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Variations in abundance of *Imbrasia epimethea* (Lepidoptera: Saturniidea) on *Petersianthus macrocarpus* in different forest types in Central Cameroon

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ABSTRACT

Edible caterpillars are of vital importance to rural communities in developing countries providing high protein values and income. However, their ecology particularly seasonal fluctuations in their numbers is still poorly understood. With the ongoing climate change and increasing deforestation, their survival is a crucial issue. The aim of this study was to assess the structural characteristics of *Petersianthus macrocarpus* (Lecythidaceae) on the abundance of edible caterpillars of *Imbrasia epimethea* (Saturniidea). The forest area on the outskirts of Yaoundé is an important production basin for edible caterpillars making a perfect medium to answer questions on the variations in the abundance of caterpillars of *I. epimethea* in relation to the forest type of *P. macrocarpus*. Concerning biometric parameters, the [20-30[cm diameter class in agroforest had more edible caterpillars (31.1 %). In the secondary forest and swamp forest, it was the [50-60[cm diameter class with respectively 34 % and 27.4 %. In terms of height, the [30-40[m height class contained more edible caterpillars (68.50 %), whereas the [60-70[m height class represented the stratum with the least edible caterpillars (5.10 %). In different forest types, the abundance of caterpillars of *I. epimethea* according to the social status of *P. macrocarpus* individuals showed that caterpillars are found in abundance preferentially on dominant individuals (52.7 % in swamp forest, 49.7 % in secondary forest and 45.6 % in agroforest). The mean abundance of *I. epimethea* caterpillars was higher in secondary forest (563 ± 62 caterpillars) compared to agroforest and swamp forest. In contrast, swamp forest had the lowest mean abundance of edible caterpillars (375 ± 24 caterpillars) according to the social status of *P. macrocarpus*. These results point way to a better understanding of the use and management of an economically important NTFP.

Keys words: Biometry, edible caterpillars, fluctuations, forest, *Petesianthus macrocarpus*.

RÉSUMÉ

Variations d'abondance d'*Imbrasia epimethea* (Lépidoptères : Saturniidae) sur *Petersianthus macrocarpus* dans différents types de forêts au Centre Cameroun

Les chenilles comestibles sont d'une importance vitale pour les communautés rurales des pays en développement, car elles fournissent des protéines et des revenus élevés. Toutefois, leur écologie, en particulier les fluctuations saisonnières de leur nombre, est encore mal connue. Avec le changement climatique en cours et la déforestation croissante, leur survie est une question cruciale. L'objectif de cette étude était d'évaluer les caractéristiques structurales de *Petersianthus macrocarpus* (Lecythidaceae) sur l'abondance des chenilles d'*Imbrasia epimethea* (Saturniidea). La zone forestière située à la périphérie de Yaoundé est un important bassin de production de chenilles comestibles, ce qui en fait un support idéal pour répondre aux questions sur les variations de l'abondance des chenilles d'*I. epimethea* en relation avec le type de forêt de *P. macrocarpus*. En ce qui concerne les paramètres biométriques, la classe de diamètre [20-30[cm dans l'agroforêt avait plus de chenilles comestibles (31,1 %). Dans la forêt secondaire et la forêt marécageuse, c'était la classe de diamètre [50-60[cm avec respectivement 34 % et 27,4 %. En termes de hauteur, la classe 30-40 m de hauteur contenait plus de chenilles comestibles (68,50 %), alors que la classe 60-70 m de hauteur représentait la strate avec le moins de chenilles comestibles (5,10 %). Dans les différents types de forêts, l'abondance des chenilles d'*I. epimethea* en fonction du statut social des individus de *P. macrocarpus* a montré que les chenilles se trouvent en abondance préférentiellement sur les individus dominants (52,7 % en forêt marécageuse, 49,7 % en forêt secondaire et 45,6 % en agroforêt). L'abondance moyenne des chenilles d'*I. epimethea* est plus élevée dans la forêt secondaire (563 ± 62 chenilles) que dans l'agroforêt et la forêt marécageuse. En revanche, la forêt marécageuse avait l'abondance moyenne la plus faible de chenilles comestibles (375 ± 24 chenilles) en fonction du statut social de *P. macrocarpus*. Ces résultats présentent des pistes pour une meilleure compréhension de l'exploitation et de la gestion d'un PFNL d'importance économique.

