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Phenology of Plant Species Found in Ugwueme Hydrocarbon Seep Site, Enugu State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

This study assessed the phenological events of plant species for flowering, fruiting, shedding of leaves, regeneration/germination, yellowing of leaves and death, every month for three consecutive years from 2018 till 2020, at Ugwueme oil seep site vegetation. Phenological information from the phenological studies of plants can be used to detect patterns associated with climate change, address environmental issues on the timing of plants life cycle, and to predict changes in the habitat and ecosystem at large. The stratified random sampling design was adopted for the study. A sampling zone of 130×60 m^2 was mapped out for the study. The zone was thereafter split into 60 grid plots, each measuring 13 x 10 m^2 and 60% of these were selected at random. Date obtained from the study was represented in a phenological diagram. Vegetation phenology showed that flowering and fruiting occur through all the months of the year, although with variations. In March-April, most herbs and woody herbs germinated or regenerated in September/October, fruited in October/November towards the end of the rainy season and became senescent, die or lie dormant in February/March. Given that, the Savanna vegetation of Ugwueme showed variations in the timing of phenlogical events, however, the diversity of available flora species can be protected to sustain its ecological integrity, especially in this era of emerging climate change disasters and food insecurity, through a longer periods of study like 10 years to understand the relationship between changes of human impact and climate change.

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1. INTRODUCTION

Phenology is the study of the relationship between seasons (climate), the timing of ecological events such as germination, growth, flowering, fruiting, yellowing of leaves and death, as well as the causes of their occurrence with respect to biotic and abiotic forces [1]. It may indicate the manifestation of well-marked seasonal periodicity in the appearance of the vegetation. It is another functional physiognomic method which may be used to supplement information on life-forms [2]. In Nigeria, the Southern and Northern Guinea savanna zones have very well marked seasonal periodicity in the appearance of vegetation. In the dry season, between January and April, after the vegetation has been burnt and when the rainy season is about to begin, the trees generally produce new leaves and flowers [3].

Phenological studies may be tedious and requires a long period for observation. However, it can provide a useful basis for more detailed investigation [3]. Data from phenlogical studies has increasingly been used to detect, explain and predict various patterns related to other forms of global change [2], as well as to address environmental issues [4]. Jenerette et al. [5] assessed the relationships between the phenology of vegetation and seasonal rainfall in summer and winter in a semi-arid region in southern Arizona, USA. Wessels et al. [6] used remotely sensed vegetation phenology to describe and predict the biomes of South Africa. They found that the phenology and productivity showed a clear relationship with the seasonality of rainfall and mean annual precipitation, respectively.

Phenological studies, monitored year after year will help in assessing the effects of pollution, man-made activities, global warning and climate change on the phenology and productivity of plant species in the ecosystem [7]. It helps in monitoring changes in the ecosystem and complexities in their vegetation over time and space for proper rangeland management and land use. There is need to know the time for flowering, fruiting, leaf production and regeneration, for the feeding and pollination by the animals to correspond with the planning and management strategies of savanna rangelands [8-11]. Plant phenology has been used for assessing the impact of climate change on the seasonality of vegetation [12], and to improve our understanding of the drivers of vegetation growth [13]. Phenology invariably affects the health of individual plants, as well as affects the health condition of organisms that rely on plants. However, shifts in plant phenology can adversely affect demography; result in agricultural failures and cause unstable ecosystem [14]. At different altitudes and growing seasons, vegetation of any area shows different physiognomic conditions and each species shows different growth forms such as leafing, flowering, fruiting and death. However, different phenological events are triggered by rainfall, water availability, altitude, temperature and photoperiod [15, 2]. The phenology of almost all the species studied showed nearly a similar pattern of response to the local climatic conditions. The climate of the study sites has heavy rainfall and high humidity, which is conducive for the growth and development of plants [16]. So far, the present work focused on the phonological observations of plant species in Ugwueme oil seep site.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study area is a crude oil seep site at Ugwueme in Awgu Local Government Area of Enugu State, Nigeria (Fig. 1). It consists of roughly elevated topography (hills with steep slopes) and could attain an altitude of about 850-400 meters above the sea level. According to Nigerian Meteorological Agency (NIMET) [17], the study area experiences a minimum temperature of 34^{o}C and a maximum temperature of 34^{o}C. The major economic activity of Ugwueme's indigenes is farming. They practice mixed farming where food crops (*Manihot esculenta, Dioscorea* sp, *Zea mays*, *Capsicum annuum*, *Solanum lycopersicum* and cash crops *(Musa paradisiaca, Elaeis guineensis, Anacardium occidentale*) are produced (Fig. 2). They also keep local livestocks such as goats and sheep for meat and for export.

