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Forest Feeding Phenology of *Pan troglodytes* (chimpanzee) east of Conkouati-Douli National Park, Republic of Congo

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ABSTRACT: This study presents the feeding phenology of chimpanzees in the forests of the Conkouati-Douli National Park (CDNP) as part of a larger assessment of its suitability for chimpanzee reintroduction. All phenological monitoring and follow-up were conducted using the methods outlined by Diouf & Zaafouri (2003). Observation yielded five species that were found to be used by chimpanzees. Some of these species were also found to be used by chimpanzees for nesting. A strong link between rainfall and phenology was found in the area. Most fruiting was observed during periods of slower rainfall, while flowering occurred in the rainy season. This study assessed more than 300 trees, including those of the species *Staudtia kamerunensis var. gabonensis, Trichoscypha acuminata, Uapaca guineensis, Vitex grandifolia* and *Xylopia aethiopica,* all of which are regularly found in the diet of chimpanzees in the CDNP. The patterns of fruiting and availability were also compared to those at other tropical forests, particularly those that also support chimpanzees. These results, though focused on only five species of trees, can constitute a database to guide further research in the CDNP, as well as in other tropical African forests, in order to properly assess chimpanzee food security and sustainability in the wild.

KEYWORDS: Phenology, species, feeding, *Pan troglodytes*, Conkouati-Douli National Park, Congo.

1 INTRODUCTION

Tropical forests lie at the heart of many international issues concerning climate change and the conservation of biodiversity. These forests are under increasing pressure; pressure that could lead to the serious degradation of their biodiversity.

During the 1980s, key stakeholders were made aware of the biological impacts of human development, helping to build focus on conservation worldwide. It led to a number of initiatives, particularly in the Congo Basin region, establishing laws to protect biodiversity and the preservation of forest resources through the creation of protected areas.

The Conkouati-Douli National Park (CDNP), part of the Mayombe Forest Complex, is last of the three forested zones that make up the Congo Basin, and is the second largest national park in Congo, second only to Odzala National Park, with an area of 504,950 ha. It is the most ecologically diverse park in the Republic of Congo.

Our study was conducted with the belief that, in order to manage this park properly, it was necessary to document the flora that sustains the wildlife living within the park.

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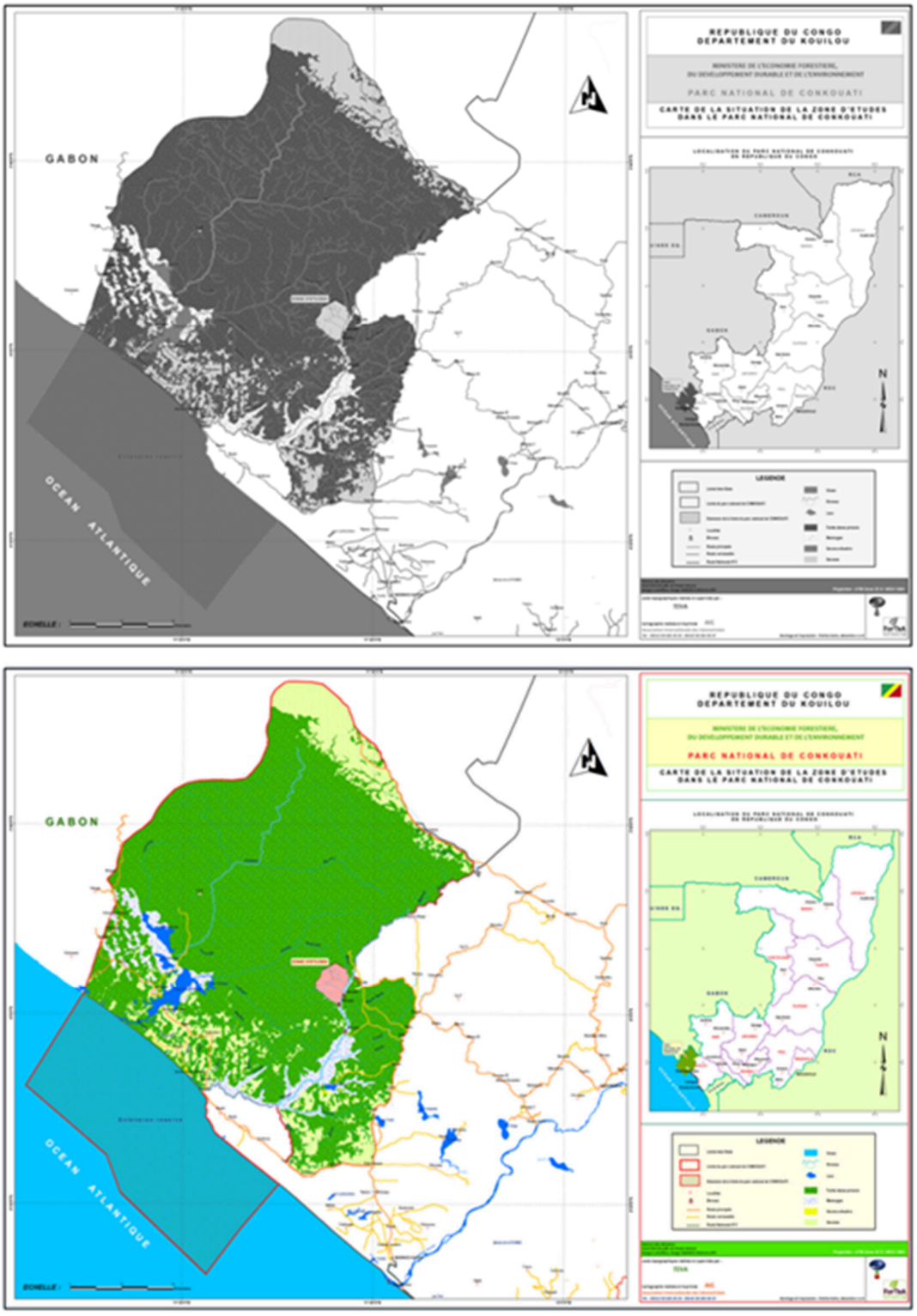