Mots clés : Biométrie, chenilles comestibles, fluctuations, forêt, *Petesianthus macrocarpus.*

INTRODUCTION

Food security remains one of the main concerns for the mankind nowadays. In fact, out of about 7 billion people in the world right now, more than 800 million, or more than one in nine of the world's population, do not have enough to eat (FAO, IFAD, WHO, WFP and UNICEF, 2022). More than a third of the world's hungry people live in Africa according to FAO, IFAD, WHO, WFP & UNICEF 2022). With the world's population expected to reach ten billion people in 2050 (Godfray et al., 2010; Van Huis et al., 2014; FAO, 2017; Mabossy-Mobouna et al., 2022), the food insecurity situation is expected to increase global food demand by up to 70 % compared to current needs (Mabossy-Mobouna et al., 2022). In order to overcome food insecurity, several alternatives have been proposed with different efficiencies. Of all those alternatives, one that has been neglected and that is becoming more popular is the use of insects as alternatives sources of proteins. This situation therefore, the need for new sources of cheaper, affordable and easily accessible nutrients is of paramount importance (Ogunleye, 2006). In this light, insects are increasingly seen as an alternative to meat for people in Africa (Van Huis, 2003; Banjo et al., 2006; Kekeunou & Tamesse, 2016; Kekeunou et al., 2020a, b). Insects are non-timber forest products (NTFPs) of animal origin. They represent nearly 80 % of the animal kingdom with more than 10 million species known to date (Premalatha & Abbasi, 2011). They are very active in the tropics and play an important role in nutrition (*Imbrasia truncata*, *Imbrasia belina*), pollination (*Apis mellifera*, *Bombus terrestris*), soil fertility improvement (*Monochamus scutellatus*) and pest control (Carabidae, Coccinellidae) (Van Huis et al., 2013). The most consumed insects belong to the orders Lepidoptera (caterpillars), Coleoptera (beetles), Isoptera (termites), Hymenoptera (bees and ants), Diptera (flies) and Orthoptera (grasshoppers, crickets and crickets) (Anankware et al., 2016; Johnson, 2010; Kelemu et al., 2015). The nutritional value of edible caterpillars in the Congo Basin is confirmed by numerous studies (Van Huis et al., 2014; Foua et al., 2015; Okangola et al., 2016; Ombeni & Munyuli, 2016; Mabossy-Mobouna et al., 2017). This nutritional value can contribute to the qualitative and quantitative improvement of the diet of populations in situations of undernourishment, malnutrition or food crisis (Ambombo, 2022). Caterpillars are not only an important source of protein for local consumption, but also provide substantial income to both rural and urban populations (Van Huis et al., 2014). Edible caterpillars are mostly found in different forest types including dense evergreen forest, secondary forest, agroforests and home gardens (Ambombo, 2022). Their appearance is seasonal following the leaf phenology itself, depending on the climate and the habitat of the host species (Ambombo, 2022). Indeed, caterpillar collection is synchronized with the bimodal rainfall regime in forest areas (Hladik et al., 1989). It is therefore certain that the ongoing environmental changes related to climate changes will be accompanied by a significant reduction in species diversity, caterpillar food abundance and biomass (Leleup et al., 1969; De Foliart, 1992). According to Ambombo (2022) their abundance varies with forest type and social status of the host tree. Studies on variations in the abundance of edible caterpillars are scarce in Cameroon's dense rainforests. Available works are those of Lisingo et al. (2010); Latham (2016); Ngute et al. (2019); Looli et al. (2021) who have worked on the identification of edible caterpillars and their host plants. Van Huis et al. (2014) ; Foua et al. (2015); Okangola et al. (2016); Ombeni & Munyuli, (2016); Malaisse et al. (2016); Mabossy-Mobouna et al. (2017); Malaisse et al. (2017); Malonga et al. (2018); Fogang et al. (2019); Mabossy-Mobouna et al (2022). The objective of this study is to evaluate the influence of structural characteristics of *P. macrocarpus* on the abundance of caterpillars of *I. epimethea*. It was hypothesised that the abundance of caterpillars of *I. epimethea* would depend on the forest type and social status of *P. macrocarpus* (Ambombo, 2022).

MATERIAL AND METHODS

Study site

Ngoumou is a locality belonging to the southern plateau of Cameroon (Vallerie, 1995). It is located between 3º32' and 3º45' North latitude and 11º12' and 11º22' East longitude; the average altitude is 730 m. The climate of this region is equatorial Guinean, hot and humid (Suchel, 1988), with a bimodal rainfall regime characterised by a short rainy season (SPS) and a long rainy season (LSW), respectively the SPS from mid-March to June and the LSW from September to mid-November. They alternate with a long dry season (GSS, mid-November to mid-March) and a short dry season (PSS in June-August). However, the latter is not a real dry season as it corresponds to a simple decrease in rainfall, the extent of which varies from year to year. The average annual temperature is around 25.7°C. The highest monthly averages are recorded between February and April and the lowest between July and August.

