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Ecological studies on *Aerangis biloba* (Lindl.) Schltr. (Orchidaceae) in NACGRAB field gene bank, southwestern Nigeria

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Abstract: *Aerangis biloba* (Lindl.) Schltr. belongs to the family Orchidaceae, which is listed as threatened under the Appendix II of the CITES. This study was conducted to estimate the population and distribution of *Aerangis biloba* in the field by National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, southwestern Nigeria. Twenty five sample plots of 50m by 50m each along line transects were randomly chosen and studies were carried out on them. The results were correlated with the factors that affect the distribution and survival of *A. biloba*. A total of 129 specimens of *A. biloba* were observed within the study area, giving a population density of 5.16 orchids per m^2. This indicates that the species is abundant in the sampled area, as a result of good population of the selected phorophytes. The analysis of the data indicated a high correlation between and among the plots (P=0.0003). *A. biloba* was observed only on nine trees among over 160 trees present in the sampling area, suggesting that these nine trees could act as phorophyte for *A. biloba* of which, *Irvingia gabonensis* and *Irvingia wombulu* harbored the highest number of orchids. The paper gives a synopsis of the economic and ecological significance of orchids. It also recommends controlled harvesting, reduced deforestation and establishment of orchid gardens as some of the effective ways of enhancing orchid conservation in Nigeria.

Keywords: *Aerangis biloba*, epiphytes, field gene bank, NACGRAB, phorophytes.

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The family Orchidaceae comprises over 850 genera and an estimated 25,000 species representing about 10% of the world's flowering plants and the largest family in species number (Roberts & Dixon 2008). The African continent harbours around 2,400 orchid species (Madison 1977). Of the 25,000 known orchid species, more than 70% are thought to live as epiphytes in tree canopies (Gravendeel et al. 2004). An epiphyte is considered to be a plant living on another plant or sometimes on other objects above ground surface and growing either partly or entirely in the air, into suspended soils, or in woody debris (Richards 1996; Moffett 2000). Barkman (1958) coined the term 'phorophyte' for the plants that support epiphytes. Orchidaceae contains 60% of all epiphytic species and 10 times as many epiphyte species as any other family of vascular plants (Kres 1986).

The genus *Aerangis* has many species in Africa and Madagascar with strikingly pretty flowers. Most African epiphytic orchids were classified in the genus *Angraecum* in the mid 18th century and Lindley described this species as the 'two-lobed Angurek' - *Angraecum bilobum* (Stewart 1975). The name was chosen to describe the leaf apex, which is often conspicuously bilobed. Although, Reichenbach had established the genus *Aerangis* in 1865, it was not until 1914 that Schlechter transferred this species into the genus *Aerangis* (Stewart 1975).

A study of the notes attached to the herbarium specimens of *Aerangis biloba* at Kew revealed that most have been collected in dense forest in the Ivory Coast and on isolated trees in the savannah areas of northern Nigeria. They are found in thickets, forest edges and small patches of woodlands as well as high forests. Many have been observed growing among plantation crops and frequently on village trees. Citrus, mango, orange, palm and coffee trees have been recorded as actual hosts for this epiphyte (Stewart 1975). Most of the plants collected in flower have been found in July and August, which is towards the end of the main rainy season in West Africa. This indicates that the plants require plenty of water prior to blooming and have a specific and predictable blooming season that corresponds to seasonal rainfall and coordination of the life-cycle of its pollinators. It thrives when planted in a slatted basket with large pieces of bark (Stewart 1975).

In terms of their ecological significance, orchids are a part of the autotrophic web of organisms, absorbing energy and converting it to food, part of which is transferred along a complex ecological food web when living in association with other living organisms. The flowers are highly attractive to nectar-feeding insects and birds. Furthermore, epiphytic orchids contribute to the complexity, structure and function of the canopy, and are important components in terms of both biomass and species diversity; they interact with vast numbers of canopy invertebrates, as well as many vertebrate species (Nadkarni 1984; Ellwood et al. 2002; Wolf & Flamenco 2003; Gravendeel et al. 2004; Monteiro et al. 2009).

As a result of the threat from over-collecting all orchids have been placed on Appendix II or higher of the Convention on International Trade in Endangered Species (CITES). Despite this protection, the ongoing general decrease in the number and size of orchid populations is mainly due to the loss and degradation of their habitats (Koopowitz et al. 2003). Because orchids are susceptible to human activities, they have been proposed as indicators of levels of human disturbance and overall ecosystem health (Turner et al; 1994; Benzing 1998).