Fig. 1. Study area in the CDNP

Bélo, a site within the park, is planned to be a release zone for the sanctuary chimpanzees of Tchimpounga.

Because chimpanzees are an endangered species and their diet is frugivorous, a phenological assessment of their preferred fruiting species is crucial to the selection of any potential release site. We therefore focused our preliminary study on the fruiting periods and availability of species consumed by chimpanzees to determine whether Bélo would provide adequate resources for chimpanzee survival.

To properly assess the phenology of all the species at CDNP that might be necessary for chimpanzee survival, we took the following steps: documenting the species consumed by chimpanzees, the periods of flowering and fruiting for these species, as well as their amplitude of fructification.

2 MATERIAL AND METHODS

2.1 FIELD OF STUDY

Conkouati-Douli National Park (CDNP) is one of the newest Congolese national parks, and is its second largest. It covers an area of 504,950 ha and is located in the Kouilou Province, straddling the districts of Nzambi and Madingo-Kayes, at the northwestern end of the landscape. It includes both terrestrial and marine ecosystems. We focused our study at Bélo, which is within CDNP's eastern section (S 3 ° 58'06.6 ", E 011 ° 36'53.2") of the park on the right bank of the Noumbi river.

2.2 STUDY METHODS

The goal of phenological monitoring is to determine, for a given site, the average timeline of development for individual taxa (appearance, development, decline) through observations at various dates. These observations focus on the development of organs, such as leaves, flowers, and fruit [1]. For the monitoring chimpanzee feeding phenology, the following steps are recommended:

- Selection of useful species for chimpanzees

A list of about 100 species of trees, shrubs, vines, and herbs was assessed for its role in chimpanzee lifestyle and diet. In this work, we present the results of five (5) plant species, ranging from as small as 20 cm in diameter, that were among the initial survey of 100 species. These 5 species were chosen based on their importance within the ecosystem as well as their key role in chimpanzee nutrition.

- Sampling

To follow the phenological evolution of the vegetation, the common technique is to conduct regular surveys during which the state of the vegetation is documented [2]. This very general method, however, must be adapted to the scope of the research being conducted, the materials being documented, and the specific methodologies referenced [3] *in* Sibidou (1991).

Frankie (1974) [4] outlines the ideal conditions for a proper phenological study:

- Choice of a relatively undisturbed study site, protected from outside pressures (bushfires, cuts, etc) and accessible at any time of the year.
- High enough population, so as to be representative of the overall population considered, thereby revealing an average behavior of the species.

Following the conditions laid out as per [4], our sampling consisted of the creation of seven (7) transects, on average 5 km-long, on which selected trees were marked (Fig. 2).