This study took place in the forest zone, notably in the semi-caducified dense rainforest. This forest has the double advantage of having a high species richness and also harbours several caterpillar species according to Balinga et al. (2004). The study site was therefore chosen in a reasoned manner in the village of Nkong-Abok in the Mefou and Akono department (Fig. 1), which is one of the major caterpillar production basins in the Central Cameroon region. This study site is located not far from the Ottotomo Forest Reserve.

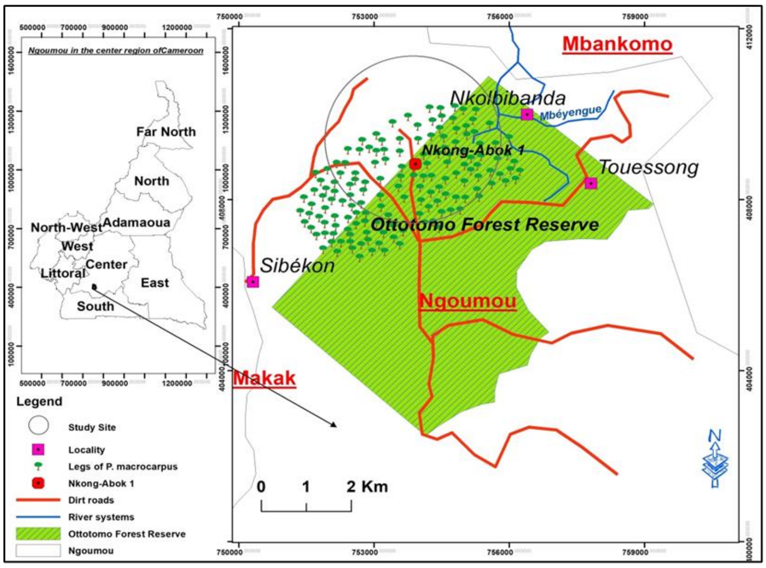

Figure 1. Location map of the study area

According to Letouzey (1985), the Ngoumou area belongs to the semi-deciduous forest sector, and is found in agroecological zone V, known as the bimodal rainforest zone. The semi-deciduous rainforest sector corresponds to the "drier peripheral semi-evergreen Guineo-congolian rain forest of White (1992)". According to Villiers (1981), it is characterised by its physiognomy (some species are defoliated at the same time for several weeks) and by its floristic composition where the importance of Sterculiaceae (*Cola altissima*, *Co. lateritia*, *Co. gigantea*, *Mansonia altissima*, *Nesogordonia papaverifera*, *Pterygota kamerunensis*, *Sterculia bequaertii*, *S. rhinopetala*, *Triplochiton scleroxylon*) and also Ulmaceae (*Celtis adolfi-friderici*, *Ce. durandii*, *Ce. mildbraedii*, *Ce. philippensis*, *Ce. zenkeri*, *Holoptelea grandis*).

Sampling plan and data collection method

The sampling plan was designed to arrange the plots along the trails in the different forest types in the vicinity of the Ottotomo Forest Reserve the sampling unit here was the host individual *P. macrocarpus*. The trail method inspired by Tosso et al. (2020) was adopted in the present study. Trails have the advantage of allowing the choice of trees to be monitored (Picard & Gourlet-Fleury, 2008). Not only does it allow the selection of priority species, but it also allows the diametric distribution of the sample to be controlled: it can be ensured that there are the same number of individuals in each diameter class (Picard & Gourlet-Fleury, 2008). Trails have also the advantage of crossing several ecologically different habitat types and of providing an accurate qualitative and quantitative description of the host species' habitat. It is in fact the target trees that define the trail and it has a length but no surface extension (Picard & Gourlet-Fleury, 2008). Thus, 4 trails were monitored for a total of 45 individuals of *P. macrocarpus*. The area of the plots was chosen on the basis of some work carried out in tropical areas by several authors (Condit, 1995; Condit et al., 1996; Condit et al., 1998, Potts et al., 2001; Tchouto, 2004; Senterre, 2005). These authors used areas varying from 100 to 1000 m² depending on the density of the host species and the topographical conditions. For the present study, rectangular plots of 500 m² (25 m x 20 m) were set up in each forest type selected.

