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Research Article

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Phenology of *Petersianthus Macrocarpus* from 2017 to 2020 and Risk of Pollinosis in Dictrict of Abidjan

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Abstract
Petersianthus macrocarpus is a plant species whose pollens are potentially allergenic. This plant is present from the coast to the centre of the country. The objective of this study is to prevent populations from being exposed to the pollens of Petersianthus macrocarpus. Specifically, it was a question of defining the flowering of Petersianthus macrocarpus, evaluating the impact of the climate on this flowering and listing the populations most exposed to P. macrocarpus pollens. The study took place in Abidjan, in the commune of Yopougon, specifically in South Niangon, from September 2017 to June 2020. Sampling by quadrat allowed to determine the number of individuals, the cover, the density and the frequency of the vegetation. Floral phenology was carried out by weekly observations using binoculars. The coverage in each quadrat was 1 and the frequency 100%. Individuals less than 6 m high did not bear any flowers. Two flowering periods were observed in the years 2017 to 2019. The first was from April to June, the second from November to January. However, there was no flowering from April to June in 2020. The evolution of rainfall in 2020 was not identical to that of the three previous years. The phenology of Petersianthus macrocarpus presents periods of high risk of pollinosis and is influenced by rainfall. Increasing wind speed exposes new populations to pollen. The installation of pollen collectors is certainly necessary to establish the pollen calendar of Petersianthus macrocarpus in Côte d'Ivoire.

Keywords: Côte d'Ivoire, *Petersianthus macrocarpus,* Phenology, Prevention, Pollinosis

Introduction
Petersianthus macrocarpus (P. Beauv.) Liben (Lecythidaceae) is a plant species known in most cases for its edible, medicinal or timber uses [1]. It is called a competitive species because it is sought after both by loggers for its timber and by local populations for its edible caterpillars [2]. This plant is present over a large part of the Ivorian territory, from the coast to the centre of the country [3]. It is abundant in the evergreen forest and in the transition zones between the evergreen forest and the semi-deciduous humid forest [4, 5]. *P. macrocarpus* prefers regions with an annual rainfall of about 2000 mm [6]. It is a bisexual species of the Dicotyledons class. The vernacular names are numerous. It is called Abalé in Côte d'Ivoire, Esia in Ghana, Minzu in Congo Abing in Gabon and Cameroon [7]. The flowering of this plant is irregular but reaches its peak around December and May [1]. During these periods, pollen released into the air can affect many people. Pollens from

birch, grasses and ragweed have already been reported [8].

P. macrocarpus pollens are potentially allergenic according to clinical studies. These studies have shown that during the flowering period of this plant, 16% of the surrounding population has allergies [9]. These allergies, also known as pollinosis, are expressed as rhinitis, cardiovascular problems, skin and eye itching [10]. The World Health Organisation (WHO) classifies allergies as the fourth most common disease in the world and considers that these pathologies represent "a major public health problem in terms of quality of life, loss of working days, cost of medicines and even mortality" [11]. According to the work of Ravault et al in 2005, pollinosis affects 10 to 30% of the world's inhabitants depending on the geographical area [12].

A single plant can produce 1 million to several million grains of pollen in one day [13]. The allergic reaction depends mainly on the correlation between the onset of symptoms and the pollination periods of the plants. The pollination season depends on the different species and their geographical location. The allergic risk of pollen exposure is known for pollens of some European plant species [14]. But this is not the case in Côte d'Ivoire.

However, today in Côte d'Ivoire, it is difficult to establish a link between allergies and the pollens involved. The lack of control tools is due to a lack of knowledge of the plant species that produce allergenic pollens in the atmosphere.This study focused on *Petersianthus macrocarpus*. It aims to determine the exposure of populations to *Petersianthus macrocarpus* pollens. Specifically, it is a question of :

define the flowering of *P. macrocarpus,*
assess the impact of the climate on flowering.
list the populations most exposed to *P. macrocarpus* pollens

Materials and Methods:

Study area

The study took place in a forest in Abidjan, in the commune of Yopougon, precisely in the district of Niangon Sud. This forest is close to the Swiss Center for Scientific Research (CSRS) and the National Center for Agronomic Research (CNRA). It extends as far as the former botanical garden of Côte d'Ivoire (Figure 1).

Figure 1: Mapping of Niangon Sud.