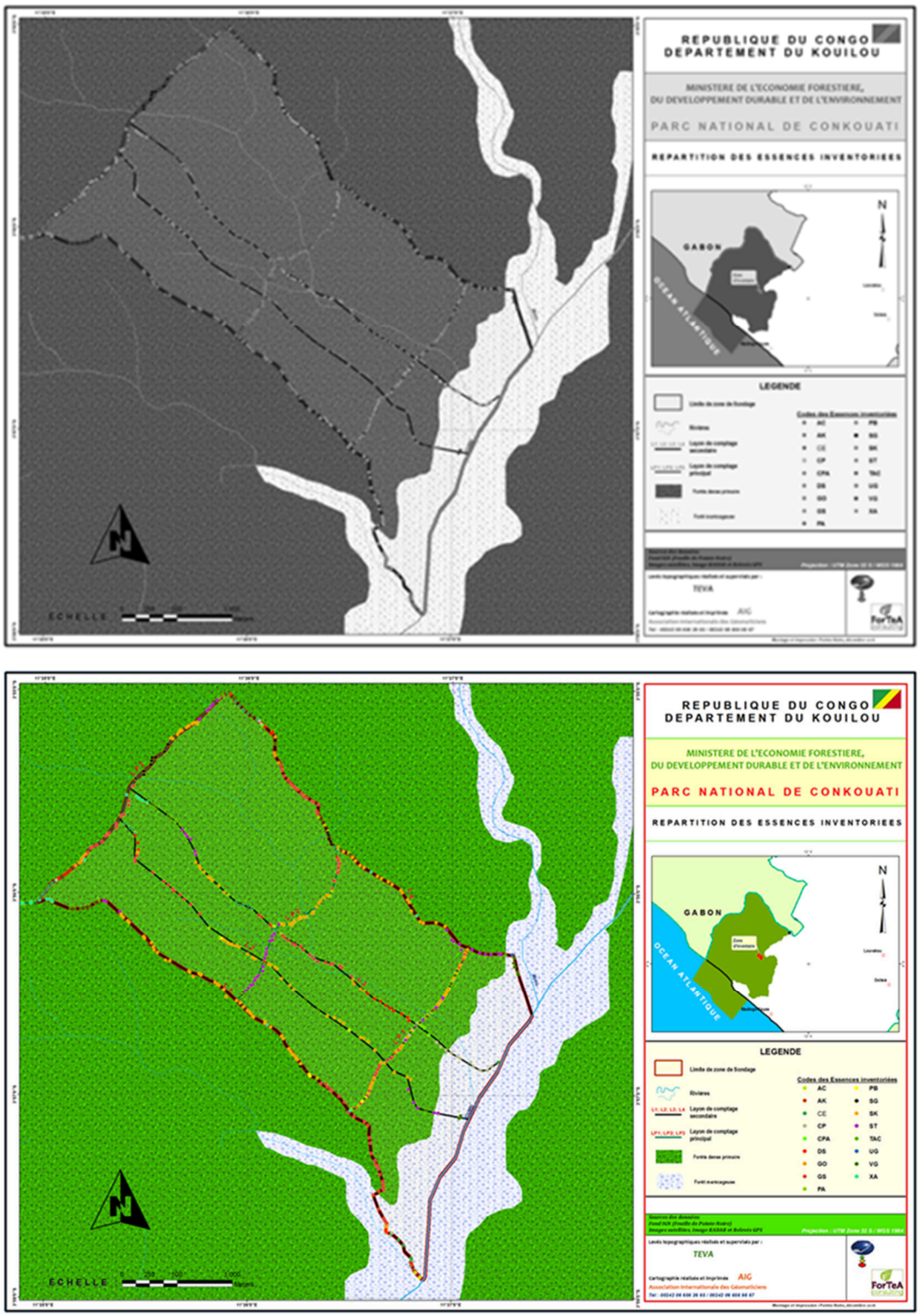

Fig. 2. Sampling transects in the study area

- Observational Criteria

The study of phenology is based on observation. Leafing, flowering, and fruiting are the three phases typically observed, called "phenophases," and whose morphological characterization differs from one individual to the next. Ewusie (1969) [5] does not distinguish stages within the phenophases and considers that "flowering" starts at the first flower buds to the time when most flowers have evolved, and he includes the fall of floral parts. He considers the start of fructification to be the fall of mature fruits. According to our study objectives, and using [5] as a model, we considered two (2) phenophases: flowering and fruiting.

We defined “flowering” as the period from the formation of the first flower buds to the moment when most of the flowers had evolved and through the fall of the floral pieces.

For our assessment of “fruiting,” we defined the process with two (2) stages: early fruiting (immature fruit, fruit set early in ripening) and fruit ripening (mature fruits, from ripening to falling fruits).

- Frequency of Observation

A high frequency of observations can guarantee the quality of the results. The time interval separating two successive observations must be shorter than the duration of the fastest process of the cycle [3]. It is therefore variable according to the species, the time of the year, and the desired events to be observed. Oftentimes the timeline is quite short, as in the case of fine organ development studies, and may range from a few days during the peak season of vegetative activity to one (1) month or more for larger nursery studies. In the case of our study, we made observations at the interval of one (01) month for 22 months (from January 2015 to November 2016), as the conditions at our study site did not permit notable observations at a more frequent interval, nor would it have yielded more conclusive results.

3 RESULTS

3.1 SELECTED SPECIES

Within the study, five (5) species were selected from the species assessed, chosen based on their use by chimpanzees. These species were determined to constitute a regular source of nutrition for chimpanzees in this area, and belong to 5 families. A total of 302 individual plants, ranging in diameter from 20 to 290 cm were surveyed (Table 1).