Botanical description of *Petersianthus macrocarpus*

Petersianthus macrocarpus (P. Beauv.) Liben, from the pilot name abing or abale, is a species of the

Lecythidaceae family (Fig. 2) described by Palisot de Beauvois (1820). Nowadays, it belongs to the group of species that were once considered as secondary and which have potential for exploitation, especially for timber and non-timber forest products (Ambombo et al., 2020). It is in this sense that abing is described as a multipurpose species as it serves as a timber, medicinal plant, domestic use and finally as a host species for edible caterpillars (Ambombo, 2022). *Petersianthus macrocarpus* is an endemic species of the sub-Guineocongolese region (Doucet, 2003), more specifically, it is a deciduous, semi-heliophilous, non-gregarious species of dense evergreen and semi-deciduous rainforests (Meunier et al., 2015). Abing is a pterochore species with anemochore fruit dispersal (Doucet, 2003; Meunier et al., 2015). According to Vivien & Faure (2011), Owusu (2012), the range of *P. macrocarpus* extends from Guinea to the Central African Republic, and southwards to the Democratic Republic of Congo and northern Angola.

Figure 2. Bole and crown of *Petersianthus macrocarpus*

Measurement of biometric parameters of individuals of *Petersianthus macrocarpus*

In the different forest types identified in the study site, 45 individuals of *P. macrocarpus* (15 individuals in agroforests, 15 in swamp forest and 15 in secondary forest) were geolocated along the trails. These *P. macrocarpus* individuals were selected because they had carried caterpillars at least once in four previous years (2014-2017). These individuals are divided according to their bole diameters from 20 cm. The following dendrometric parameters were measured: diameter at breast height and height of the host species as well as of companion individuals in order to define the social status of *P. macrocarpus*. These dendrometric parameters of the trees were measured using a circumferential tape for diameter measurements and a "Suunto" clinometer for height measurements.

Ecology of *Imbrasia epimethea*

Imbrasia epimethea (Drury, 1772) is an edible caterpillar of the family Saturniidae (Fig. 3). It is a nocturnal lepidopteran from a trophic point of view, this species is polyphagous, meaning that it infers several plant species. *Petersianthus macrocarpus* is its main host in the Nkong-Abok area Ambombo (2022). During its larval stage, *I. epimethea* feeds exclusively on the foliage of its host species and undergoes several moults (Between 4 and 6 wash stages separated by successive walls according to Roth (1980).

Figure 3. Caterpillars of *Imbrasia epimethea*

Caterpillar collection was based on the method of Tabi et al. (2016). According to the technique, an area equivalent to the projection of the crown on the ground was defined around each *Petersianthus macrocarpus* plant (Fig. 4), then cleared of shrubs and herbaceous plants to facilitate the counting of caterpillars falling to the ground.

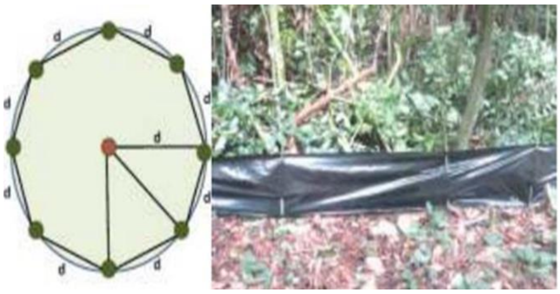

Figure 4. Marking out the projection of the tree crown on the ground (Tabi et al., 2016)

A perimeter was set around each host plant using tarpaulins, which were laid out in the form of hedges supported by stakes. The aim was to trap the caterpillars within the defined perimeter so that they could be counted. Numbers were estimated on the basis of sight counts. According to Khasirikani (2009), sight counts are a method used to estimate the numbers of terrestrial vertebrates.

Data analysis

Microsoft Excel Office Professional 2010 spreadsheet was used to enter and reconcile the data. Statistical analyses were performed using R software version 3.5.2 R Core Team 2020 and Micosoft Excel Office Professional 2010. The Shapiro-Wilk test was used to test the normality of the data for the different variables in order to perform an analysis of variance. The ANOVA followed by the Tukey HSD multiple comparison test were performed at the 5 % significance level.

RESULTS

Structural characteristics of *Petersianthus macrocarpus* in forest types

The result of the study of the distribution of P. macrocarpus individuals by diameter classes in the different forest types is shown in figure 5. To better illustrate the horizontal structure of *P. macrocarpus*, 11 diameter classes were formed. In all forest types, *P. macrocarpus* individuals show an erratic diameter structure. The diameter classes I to V have more individuals in all forest types under study. Diameter classes I and IV (from [20-30[cm and [50-60[cm) have more individuals than the other diameter classes in the agroforest and swamp forest (60 % vs 46,6 %). In the secondary forest, diameter classes IV and V ([50-60[cm and [60-70[cm) have more individuals.