In Nigeria, very little attention has been given to the study of orchids. Worse still, there are no accurate surveys on the diversity, population and conservation status of orchids. It has been reported that the orchids *Habenaria nigerica*, and *Diaphananthe dorotheae* are exclusive endemics for Nigeria; Segerback (1983) described 104 species of orchids for Nigeria, but Jayeola (1991) encountered over 400 species for the country indicating a richer diversity of orchid species than was previously thought. Since very few people are involved in orchid cultivation in Nigeria, most of the orchid flowers harvested for ornamental purpose comes from the wild. With increasing anthropogenic disturbances, epiphyte species richness declines (Hietz 1999; Kromer & Gradstein 2003) and community composition changes (Werner et al. 2005). Therefore, this study was conducted to assess the population of *Aerangis biloba* in the field gene bank of National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, southwestern Nigeria with the view of studying the effects of the ecological factors on the population and distribution of this orchid within the gene bank. This study is part of the proposed extensive study on the orchid survey in Nigeria.

Materials and Methods

Study Area

The field gene bank of National Centre for Genetic Resources and Biotechnology (NACGRAB) was established in 1987, as an ex situ collection site for indigenous recalcitrant plants in Nigeria. It is about 12ha wide, lying on the latitude 7^{0}22' North of the equator and longitude 3^{0}50' East of the Greenwich Meridian. The Field Gene bank of NACGRAB contains a large variety of plants with diverse growth forms. According to Borokini et al. (2010), 361 plants have been identified in the field gene bank, comprising 160 trees, 119 herbs, 55 shrubs and 27 vines. Some of the plants established on the field gene bank are in plantations, while others are scattered within the field. The climate of the study area is characterized by high temperature and a bimodal rainfall pattern. The annual total and mean rainfall was 1,435.8 and 99.87 mm respectively for year 2008. Rainfall for the area spans from February to December, with peak in September (289.9mm); no rainfall was recorded for November. The mean annual minimum and maximum temperatures were 24.57^{0}C and 32.1^{0}C respectively for 2008, while the relative humidity was lowest at 53% in January and highest at 92% in August. Agrometeorological records from 1979 to 2008 show insignificant difference in the data taken for rainfall, temperature and relative humidity. Image 1 shows the location of the study area within Nigeria.

Data collection and analysis

This survey was carried out between 1 and 5 September 2010. It involves an enumeration of the orchids within 50x50 m plots laid along line transects within the field gene bank at an interval of 25m. Twenty five sample plots were laid; making a total of sampled

Image 1. Map of Nigeria showing the location of study area

area to be 6.25ha that is 52.08% of the total field gene bank area. Furthermore, the phorophytes on which the orchids were found were noted, the population of the phorophytes and the height of the orchids on the phorophytes was also documented. Photographs of *A. biloba* on the phorophytes were taken. The results were subjected to statistical analysis to determine the population density, analysis of variance (ANOVA) and test of significance using PAST Statistical software (Hammer et al. 2001). The population density within each plot was calculated as the number of occurrence divided by the area of the plot in sq.m.

Results

A total of 129 *Aerangis biloba* were identified in the 25 plots sampled within the field gene bank of NACGRAB, Ibadan, Nigeria; giving a population density of 5.16 (Table 1). This result indicates that the species is abundant in the field gene bank. Table 1 shows the occurrences of the orchid in each of the sampled plot and the trees identified in each of the plots. Furthermore, the phorophytes for the epiphytic orchid include *Irvingia gabonensis*, *Citrus* spp, *Spondias mombin*, *Irvingia wombulu*, *Tecoma stans*, *Azadirachta indica*, *Psidium guajava*, *Albizia odoratissima* and *Mangifera indica*. Table 2 shows the population of each of the identified phorophytes for this orchid species within the sampled area of the field gene bank; while images 2–3 are the photographs that illustrate the orchids growing on the phorophytes within the field genebank. The epiphytes were attached to the phorophytes either on the main trunk or the branches. The orchid population on each of the phorophyte ranges from one to seven per plant. *I. gabonensis* had up to seven orchids per phorophyte,