Table 1. Species monitored, number of individuals monitored and results

Species	Family	Number of Individuals monitored	Number of productive plants (proportion to the population of the species)
Staudtia kamerunensis var. gabonensis	Myristicaceae	213	115 (54)
Trichoscypha acuminata	Anacardiaceae	7	07 (100)
Uapaca guineensis	Phyllanthaceae	7	07 (100)
Vitex grandifolia	Lamiaceae-Viticoideae	55	20 (36.36)
Xylopia aethiopica	Annonaceae	20	17 (85)
TOTAL		**302**	**166 (55)**

3.2 THE PHENOLOGY OF SPECIES

The different phenological behaviors of these 5 species are detailed below:

3.2.1 STAUDTIA KAMERUNENSIS WARB. VAR. GABONENSIS FOUILLOY

- Description of the species

Evergreen, dioecious or monoecious, a medium to fairly large tree up to 35 m tall; trunk up to 90 cm in diameter, crimson inner bark, exuding an abundant, aqueous, dark red juice. Leaves alternate, simple and entire; blade narrowly oblong to oblong-lanceolate or narrowly elliptical, 5.5-16 cm × 1.5-6.5 cm. Unisexual, regular, short-haired and dense reddish-brown flowers. Fruit is an ellipsoid drupe 2-5 cm × 1.5-4.5 cm, in groups of 20, slightly fleshy at maturity, dehiscent in 2 valves, containing 1 single seed. Seeds ellipsoid or ovoid, 1-2 cm long, dark brown, with a finely fleshy aril, red or pink, almost completely enveloping the seed (www.prota4u.org, Fig. 3).

Fig. 3. Mature fruits in Staudtia kamerunensis Warb. var. gabonensis Fouilloy

- Chimpanzee Use

The use of this species by chimpanzees is limited to the consumption of mature fruits.

- Phenological cycle of the species

Within CDNP, *Staudtia kamerunensis var gabonensis* produces fruit almost all year round. Flowering and fruiting is abundant because of the length of each phase, nine (9) months for flowering and ten (10) months for fruiting. Phenological observations of this species have shown that flowering begins in January, peaks between April and June, and ends in September. More than 20% of the surveyed plants bloomed in the study area. Fruiting follows the month after the initial flowering, in February, with fruit ripening commencing in April and reaching its peak during the dry season and until the arrival of the rains in October that go through the end in January. A total of 54% of the observed trees within the study site were productive during the observation period (Fig. 4).

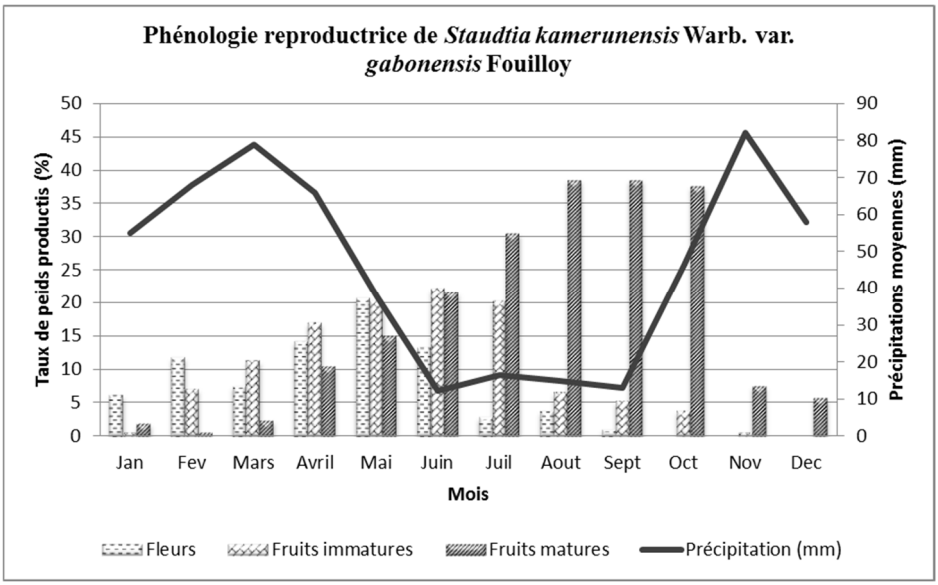

Fig. 4. Reproductive phenology of Staudtia kamerunensis Warb. var. gabonensis Fouilloy

3.2.2 TRICHOSCYPHA ACUMINATA ENGL.

- Description of the species

Trees up to 20 m tall and 40 cm in diameter. Leaves alternate, an imparipinnate compound, large, up to 1.5 m long. Dioecious and cauliflower plants. Inflorescences in pendent pyramidal panicles on the bumps of the trunk. Flowers are reddish-brown on the outside. Fruits are in bunches of twenty to a hundred oblong drupes measuring up to 7 x 4 cm; red, velvety,

densely pubescent with single, white hairs; fleshy pulp, juicy, red; oblong nucleus with tough endocarp (www.prota4u.org, Fig. 5).