2.2 Sampling Design and Techniques

A stratified random sampling field technique by Osuji et al. [18] was adopted for the study. Sampling zones were erected based on grid system with the aid of measuring tape, ropes and pegs. A sampling zone of 130 x 60 m^2 was

erected around the epicenter; the epicenter is the point of oil seepage (Fig. 3). The zone was thereafter split into 60 grid plots, each measuring 13 x 10m^2 and 60% of these (i.e. 36 grid plots) were selected at random. To sample each chosen plot, quadrats were established as follows (a) 4mx 4m for shrubs (b) 1 m x 1m for herbs and grasses. During sampling, plant species inside the quadrat as well as those at the quadrat edge, but with about 75% of their branches inside the quadrat were sampled (Fig. 4).

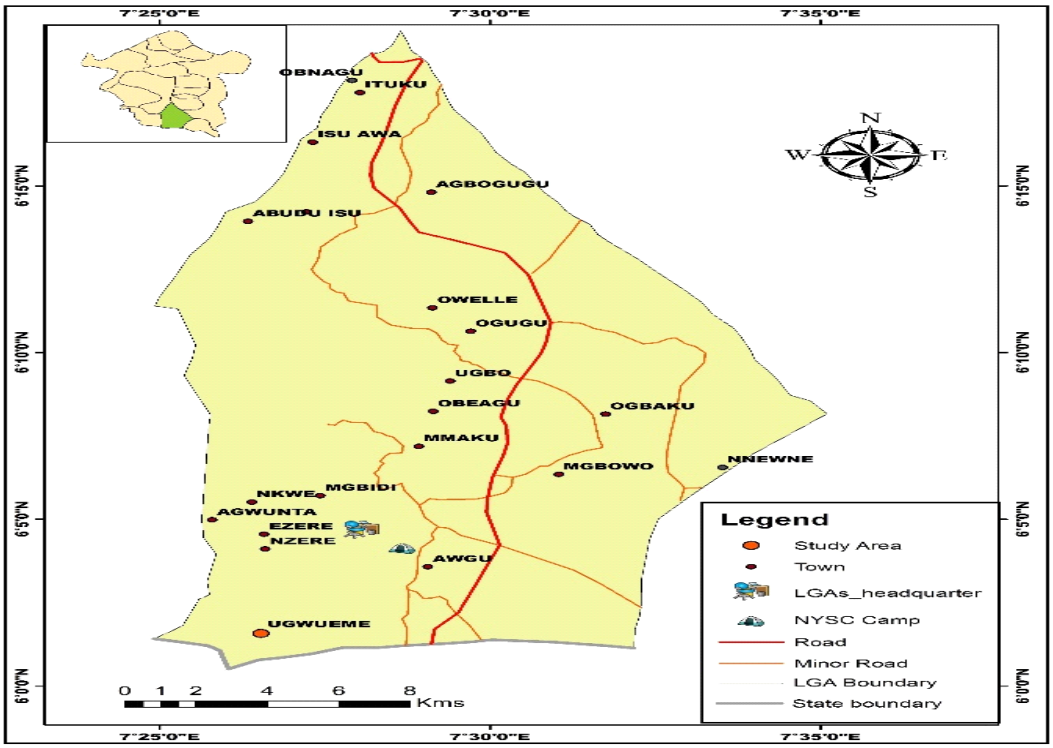

Fig. 1. Map of Awgu showing Ugwueme

Fig. 2. Morphology of plant species

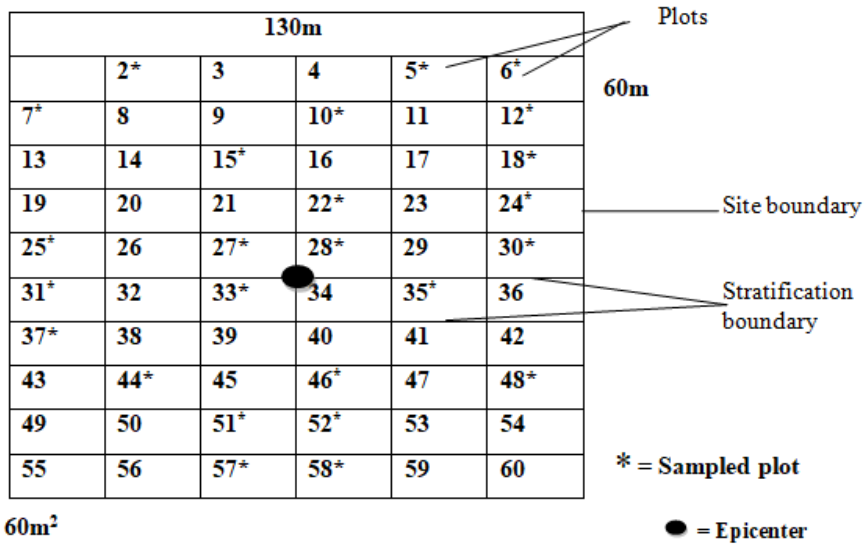

Fig. 3. Schematic representation of sampling design showing sample grid plots and epicenter of oil seep