The average diameter of *P. macrocarpus* individuals is largest in secondary forest followed by agroforest (Table 1).

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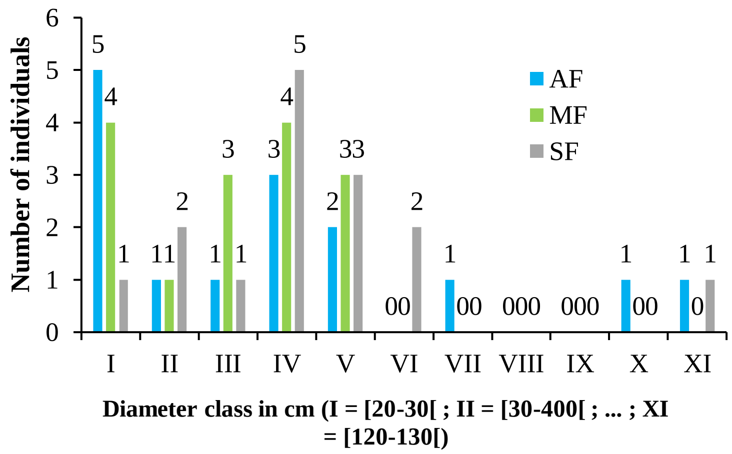


MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest

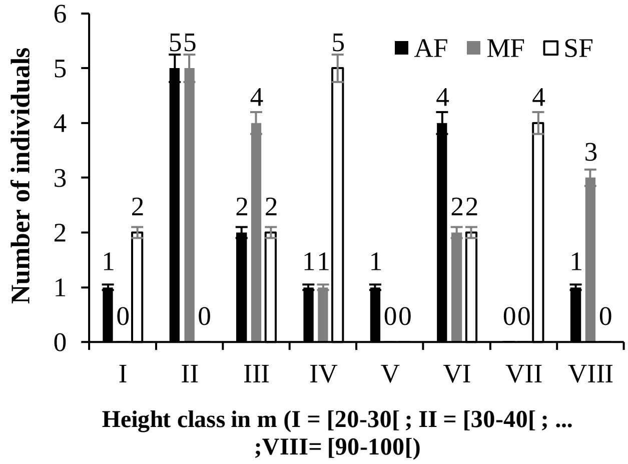
Figure 5. Diameter structure of *Petersianthus macrocarpus* in different forest types.

Table 1. Dendrometric characteristics of *Petersianthus macrocarpus* by forest type (n = 15)

Dendrometric parameters	AF	MF	SF
Average diameter (cm)	57.5 ± 34.3	46 ± 14.2	58.4 ± 23.6
Average height (m)	49.4 ± 19.6	51.4 ± 19.7	58.2 ± 21.9

MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest

Swamp forest has the smallest average diameter (46 ± 14.2 cm). The individuals under study do not have large diameters (Fig. 5). However, in the agroforest, there are two individuals with diameters in the ranges [110-120[cm and [120-130[cm and one individual in the secondary forest. For all *P. macrocarpus* individuals across forest types, the height structure shows an irregular or erratic pattern like in the diameter structure (Fig. 6). In swamp forest and agroforest, *P. macrocarpus* individuals in the [30-40[m height class are the most widespread. The [50-60[m height class in secondary forest has more individuals. This height class ([50-60[m) has the highest proportion of individuals (33,3 %) in all forest types. The average height of *P. macrocarpus* individuals is highest in secondary forest (58.2 ± 21.9 m) followed by swamp forest (Table 1). Agroforest has the lowest average height (49.4 ± 19.6 m). The [90-100[m height class is the highest with one individual in the agroforest and three individuals in the swamp forest. Only the agroforest has individuals represented in all height classes except the [80-90[m class.

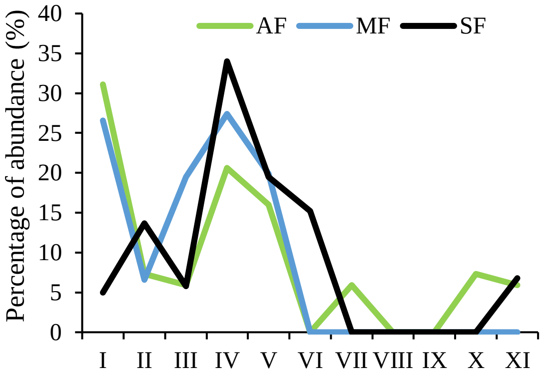


MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest

Figure 6. Evolution of the abundance of *Imbrasia epimethea* caterpillars in relation to the diameter classes of *Petersianthus macrocarpus*

Variation in abundance of caterpillars of *Imbrasia epimethea* as function of diameter

The abundance of caterpillars varied between the diameter classes (Fig. 7). Caterpillar abundance is highest in class IV regardless of the forest type considered. In the agroforest, the [20-30[cm diameter class has the most caterpillars with 31.1 % (2,169 edible caterpillars).