Fig. 5. Mature Fruits of Trichoscypha acuminata Engl.

- Chimpanzee Use

The mature fruits of *Trichoscypha acuminata* are eagerly consumed by chimpanzees as well as by other primates in general. The use of this tree by chimpanzees is limited to the consumption of its fruits.

- Phenological cycle of the species

The fruiting of *Trichoscypha acuminata* operates on an annual frequency. It produces fruit once a year between June and January. The flowering period is 5 months on average; it starts from June to October and usually reaches its peak in August with 100% of the plants observed in bloom. Fruit development lasts 3 months, on average, and goes from August to November. The peak of fruit ripening occurs between November and December, with mature fruits falling through to the end of January. All of the plants of this species within the study site came into production during our observation period.

Outside this normal cycle, an additional episode was observed of low-amplitude flowering that did not result in maturation, during February through April. (Fig. 6)

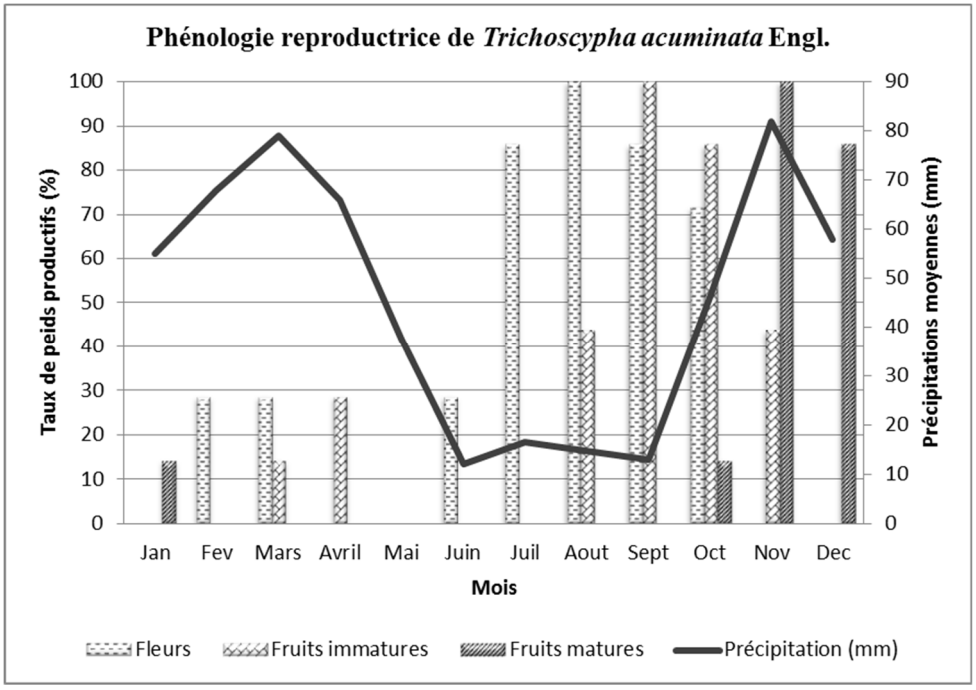

Fig. 6. Reproductive phenology of Trichoscypha acuminata Engl.

3.2.3 UAPACA GUINEENSIS MÜLL.-ARG.

- Description of the species

Dioecious tree, small to medium-sized, up to 18 (-30) m tall; up to 100 cm in diameter, often on rounded stilt roots that are up to 3 m tall. Leaves alternate, grouped towards the ends of the branches, simple; broadly obovate lamina, (5-) 9-24 cm × (2-) 4-10 (-17) cm. Male inflorescence: axillary, globose to ovoid capitulum, 4-7 mm in diameter; solitary female flowers; pedicel 8-15 mm long, 6 unequal calyx lobes, triangular to rounded, 1-1.5 mm long. Fruit: almost globose drupe 2-2.5 cm in diameter, warty, glabrous, greenish, 3-ringed, usually 1 seed per nucleus (www.prota4u.org, figure 7).

Fig. 7. Mature Fruits of Uapaca guineensis

- Chimpanzee Use

The plants of this species, *Uapaca guineensis,* are used by chimpanzees for nesting. The mature fruits of this species are also very popular with chimpanzees.

- Phenological cycle of the species

Uapaca guineensis has an annual cycle that depends on the rainfall in the area. Flowering lasts 4 months on average and occurs between November and March, during the rainy season. Fruit development starts in January, ripening in March reaching its peak between April and June and ending in July. During the months of August and September, the driest months of the year in this area, no fruiting or flowering events were noted. All the plants observed came into production during the study period (Fig. 8).