Image 2. *Aerangis biloba* growing on the stem of *Irvingia gabonensis*

Image 3. *Aerangis biloba* with whitish flowers

Table 1. Occurrences of *Aerangis biloba* within the 25 plots sampled

Plots	Occurrences	Density	Trees identified within each plot
1	21	0.0336	*Irvingia gabonensis*, *Adansonia digitata*, *Psidium guajava*
2	18	0.0288	*Irvingia gabonensis*, *Kigelia africana*, *Terminalia ivorensis*, *Nauclea didderrichii*, *Mangifera indica*, *Blighia sapida*
3	11	0.0176	*Irvingia gabonensis*, *Kigelia africana*, *Terminalia ivorensis*, *Terminalia superba*, *Spondias mombin*, *Pentacheltthra macrophylla*, *Dacryodes edulis*, *Polyathia longiflora*
4	0	0	*Ficus iteophylla*, *Ficus mucoso*, *Treculia africana*, *Pterocarpus santalinioides*, *Tabebuia rosea*, *Samanea saman*, *Khaya grandifoliola*, *Synsepalum dulcificum*
5	1	0.0016	*Citrus* sp., *Musa* sp., *Entandrophragma cylindricum*, *Harrisonia abyssinica*, *Costus afer*, *Terminalia catappa*
6	0	0	*Terminalia catappa*, *Lagerstroemia speciosa*, *Hibiscus rosa-sinensis*, *Melicia excelsa*, *Hura crepitans*
7	2	0.0032	*Mangifera indica*, *Funtumia elastica*, *Eucalyptus camaldulensis*, *Terminalia superba*, *Khaya grandifoliola*, *Dalbergia sissoo*
8	6	0.0096	*Mansonia altissima*, *Mangifera indica*, *Cedrela odorata*, *Leucaena leucocephala*
9	0	0	*Elaeis guineensis*, *Cola millenii*, *Cola gigantea*, *Kigelia africana*, *Musa* sp., *Terminalia superba*
10	9	0.0144	*Citrus* sp., *Tecoma stans*, *Enterolobium cyclocarpum*, *Nauclea diderrichi*, *Anthonotha macrophylla*, *Casuarina equisetifolia*
11	16	0.0256	*Citrus* sp., *Musa* sp., *Enterolobium cyclocarpum*, *Theobroma cacao*, *Gliricidia sepium*, *Klainedoxa gabonensis*
12	0	0	*Hollarhena floribunda*, *Delonix regia*, *Eugenia vitiflora*, *Hura crepitans*, *Calophyllum inophyllum*, *Anacardium occidentale*
13	1	0.0016	*Albizia odoratissima*, *Tectona grandis*, *Gmelina arborea*, *Terminalia superba*,
14	0	0	*Newbouldia laevis*, *Afzelia africana*, *Monodora myristica*, *Acacia nilotica*, *Tetrapleura tetraptera*, *Plumeria rubra*
15	1	0.0016	*Tecoma stans*, *Rauvolfia vomitoria*, *Blighia sapida*, *Parkia biglobosa*, *Cedrela odorata*, *Jatropha curcas*
16	1	0.0016	*Citrus* sp., *Treculia africana*, *Lecaniodiscus cupanioides*, *Ceiba petandra*, *Persea americana*
17	2	0.0032	*Azadirachta indica*, *Morinda lucida*, *Khaya senegalensis*,*Griffonia simplicifolia* , *Triplochiton scleroxylon*
18	0	0	*Moringa oleifera*, *Ficus exasperata*, *Bombax glabra*, *Sterculia tragacantha*, *Syzygium zamarangensis*, *Melia azaderach*
19	0	0	*Khaya ivorensis*, *Artocarpus altilis*, *Melicia excelsa*, *Leucaena leucocephala*, *Daniella ogea*, *Hevea brasiliensis*
20	10	0.016	*Irvingia wombolu*, *Chrysophyllum albidum*, *Carica papaya*, *Spondias mombin*, *Mangifera indica*
21	17	0.0272	*Irvingia wombolu*, *Jatropha curcas*, *Carica papaya*
22	12	0.0192	*Irvingia wombolu*, *Cnidoscolus alternifolius*, *Hevea brasiliensis*, *Calotropis procera*
23	1	0.0016	*Albizia odoratissima*, *Samanea saman*, *Musa* sp., *Tamarindus indica*, *Tetrapleura tetraptera*, *Cleistopholis patens*
24	0	0	*Cochlospermum reliogiosum*, *Terminalia superba*, *Terminalia ivorensis*, *Khaya ivorensis*, *Pinus caribaea*
25	0	0	*Annona senegalensis*, *Albizia lebbeck*, *Acacia auriculiformis*, *Dalbergia latifolia*, *Eugenia vitiflora*, *Delonix regia*, *Gmelina arborea*
Total	**129**	**0.2064**	

and many of the *I. gabonensis* stands have *A. biloba* growing on them. It was also noted that the height of the epiphytes on the phorophytes range from 0.7 to 2.9 m.