Enumeration of the number of individuals of *Petersianthus macrocarpus*

The *Petersianthus macrocarpus* study area was defined in August 2017, following a roving survey. The number of individuals of the species was then estimated from September 2017 using the quadrat method [15]. Four quadrats were installed in the study area (Figure 2). New shoots after November 2017 were not taken into account.

The quadrat sampling measured the coverage, density and frequency of vegetation formation. Cover corresponds to the percentage of the quadrat area that is covered by a given species. Density corresponds to the number of individuals that have taken root in each quadrat. Frequency corresponds to the percentage of all the quadrats in which at least one plant of a given species has taken root.

$$\text{density} = \frac{\text{number of individuals}}{\text{area (hectare)}}$$

Coverage has been estimated based on the following indicators [16]:

i: only one individual present, coverage < 5% ;
r: rare or very rare individuals, coverage < 5%;
+: very few individuals present, overlap < 5%;

1. few to abundant individuals, overlap < 5%;
2. individuals in variable numbers, recovery between 5 and 25%;
3. Variable number of individuals, recovery between 25 and 50%; +: Variable number of individuals, recovery between 25 and 50%;
4. Variable number of individuals, 50-75% recovery;
5. variable number of individuals, 75% overlap ≥.

Figure 2 : Installation site of the quadrats.

Populations exposed to *P. macrocarpus* pollens

Populations exposed to *Petersianthus macrocarpus* pollens have been mapped by Google Map.

Results

Coverage, frequency and density

The GPS data for the different quadrats are presented in Table I. The number of individuals of *Petersianthus macrocarpus* occupies less than 25% of the surface area of each quadrat, which is 3200 m2. The coverage is therefore 1. Having found at least one individual in each quadrat, the frequency is 100%. In quadrats 1 and 2, the density of flowering and fruiting individuals is 12.5. This density is 6.125 in quadrat 3 and 9.375 in quadrat 4. Flowering is therefore identical in quadrants 1 and 2, whereas there are more individuals in quadrat 2 (Table II).

Table I : GPS data of the quadrats,

Quadrats	1	2	3	4
GPS data	5.331879, -4.130748	5.332178, -4.133023	5.328845, -4.133624	5.328888, -4.132251

Table II : Density of *Petersianthus macrocarpus* individuals in each quadrat in 2018

Densities (Number of individuals/ hectare) Quadrats	Di	Da	Db
1	d1=37,5	d''1=12,5	d'1=25
2	d2=59,375	d''2=12,5	d'2=46,875
3	d3=28,125	d''3=6,125	d'3=21,875
4	d4=31,125	d''=9,375	d'4=21,875

Di : Density of all individuals in the quadrat
Da : Density of individuals with leaves, flowers and fruits
Db: Density of leafy individuals, without flowers or fruits

Particularities of the species

The individuals of *Petersianthus macrocarpus* encountered have a size that varies from 50 cm to 35 m. Individuals smaller than 6 m were only found in quadrat 2. Two types of leaf coloration were observed. There are green leaves and red leaves. The higher the size of the trees, the smaller the size of the leaves. Flower buds, blooming flowers and fruits were only found on individuals larger than 6 m (Table III). The appearance of flowers is followed by fruiting. The petals and stamens are easily detached from the sepals (Figure 3). The sepals are fused to the flower receptacle. Fruits can be distinguished from leaves and flowers by their winged appearance and hardness (Figure 4). The brightness of the first fruits gives the impression of flowering. However, in many cases this flowering has already passed.

Table III : Number of individuals by size of *Petersianthus macrocarpus* in 2018.

Size (m)	[0-3]	[3-6]	[6-11]	[11-15]	[15-20]	[20-35]	TOTAL
Presence of flowers	0	0	3	4	4	2	13
No flowers	11	4	9	4	8	3	37
Total	11	4	12	8	12	5	52

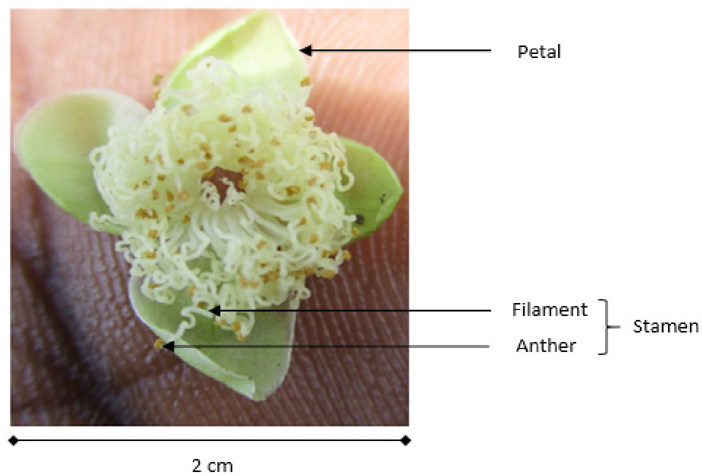

Figure 3 :*Petersianthus macrocarpus* flower.