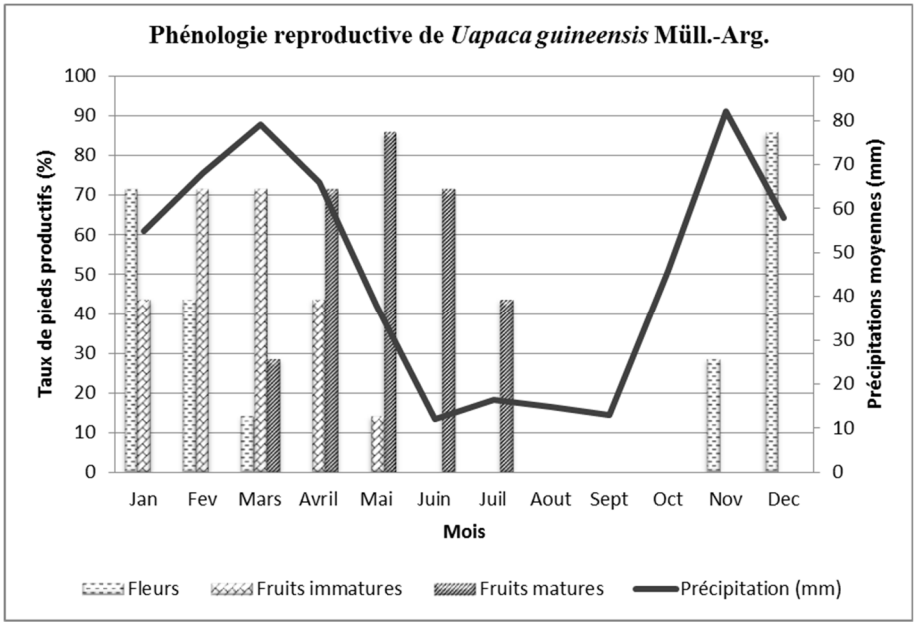

Fig. 8. Reproductive phenology of Uapaca guineensis Müll.-Arg.

3.2.4 VITEX GRANDIFOLIA GURKE

- Description of the species

Vitex grandifolia is a shrub or evergreen tree, small to medium-sized, up to 20 m tall, 60 (-120) cm in diameter. Leaves opposite, compound fingered with 5 (-7) leaflets; leaflets obovate, 13-40 cm × 6-20 cm, whole, finely leathery, glabrous. Inflorescence an axillary cyme, compact, up to 7 cm long, many-flowered; peduncle up to 5 cm long. Flowers bisexual, yellowish, finely hairy. Fruit is an ellipsoid to globose drupe 1.5-2 cm long, yellowish when ripe but later become black and fleshy, containing up to 4 seeds (www.prota4u.org, Fig. 9).

Fig. 9. Immature fruits of Vitex grandifolia Gurke

- Chimpanzee Use

This species' ripe fruits are eaten by chimpanzees, and they use the tree for nesting.

- Phenological cycle of the species

While the annual cycle of production was observed to be normal, there were some short episodes of flowering (less than 5% of observed individuals) and an abnormal appearance of fruit in the fourth quarter of the year. The normal cycle of this species begins in January with flowering reaching its peak in February, and fruit appears between February and June. The fruits reach their maturity from March to June, with a big peak of development in the latter month. It has been noted that the appearance of fruits occurs during the rainy season, but maturation of those fruits only occurs during the end of rainy season in May until July-August. Thirty-six (36)% of the plants surveyed were productive during our observations (Fig. 10).