Fig. 4. Habitat and quadrate study of plant

2.3 Estimation of Flora

The method of estimation of flora in Ugwueme oil seep site was based on standard methods modified according to Nwadinigwe [2]. In each randomly selected quadrat, all plants within each species were carefully counted and recorded against the name of the species. Unidentified plant species were obtained and each one was pressed between absorbent old newspapers in a wooden herbarium frame carrying a label. Specimens were later identified by the help of a Taxonomist, Mr. Alfred Ozioko at the Bioresource Centre, Nsukka.

2.4 Method of Studying Phenology

The quadrats were laid at the site of the study. The plant species within the quadrat were identified, marked or tagged. Each plant was

monitored every month for flowering, fruiting, shedding of leaves, regeneration of leaves, yellowing of leaves and death. Each phenological process observed or not observed was marked accordingly [5]. Data were collected on a monthly basis.

3. RESULTS

The plant was investigated for the period of three years in the study area for germination, flowering, fruiting, yellowing of leaves, and death. Thereafter, the observed information were represented in phonological diagram (Table 1).

3.1 Germination/Leafing

The seedlings and new shoots of annuals and perennials started emerging from ground at the onset of rainy season in the month of March and the number steadily increased up to June. The peak period of germination in herbaceous plants was April (Table 1). The perennial grasses such as *Cymbopogon* and *Paspalum* sprouted from the rhizome/root-stocks. There is an integration of the phenological activities in most herbaceous plant species especially flowering and fruiting which occur in the same month. The herbs that germinated or regenerated with the first rains in March and April were *Aspilia africana*, *Amaranthus hybridus*, *Cynodon dactylon*, *Panicum maximum*, *Chloris pilosa*, *Andropogon tectorum* and *Andropogon gayanus* (Table 1).

3.2 Flowering

Most herbaceous plants started flowering with increase in temperature during May-June and that continued up to August, and another set of species initiated flowering when the ambient temperature started falling in the later part of September to October (Table 1). Furthermore, the trees and shrubs have two peaks of flowering in May and December.

3.3 Fruiting

Flowering and fruiting in herbaceous species are simultaneous, since the majority of them need to complete their life cycle within a short span of time. At Ugwueme, most herbs mostly fruited in October towards the end of the rainy season while woody plants mostly fruited in September/October (Table 1). Almost all tree species had phenological pattern that synchronized flowering and fruiting in dry months.

3.4 Death/Rest

Majority of the annual herbs characteristically complete their life cycles with no resting period. Death or resting phase of most herbs started during Nov to Feb, while the peak was observed in the month of January (Table 1). In the study area, dry season is the most difficult season for the normal survival of herbs as a result of the severe climatic conditions. On the other hand, perennials develop continuously but most of them undergo a period of rest in which active growth and flowering reduced even though the environment continues to be favourable. Hence, senescence and death are negligible among trees and shrubs when compared with the herbs.

It was noted that plants of the same species growing side by side may not flower and fruit at the same time. One may flower and fruit while the other may not flower and fruit even for the year. Again, in one plant, some branches may not flower and fruit along with other branches. These characteristics were observed in *Daniellia oliveri* and *Mangifera indica*.

The summary of phenology of these species separated into herbs, woody herbs, shrubs and trees is presented in Table 2.

4. DISCUSSION

Phenology is a periodic phenomenon in plants. The climate of the study sites has heavy rainfall and high humidity, which is conducive for the growth and development of plants [16]. The results of the present investigation showed that flowering and fruiting occur throughout all the months of the year, although with variations. This is in agreement with the observation of Marqucus et al. [19] who noted that floral activities in the subtropics occur throughout the year; in contrast to the temperate areas where low temperatures make it impossible for floral activities to take place all the year round. In March-April, most herbs and woody herbs germinated or regenerated; fruited in October/November towards the end of the rainy season and became senescent, die or lie dormant in January/February. These are mostly annual species and perennial with an annual ephemeral phase. A typical example of the latter is *Chromolaena odorata*, whose meristem is seasonally activated to produce an annual growth in the rainy season, only to have its aerial parts die off in the dry season. These herbaceous species have a short cycle