Figure 4 : Branch of *Petersianthus macrocarpus.*

Flowering periods

From September 2017 to June 2020, *Petersianthus macrocarpus* flowered twice in the same year. The first started in April and ended in June, the second started in November and ended in January of the following year. However, in 2020, no flowers were observed from April to June in the different quadrats (figure 5). A flower becomes a fruit in less than two weeks after its appearance. In contrast to the flower, which lasts less than a week before wilting, many fruits persist on the tree for more than three months, sometimes until the next flowering.

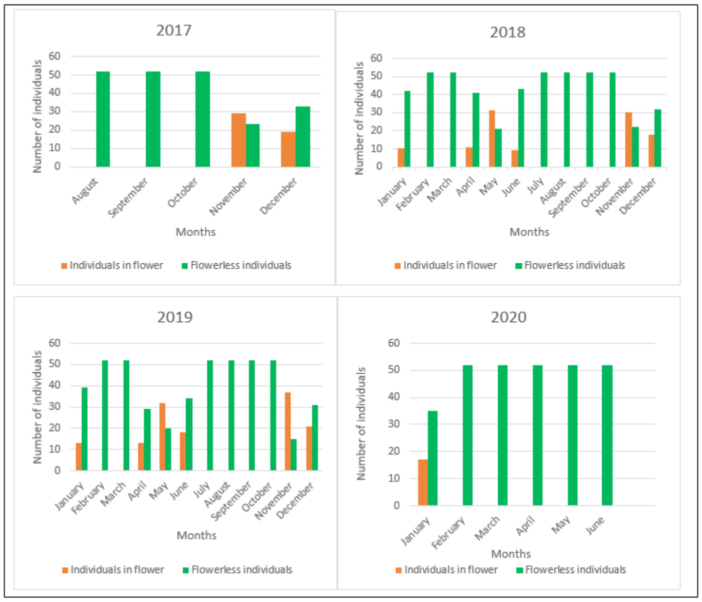

Figure 5 : Flowering evolution of *Petersianthus macrocarpus* from 2017 to 2020.

State of the climate during flowering

Evolution of rainfall during flowering

Flowering, which begins in April, is preceded by an increase in rainfall in March. Rainfall peaks in June and then decreases until August. On the other hand, the flowering which starts in November is preceded by a decrease in rainfall in October. This rainfall decreases until December (Figure 6).

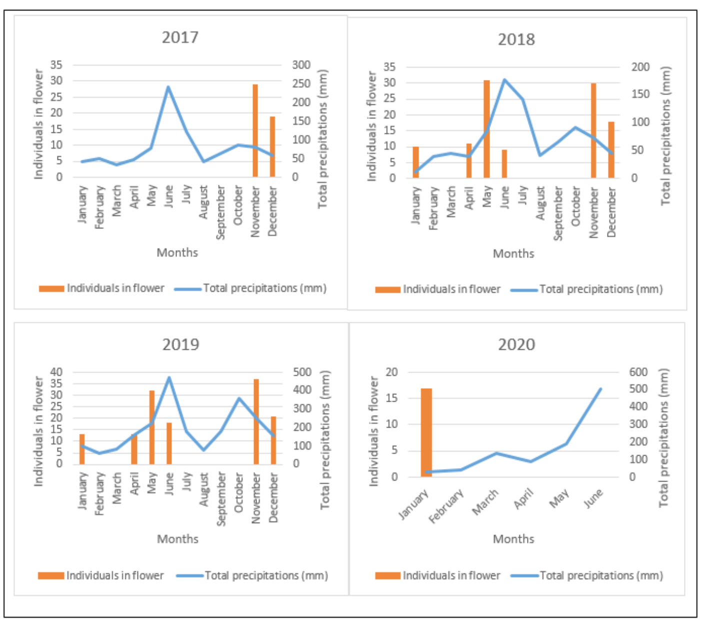

Figure 6: Influence of rainfall on the flowering of *Petersianthus macrocarpus* from 2017 to 2020.