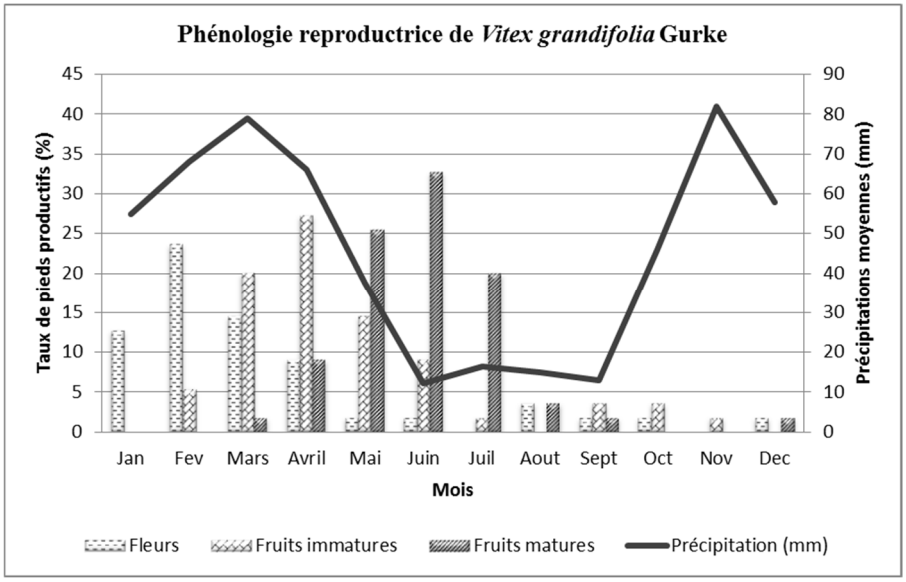

Fig. 10. Reproductive phenology of Vitex grandifolia Gurke

3.2.5 XYLOPIA AETHIOPICA (DUNAL) A. RICH.

- Description of the species

This tree can be up to 30 m tall and 70 cm in diameter. Leaves alternate, simple; elliptical limbs up to 20 x 9 cm, leathery, pointed apex. Inflorescences in fascicles of 2-6 flowers or solitary flowers. Trimeric flowers about 5cm long, whitish in color, very fragrant, hermaphrodite. Fruits: clusters of 20-30 cylindrical follicles, up to 6 x 1 cm, slightly constricted between the seeds, red-brown on the outside, turning completely after dehiscence, bright red on the inside. 4-9 seeds are present, shiny brown with an orange aril (www.prota4u.org, Fig. 11).

Fig. 11. Fruits of Xylopia aethiopica

- Chimpanzee Use

Chimpanzees consume the mature fruit of this species, either taken directly from the tree or from those fruits that have fallen at the foot of the tree.

- Phenological cycle of the species

Xylopia aethiopica experiences a normal phenological cycle. Flowering lasts approximately 4 months from May to August, with peak flowering in July. Fruit development begins in June and lasts about 3 months. Maturation begins in August and peaks

between September and November with more than 80% of observed plants bearing mature fruit. Mature fruits were observed until March (Fig.12).

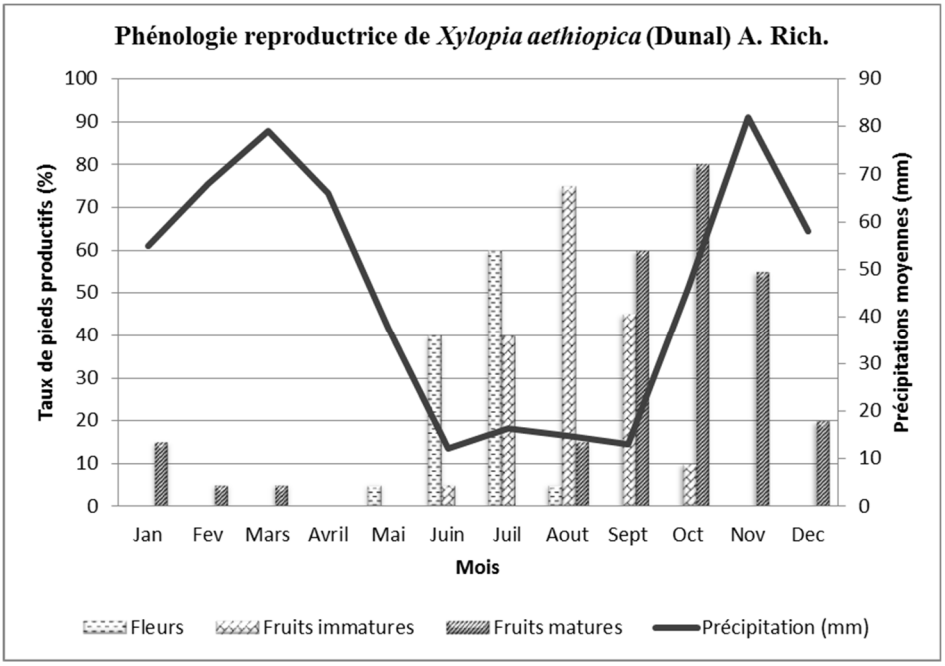

Fig. 12. Reproductive phenology of Xylopia aethiopica (Dunal) A. Rich.

4 DISCUSSION

Although *Staudtia kamerunenis var gabonensis* bears fruit all year round, there is a peak of fruit ripening within the dry season. This trend is also observed in *Uapaca guineensis* and *Vitex grandifolia*. The fruit ripening of *Xylopia aethiopica* occurs at the end of the dry season, while the ripening of *Trichoscypha acuminata* occurs during the rainy season.