Diameter class in cm (I = [20-30[; II = [30-40[; ...; XI = [120-130[

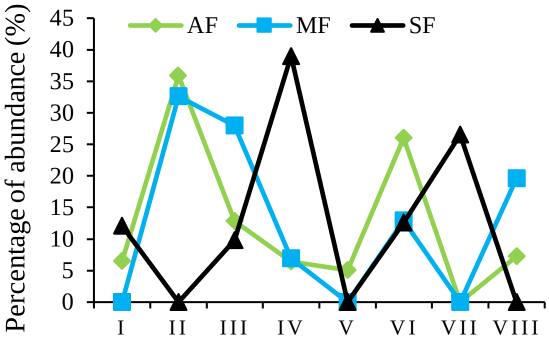
**MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest*

Figure 7. Evolution of the abundance of *Imbrasia epimethea* caterpillars in relation to the diameter classes of *Petersianthus macrocarpus*

The abundance of edible caterpillars decreases for the diameter classes [80-90[cm and [120-130[cm in both agroforest and swamp and secondary forest (cor = -0,2). It should be noted that *P. macrocarpus* harbours edible caterpillars from 20 cm diameter and *I. epimethea* caterpillars are less abundant on large diameter individuals in all forest types. Overall, secondary forest has the highest percentage abundance of edible caterpillars by diameter of *P. macrocarpus* (38.6 %). It is followed by agroforest with 33.8 % and swamp forest with 27.6 %.

Variation in abundance of caterpillars of *Imbrasia epimethea* with height

The [30-40[m height class in agroforestry and swamp forest has the highest abundance of *I. epimethea* caterpillars (Fig. 8) with 35.9 % and 32.6 % respectively.



Height class in m (I = [20-30[; II = [30-40[; ... ; VIII = [90-100[)

**MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest*

Figure 8. Evolution of the abundance of *Imbrasia epimethea* caterpillars in relation to the height classes of *P. macrocarpus*

On the other hand, the height classes [50-60[m and [60-70[m have a low percentage of edible caterpillars in swamp forest and agroforest (6.9 % and 5.1 %). In the secondary forest, the [50-60[m height class has the most edible caterpillars, with 39 %. The height class [40-50[m has the lowest percentage of edible caterpillars (9.8 %) in secondary forest. Overall, the [30-40[m height class contains more edible caterpillars with 68.50 %. This is the height class where the trees have sufficient foliage to provide food for the edible caterpillars. In contrast, the height class [60-70[m is the stratum with the least number of *P. macrocarpus* individuals under study with few edible caterpillars (5.10 %; cor = -0,07).

Mean variation in abundance of caterpillars of *Imbrasia epimethea*

Social status in the context of this study refers to the vertical competition between *Petersianthus macrocarpus* and its closest neighbours. Thus, *P. macrocarpus* can be dominant, codominant or dominated. The multi-factor analysis of variance shows that there is no significant difference in the mean abundance of edible caterpillars according to social status within the agroforest ($p>0.05$) (Table 2).

Table 2. Average number of edible caterpillars by social status and forest types (n= 15)

Social status of the host species	AF	MF	SF
Dominant	454 ± 72^{ab}	375 ± 24^{b}	563 ± 62^{a}
Codominant	490 ± 62^{ab}	381 ± 13^{ab}	502 ± 95^{ab}
Dominated	456 ± 41^{ab}	390 ± 5^{ab}	496 ± 60^{ab}

**MF: Swamp Forest; AF: Agroforest; SF: Secondary Forest. a, b, ab: significant at the 5 % and 1 % probability levels respectively*

However, in swamp forest, the mean abundance of edible caterpillars of dominant individuals is statistically different from those of codominant and dominated individuals. For codominant and dominant individuals, there was no significant difference in the mean abundance of edible caterpillars within the swamp forest ($p>0.05$). For the secondary forest, the average abundance of edible caterpillars within this forest type and according to the social status of *P. macrocarpus* individuals follows the same logic as in the swamp forest. Concerning the dominant individuals, across forest types there is a significant difference in the mean abundance of edible caterpillars ($p<0.001$). However, the dominant and co-dominant individuals with regard to the mean abundance of edible caterpillars of *I. epimethea* did not differ significantly within the different forest types ($p>0.05$). The average abundance of caterpillars is higher in secondary forest (563 ± 62 caterpillars) compared to agroforest and swamp forest. On the other hand, swamp forest had the lowest mean abundance of edible caterpillars (375 ± 24 caterpillars) according to the social status of *P. macrocarpus*.