Table 1. Phenological diagram of plant species found at Ugwueme sites

	Plant species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Set.	Oct.	Nov.	Dec
1	*Alchornea cordifolia*												
2	*Allophyllus africanum*												
3	*Amaranthus hybridus*												
4	*Andropogon gayanus*												
5	*Andropogon tectorum*												
6	*Artocarpus altilis*												
7	*Aspilia Africana*												
8	*Axonopus compressus*												
9	*Capsicum annuum*												
10	*Chamaecrista mimosoides*												
11	*Chloria pilosa*												
12	*Chromolaena odorata*												
13	*Colocasia antiquorum*												
14	*Conoclinium coelestinum*												
15	*Costus afer*												
16	*Cymbopogon citrates*												
17	*Cynodon dactylon*												
18	*Daniellia oliveri*												
19	*Dialium guineense*												
20	*Dioscorea alata*												
21	*Elaeis guineense*												
22	*Erythrophleum suaveolens*												
23	*Euphobia thymifolla*												
24	*Ficus sur*												
25	*Holarrherna floribunda*												
26	*Hyparrhenia barteri*												
27	*Irvingia gabonensis*												
28	*Lecaniodiscus cupanioides*												
29	*Lonchocarpus cyanescens*												
30	*Mangifera indica*												
31	*Manihot esculenta*												
32	*Margaritaria citrates*												

	Plant species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Set.	Oct.	Nov.	Dec
33	*Millettia aboensis*												
34	*Murraya koenigii*												
35	*Sarcocephalus latifolius*												
36	*Ocimum basilicum*												
37	*Olax subscorpioidea*												
38	*Panicum maximum*												
39	*Parkia biglobosa*												
40	*Paspalum veginatum*												
41	*Phylanthus amarus*												
42	*Ricinus communis*												
43	*Sida acuta*												
44	*Sida cordifolia*												
45	*Talinum fruticosum*												
46	*Tridax procurnbens*												
47	*Vernonia amygdalina*												
48	*Vitex doniana*												
49	*Zea mays*												
	Months	Jan.	Feb.	Mar.	Apr	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.

Key:

- Leave emergence
- Flowering
- Fruiting
- Yellowing of leaves
- Death
- Flowering/fruiting

Table 2. Summary of the phenology of species at Ugwueme vegetation (no of species)

Phenology of herbs and woody herbs	Jan	Feb	mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec.
Germination	0	0	1	21	20	16	0	0	0	0	0	0
Flowering	0	0	0	1	1	3	4	5	7	17	2	1
Fruiting	1	0	0	1	2	1	2	10	5	16	7	4
Death	20	20	19	1	0	0	0	0	0	0	5	12
Phenology of trees and shrubs												
Flowering	7	5	6	5	9	7	5	0	4	4	3	10
Fruiting	2	0	2	7	6	7	9	8	10	14	5	3
Death	1	1	1	0	0	0	0	0	0	0	0	0

(5-7 months) from germination to flowering period. Their roots are normally shallow. They utilize the shallow soils and their competitive ability is quite low [20]. Moreover, the results of the study showed that the majority of the herbaceous species germinate in April when the rainfall is moderate at the beginning of the rainy season. This agrees with Baudena et al. [21] who observed that germination and growth in the savanna regions occur in the period of early rains immediately after fruiting and dispersal and after the fires might swept the herbage. In most of the trees and shrubs, leafing and regeneration are more uniformly distributed throughout the year than the herbaceous species. Even in the dry season (December to March) trees like *Daniellia oliveri*, *Nauclea latifolia*, *Lacaniodiscus cupanioides*, and *Olax subscorpioidea* produce leaves when most herbaceous species are turning brown and dying off. In the present investigation, the results showed that trees and shrubs have peak of flowering in December, fruited mostly in September and October. Almost all trees had phenological pattern which synchronized flowering and fruiting in dry season. This agrees with the observation of Nwadinigwe [20] who reported that the dry season is the time for flowering and fruiting for many savanna species so that fruits are ready for dispersal after the fires and before the rains. In woody tree species, the ripening of fruits began in late part of rainy season and continued up to end of cool and dry period which is due to differences in time taken for fruit maturation. Senescence and death are negligible among trees and shrubs when compared to the herbs. These trees and shrubs are mostly perennial species with seasonal or continuous growth and they possess deep roots utilizing the deeper soils. These investigations are in agreement with the work of Nwadinigwe [20], who reported that perennials develop continuously but most of them undergo a period of rest in which active growth and flowering are reduced even though the environment continues to be favourable. Although Tanee and Albert [22] reported reduction of soil nutrient content in oil polluted site and Johnson et al. [23] who said that oil contamination declines plant performance. From a close observation the crude oil seepage did not show remarkable differences in vegetation phenology of the study sites. However, the vegetation at the oil-seep site had few species number, than the control site.

5. CONCLUSION

Plants perform various vegetative and reproductive functions throughout the year in order to survive in the ecosystem. This work provided the phonological timing of different plant species and this will serve as a guide to planning for specific land uses in normal environments. More so, from a close observation the crude oil seepage did not show remarkable differences in vegetation phenology of the study sites.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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