These defined periods of fructification have also been observed in other tropical forests. The works of [6] and [7] in [8] reported several species clustering their fruiting within the dry season. Daubenmire (1972) [9] observes, in the semi-deciduous forest of Costa Rica, that large trees fruit just before the rainy season. In Nigeria, [10] observed the fruiting of twenty-six (26) valuable species, and also found maximum production occurred at the end of the dry season. Menga (2012) [11], in the DRC, also noted the maturity of *Milettia laurentii* fruits in the dry season, specifically during the transition from the dry season to the rainy season. For *Pericopsis elata* in Yangambi (DRC) and surveyed by [12], fruiting begins in the dry season and extends into the rainy season in October. In the Ivory Coast, as observed by [8], trees within tropical forests tend to grow in the heart of the dry season; that is to say, taking into account the water reserves of the soil, just before the water deficit settles, or, in other words, at the end of the activity cycle. Richards (1952) [13] in the New Hebrides, reports that, when there is a dry season, that it is a key time for fruiting.

Flowering, in our study area, occurs mainly in the height of rainy season, the “big rains,” between February and June. *Trichoscypha acuminata* and *Xylopia aethiopica* are the only exceptions to this trend among the five species documented. These observations have also been reported in several equatorial semi-deciduous forests. Gillet *et al.* (2008) observed rainy season flowering in more than 50% of the ten (9) commercial species they surveyed in their phenological assessment at Pokola in northern Republic of Congo. Menga (2012) [11], in the DRC, noted the flowering of *Millettia laurentii* in the rainy season during its leaf-emergence period. Medjibe (2001) [14]; and [15] made the same observations in *Entandrophragma spp.* within the Central African Republic. According to [16], *Prioria balsamifera*, *Terminalia superba,* and *Xylopia welwitschii* in the DRC also produced flowers during the rainy season. Poupon (1979) [17], at Fété Olé in northern Senegal, noted that more than 60% of the species observed in the woody strata there were in bloom during the rainy season, with the rest of the species blooming in the dry season.

Overall, the plants within our study site and their phenology are closely related to the seasonality of precipitation in the area. Fruiting occurs during periods of slowing rainfall and flowering occurs within the rainy season.

These observations have allowed us to document the similarities and differences of phenological behavior between the species within the CDNP and those same species in other tropical forests in Africa, and gauge whether that behavior can support reintroduced chimpanzees.

For example, *Staudtia kamerunensis* Warb. *var. gabonensis* Fouilloy fruits almost all year in Congo and Gabon according to the observations of [18].

Trichoscypha acuminata Engl. has nearly identical fruiting months and the same amplitude both in the Congo, Gabon [19] and in the Ivory Coast [8].

The fruiting period of *Uapaca guineensis* Müll-Arg. is longer in Gabon and Tanzania [8], [19] compared to our observations in the Congo. In the Ivory Coast, it stretches over two periods. Similarly, however, there was fructification of this species in all four countries between March and April.

In Gabon [19] the fruiting of *Vitex grandifolia* Gürke begins 3 months earlier than it does in Congo but ends within the same period, in both countries, after more than 6 months of production.

The fruiting amplitude of *Xylopia aethiopica* (Dunal) A. Rich. in Congo and Gabon [19] is more than seven (7) months, and it is shorter than it is in Ivory Coast [8] where it is completed within 4 months. The months of December, January, and February are the key months for fruiting in this species in all 3 countries.

Given the previous work documented for these species in other tropical forests, the phenological behavior of these species is not surprising. And, among the observations, a periodicity of fruiting and flowering in dense, equatorial forests is consistent. As [20], [18] argues, the reproductive cycles of tropical species are conditioned by the rhythm of the rains. These observations reflect our findings at Bélo, within the forests of the Congo Basin.

As a chimpanzee's diet is primarily frugivorous [21], the knowledge of phenology, or, specifically, the fruiting period of those species consumed by chimpanzees, is very important for their survival in the wild. The knowledge of the fruiting periods of these species can not only shed light on chimpanzee behavioral patterns but can aid in the establishment of their improved conservation. As Bélo is part of a national park with both wild chimpanzees and semi-captive, the knowledge of the phenological map of their preferred feeding will dictate management and planning for its future as a release site. Based on a number of studies, appropriate chimpanzee habitat is defined by two key elements: the spatial and temporal distribution of food and plant species useful for the construction of their nests.

5 CONCLUSION

By studying the plant species at Bélo and increasing our knowledge of the phenology of chimpanzees' preferred species, we now know when fruits are available throughout the site. And, by comparing our results with those from other chimpanzee habitats across Africa, whether these species can sustain the reintroduction of chimpanzees to the site. Our results for than 300 plants in the area constitute a database that can serve as a guide for park managers and conservation stakeholders. It can additionally guide the use of practical measures for the sustainability of the natural resources that abound in this area. And, noting Bélo's phenological similarity to other forests of tropical Africa, some of which are home to wild chimpanzees (northern Congo, Gabon), these guidelines can be used continent-wide

Though our objectives were met through the completion of this research, further investigations should be conducted on the additional species that will be necessary to sustain an increased chimpanzee population in Bélo and throughout CDNP.

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