pezzini FF,Ranieri BD,Brandão D O,FernandesGW,Quesada M,Espírito-Santo MM, Jacobi CM. Changes in tree phenology along natural regeneration in a seasonally dry tropical forest. Plant Biosystems, DOI: 10.1080/11263504.2013.877530. 2014: 1-10.

27. Richardson AD, Keenan TF, Migliavacca M, Ryu Y, Sonnentag OToomey M. Climate change, phenology, and phenological control of vegetation feedbacks to the climate system. Agricult Forest Meterol: 2013 :169: 156-173.

28. Sepulchre F, Dainou K, Doucet J-L. Étude de la vulnérabilité de 18 essences ligneuses commerciales d'Afrique centrale reprises sur la liste rouge IUCN. Rapport d'étude conjointe ATIBT, Faculté universitaire des Sciences agronomiques de Gembloux, Laboratoire de Foresterie des Régions tropicales et subtropicales et NATURE +:2008.

29. Stahle DW, Mushove PT, Cleaveland MK, Roig F, Haynes GA. Management implications of annual growth rings in Pterocarpusangolensis from Zimbabwe. Forest EcolManag. 1999: 124: 217-229.
30. Vivien J, Faure JJ. Arbres des forêts denses d'Afrique centrale. 2nd edition Copyright NGUILA KEUROU (J.J. FAURE), ISBN:978-2-9509-9700-7: 2011.
31. Yalibanda, Lejoly J. Phénologie en forêt dense de Ngotto (RCA): bilan de trois années d'observation. Ecofac; 1998.