Influence of social status of trees

The abundance of caterpillars of *I. epimethea* according to the social status of *P. macrocarpus* individuals within the different forest types (Fig. 9) shows that caterpillars are found in abundance preferentially on dominant individuals. Thus, 52.7 % of edible caterpillars were counted on dominant individuals in swamp forest (with a height varying from 30 m to 90 m) as opposed to co-dominant individuals (26.80 %) with a height varying between 35 and 45 m, and dominant individuals (20.50 %) with a height between 40 and 70 m. In secondary forest, abundance is still found in the dominant individuals (49.70 %), whose height varies from 20 to 70 m. However, the dominant (40-80 m height) and codominant (25-85 m height) individuals have almost the same percentage of abundance (25 %). In the agroforest, dominant individuals (45.60 % with a height between 35 and 70 m) have the highest percentage abundance. Co-dominant individuals (30-90 m height) have the highest percentage of edible caterpillar abundance (28.20 %) than dominant individuals (26.20 % with a height ranging from 25 to 70 m).

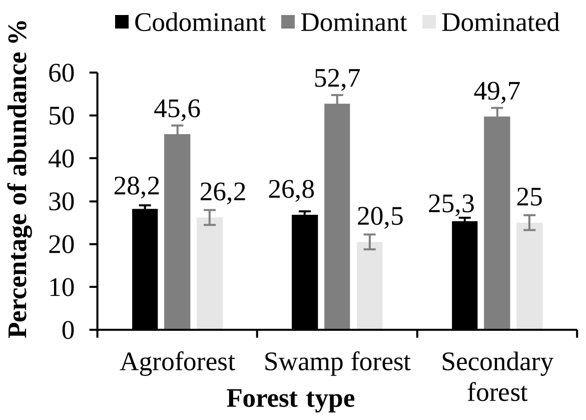


Figure 9. Carterpillar abundance by forest type and social status of *Petersianthus macrocarpus*

DISCUSSION

Characteristics of structural parameters in *Petersianthus macrocarpus*

Individuals of *P. macrocarpus* are found in abundance in the diameter classes I to V ([20-30[cm ... [60-70[cm). However, the diameter classes ([50-60[cm and [60-70[cm) are the most important in each forest type as they ensure the renewal of the host species. Durrieu de Madron & Daumerie (2004) state in this sense that studies on fruiting diameter show that *P. macrocarpus* fruits from 60 cm onwards, which means that 80 % of the trees with a diameter of more than 60 cm are seed carriers. The individuals selected for the study are not large enough in diameter in all forest types. This remark shows the young character of the population of *P. macrocarpus* in the study area. The height of a tree establishes the life stratification of winged species like butterflies (Ambombo, 2022). In swamp forest and agroforest, the [30-40[m height class has more individuals. However, in the secondary forest, the [50-60[m height class has more individuals of *P. macrocarpus*. This difference could be explained by the competition in the secondary forest. Indeed, the individuals that host the edible caterpillars in the secondary forest have to climb up to the canopy level in order to capture more light for good photosynthesis because the caterpillars' diet depends on the foliage of the host species. For all the individuals of *P. macrocarpus* according to forest types, the population structure of the individuals shows an irregular or erratic form. Sabatier & Prévost (1989) indicate in this sense that certain species can have sometimes an aggregative behaviour, sometimes an erratic behaviour, and this is very often related to the edaphic conditions.