Temperature evolution during flowering

The flowering in April began under a drop in temperature. But the second flowering, which starts in November, is under a rise in temperature (Figure 7). The lowest temperature is recorded in August. This month records the lowest flowering.

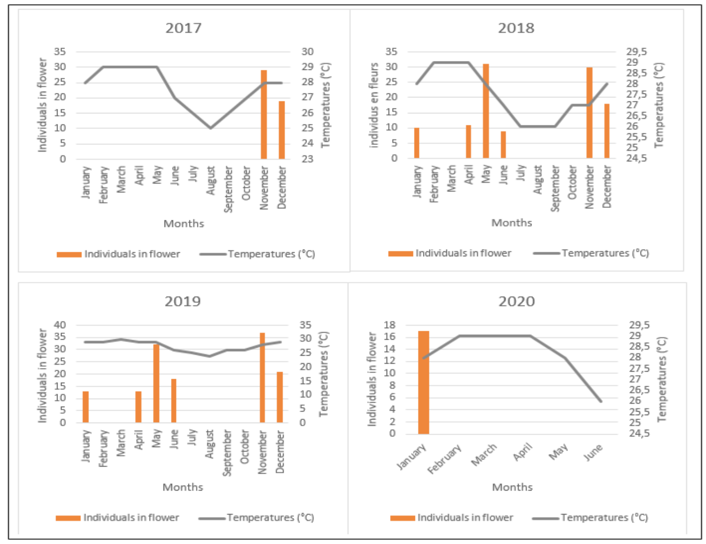

Figure 7 : Influence of temperature on the flowering of *Petersianthus macrocarpus* from 2017 to 2020.

Wind speed and air humidity from 2017 to 2020

Wind speeds increased during 2017 and 2019. The minimum wind speed increased from 14 km/h in 2017 to 18 km/h in 2019. The peaks of the first two years are reached in August. That of 2019 is reached in September. The peak increased from 19 km/h in 2017 to 22 km/h in 2019. This speed has therefore increased by more than 15%. From January to June 2020, all average monthly wind speeds were above the peak reached in 2017 (Figure 8). During these three years, atmospheric humidity was very high in the months of June to November, ranging from 82-84% in 2017 and 82-87% in 2019 (Figure 9).

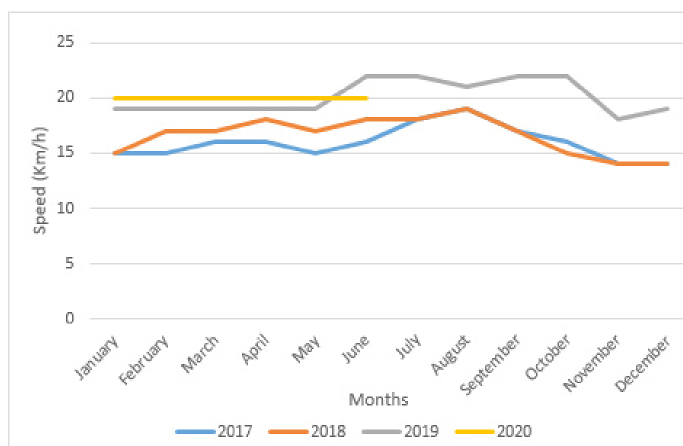

Figure 8 : Wind speed variation from 2017 to 2020.

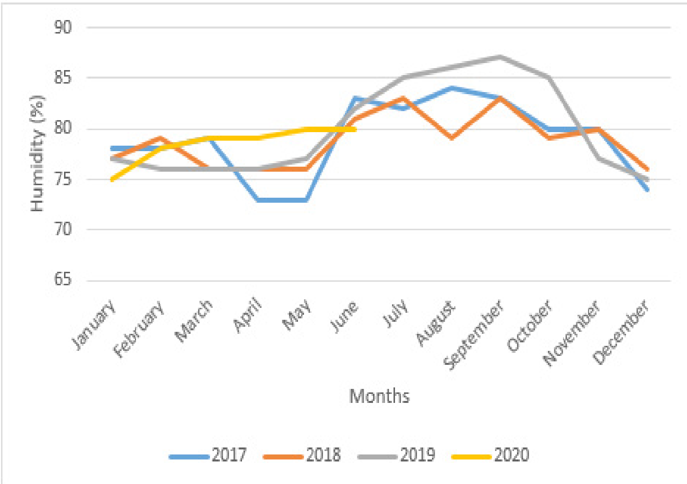

Figure 9 : Air humidity change from 2017 to 2020.