Variability in caterpillar abundance depending on forest structure

Depending on structural parameters and diameter classes, the abundance of caterpillars of *I. epimethea* varies between individuals of *P. macrocarpus*. The [20-30[cm diameter class has more caterpillars in agroforest, and the [50-60[cm diameter class in secondary and swamp forest with 34 % and 27.4 % respectively. However, the [80-90[cm and [120-130[cm diameter classes have a low percentage of edible caterpillar abundance in the agroforest. Similarly, the [20-30[cm and [30-40[cm classes have low percentages of *I. epimethea* caterpillars in swamp forest (5 %) and secondary forest (6.6 %). These results are similar to those of Tabi et al. (2016) who showed that *I. oyemensis* caterpillars were preferentially found on individuals between 45 and 80 cm in diameter. In view of these results, it is important to underline that *P. macrocarpus* individuals that have not yet reached fruiting diameter have more *I. epimethea* caterpillars compared to large diameter individuals. Regarding height classes, the [30-40[m height class has more *I. epimethea* caterpillars in agroforest and swamp forest (35.9 % and 32.6 %). In secondary forest, the [50-60[m height class has more caterpillars. These results are similar to those of Tabi et al. (2016). In this sense they state that, given the height of the trees, the saplings with the most caterpillars are those that are still growing, whose foliage is exposed to full light and are in their reproductive age (seed production). In contrast to the [40-50[m, [50-60[m and [60-70[m height classes in secondary forest (9.8 %), swamp forest (6.9 %) and agroforest (5.1 %) which have fewer *I. epimethea* caterpillars. The low abundance of caterpillars in these height classes could be due to the environment on *P. macrocarpus* individuals, but also to the ecology of *Imbrasia epimethea* caterpillars.

Variability in caterpillar abundance with forest type and social status of trees

Overall, depending on the social status of *P. macrocarpus* individuals, caterpillars of *I. epimethea* have a preference for dominant individuals in all three forest types. These observations are close to those of Tabi et al. (2016) with respect to the Dawking V index. This index refers respectively to dominant individuals and mostly having already reached the regular fruiting diameter where *I. oyemensis* caterpillars are preferentially found on *Entandrophragma cylindricum*. These trees have their crowns fully exposed to direct sunlight. The exposure of the dominant *P. macrocarpus* individuals to light would contribute to a significant oviposition of moths on this species. However, in the swamp forest, caterpillars are found second on codominant individuals (26.8 %), 28.2 % in the agroforest and 25 % in secondary forest on codominant and dominated individuals, whose percentage abundance is identical. Depending on the social status and forest type of *P. macrocarpus*, the analysis of variance of the mean abundance of *I. epimethea* caterpillars was not statistically different in the agroforest. For the secondary forest and swamp forest, a significant difference in the average abundance of *I. epimethea* caterpillars was observed between dominant and codominant and dominated individuals. This variation in average caterpillar abundance is mainly influenced by the variability of caterpillar abundance in each tree, which depends closely on the season and its living environment (Ambombo, 2022). However, the dominant individuals due to their position in the upper stratum of each forest type have the highest average abundance of edible caterpillars. Naturally, the secondary forest has the highest average because *P. macrocarpus* is in its preferred biotope and all the resources necessary for a better development of the caterpillars reside there, unlike the other forest types.

CONCLUSION

This study allowed to identify the variation in abundance of caterpillars of *I. epimethea* according to the biometric parameters and the social status of *P. macrocarpus* in each forest type. *Petersianthus macrocarpus,* depending on its dispersal pattern and its high probability to establish and grow in the study area, develops an erratic behaviour depending on the edaphic conditions. Regarding the variation in the abundance of edible caterpillars according to the type of forest, it appears that *P. macrocarpus* occurs in secondary forest, swamp forest and agroforest (old fallow land, fields and cocoa plantations). Regarding biometric characteristics, secondary forest has the highest percentage of abundance of edible caterpillars according to the diameter of *P. macrocarpus* (38.6 %). It is followed by agroforest with 33.8 % and swamp forest with 27.6 %. The [30-40[m height class contains more edible caterpillars with 68.50 %. On the other hand, the height class [60-70[m is the stratum with few individuals of *P. macrocarpus* under study and also has a low percentage of edible caterpillars (5.10 %). The results of this study regarding the social status of *P. macrocarpus* show that edible caterpillars have a preference for dominant individuals compared to codominant and dominant individuals. This preference is dependent on the positioning of these individuals in the canopy. The average abundance of caterpillars as a function of social status in secondary forest is also found on dominant individuals of *P. macrocarpus*. In swamp forest, the preference still lies with the dominant individuals. However, in the agroforest according to the social status of *P. macrocarpus*, there is no significant difference in the mean abundance of caterpillars of *I. epimethea*. Knowledge of the parameters that play a determining role in the fluctuation of *I. epimethea* caterpillars on *P. macrocarpus* is crucial for the development of breeding techniques for this NTFP.

Recommendations

Edible caterpillars are an important source of protein in rural areas, but the ecology of the host species is still poorly understood in most cases. The damage inflicted on forests has a major impact on the habitat of these NTFPs and on their long-term survival. It is therefore essential to: (i) identify the different tree species that harbor edible caterpillars in order to study their ecology in relation to their host species; (ii) provide more data on the nutritional value of edible caterpillars in order to promote them more effectively as an alternative source of protein.

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Conflict of interest

The authors declare that they have no competing interests.

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