Effect of wind and humidity on *Petersianthus macrocarpus*

In the quadrats, the wind had blown some individuals had lost their still fresh branches. But outside the quadrats, in addition to the loss of branches, stems of *Petersianthus macrocarpus* had fallen. Moisture caused other plants to rot, as their roots were attached to the ground.

Populations exposed to *Petersianthus macrocarpus* pollens

The populations exposed to *Petersianthus macrocarpus* pollens include all CNRA and CSRS staff, the surrounding courtyards, ORSTOM primary schools and, from a distance, the village of Adiopodoumé, the sub-prefecture of Songon, and the commune of Yopougon (Figure 10). All of these populations are located less than 200 km from the forest housing *Petersianthus macrocarpus.*

Figure 10 : Presence of populations in the vicinity of *Petersianthus macrocarpus.*

The green rectangle indicates Forest sheltering *Petersianthus macrocarpus*

Discussion

The presence of *Petersianthus macrocarpus* in the study area is considerable as the frequency is 1. Not all individuals flower at the same time. Moreover, individuals smaller than 6 m are not able to produce flowers. For these two reasons, only one third of the individuals were in bloom during the study. Double flowering in the same year was reported in Owusu's work in 2012 around December and May [1]. Specifically, it extends from April to June and from November to January. This double flowering exposes the populations to more pollen emitted into the atmosphere. The delay in flowering in 2020 is preceded by a drop in rainfall from March to April, followed by a sharp rise in rainfall from May to June. Rainfall in 2020 was significantly higher than three years earlier [17]. Indeed, during these three years, rainfall increased from March to June before decreasing.

From September 2017 to June 2019, the phenology of *Petersianthus macrocarpus* did not seem to be influenced by the climate. However, the change in rainfall in 2020 could be responsible for the absence of flowers from April to June. Therefore, Onguene et al. claim that rainfall has an impact on the leaf renewal of *Petersianthus macrocarpus* [6]. Rainfall influences the flowering dates of some plant species [18]. A change in floral phenology can therefore shift the period of onset of allergic symptoms related to *Petersianthus macrocarpus* pollens. A similar case has been observed with birch, ash, grass and sagebrush species [19]. A good prediction of the flowering periods of a species with allergenic pollens would limit the risk of exposure to its pollens. This is demonstrated in studies on phenological monitoring [20]. The wind speed that increased from 2017 to 2020 could carry pollens very far from their habitats. Consequently, some populations not yet exposed to *Petersianthus macrocarpus* pollens due to their remoteness could be exposed now. In particular, populations located less than 200 km from the forest sheltering *Petersianthus macrocarpus.* This is because the pollen, once released by the anthers, can be carried by the wind for more than 200 km [21]. Also, as the species is tree-dwelling, its pollen can easily remain in the forest on shrubs and grasses.

All these conditions of exposure of the population to pollen predispose them to contracting pollinosis. A similar case is reported in a study on the etiopathogenic role of pollen [22]. As the mode of dispersal of *P macrocarpus* is anemochory the proliferation of the species over the years would be considerable, as each year several fruits are produced and spread in the wild[6].

Thus, the climate through wind and rainfall would contribute to the spread of pollinosis through its impact on the flowering of P. macrocarpus. Knowledge of the phenology can thus help to prevent pollinosis. In France, the determination of the allergic risk of exposure to pollens ''RAEP'' has made it possible to establish the allergopollinic calendar of plant species with allergenic pollens [14]. In turn, the phenological, climatic and cartographic data from this study, as well as the populations of Yopougon, allergic to *Petersianthus macrocarpus* pollens according to the work of Yapo-Crezoit et al in 2016, are four elements that could indicate the allergic risk of exposure to *Petersianthus macrocarpus* pollens in Côte d'Ivoire [10].

Conclusion

At the end of this study, we note that the phenology of *Petersianthus macrocarpus* made it possible to indicate the flowering periods of the species. The flowering of *P. macrocarpus* extends from April to June and from November to January. These are the periods during which the risk of contracting pollinosis is high. However, this phenology is influenced by rainfall. In addition, the increase in wind speed favours the spread of pollen over a larger surface area and therefore exposes the population to pollinosis. Consequently, climatic variations have an indirect impact on the health of the population. This work on the correlation between pollen and pollinosis is being carried out for the first time in Cote d'Ivoire. The installation of sensors would give a clear idea of the pollen concentrations of *Petersianthus macrocarpus* in order to establish the pollen calendar of the year in in Côte d'Ivoire,

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