The statistical analysis showed that the variation of the occurrence of the orchids within and among the plots are highly significant (P=0.0003) indicating that the occurrence of the epiphytic orchid is relatively dependent on the availability and abundance of its specific phorophyte. The standard deviation was 6.89 (Table 3) and the population density within each plot ranged from 0 to 0.0336 (Table 1), which further shows the interdependency of epiphytic orchids on their corresponding phorophytes.

Table 2. Phorophytes population in the NACGRAB Field Gene bank

	Name of Phorophyte	Plant family	Population
1	*Citrus* spp.	Rutaceae	134
2	*Irvingia gabonensis*	Irvingiaceae	612
3	*Irvingia wombulu*	Irvingiaceae	301
4	*Mangifera indica*	Anacardiaceae	97
5	*Spondias mombin*	Anacardiaceae	5
6	*Tecoma stans*	Bignoniaceae	2
7	*Azadirachta indica*	Meliaceae	16
8	*Psidium guajava*	Myrtaceae	3
9	*Albizia odoratissima*	Mimosaceae	18

Discussion

Aerangis bloba is relatively abundant in the field gene bank due to high population of the preferred phorophytes, which provided medium of establishment. The pollination of the flowers by native moths and spread of the seeds by air currents from tree to tree further promoted the establishment of the orchid in this area. Only nine of the 160 trees in the field gene bank were identified as phorophytes for *A. biloba*. This indicates that *A. biloba*, like many other epiphytic orchids, are only able to germinate and survive to reproductive age on certain phorophytes. The occurrence of orchids in a plot increases with increase in the phorophyte population within the plot. This indicates that the occurrence of the orchids is dependent on the phorophytes, therefore, the presence, population and distribution of the phorophytes determines the distribution and the frequency of the orchids within the plots. Likewise, the survival and conservation of the orchids is highly dependent on specific tree species, which act as phorophytes (hosts) for the orchids. This study has, therefore, revealed a significant number of phorophytes for *A. biloba*. The abundance and distribution of these phorophytes will help in the conservation of this orchid species.

While some previous studies reported little or no phorophyte specificity among some epiphytes (Johansson 1974; Sanford 1974; Todzia 1986; Ackerman et al. 1989; Zimmerman & Olmsted 1992; Ackerman et al. 1996); other authors reported phorophyte specificity among some vascular epiphytes (Went 1940; Frei 1973; ter Steege & Cornelissen 1989; Merwin et al. 2003). Although epiphytes are a significant component of overall plant diversity, relatively little is known about the specificity of the association between epiphytes and their phorophytes. This association is of particular interest since epiphytes are confined to a patchy and discontinuous distribution of suitable substrate. The specificity of the orchid-phorophyte relationship may have direct bearing on the abundance of epiphytic taxa, particularly as increasing rates of anthropogenic-related habitat disturbance exacerbate the patchiness of suitable substrate (Trapnell & Hamrick 2006). Therefore, there is the need to study further the ecological associations between orchids and phorophytes and study the selective nature of epiphytic orchids for phorophytes, with the aim of assessing their conservation status.

Orchids are dependent on their host trees for survival, and hence, deforestation could likely increase the chances of orchids being threatened in their habitats. Riofrio et al. (2007) noted that deforestation practices pose a major threat for the survival of orchids, as they are greatly dependent on the environmental conditions of the forests that sustain them and the host trees on which they grow. In the light of this, Riofrio et al. (2007) advocated for studies on the patterns of spatial distribution and colonization of secondary succession forests regenerated after deforestation. It is therefore, recommended that deforestation should be discouraged, as they do not only cause a lot of environmental damage to the natural ecosystem, but also increase the risk of extinction of orchids that depend on them. It is also interesting to note that as some orchids are considered as threatened, some new species are being discovered such as *Vanda longitepala*, which was discovered in northern Burma (Roberts et al. 2008). However, such new discoveries would not be possible if the habitats (the forests) have been degraded through deforestation and land use changes.

Table 3. Analysis of the data collected on *Aerangis biloba* in NACGRAB field gene bank

	Sum of squares	Df	Mean squares	F cal	
Between groups	768.32	1	768.32	15.12	0.0003098***
Within groups	2439.36	48	50.82		

As all orchids are considered threatened and extinction of orchids reported in some countries; it should be noted that extinction of orchids have extensive detrimental effects on ecosystem health. The field gene bank has a uniform climatic condition, elevation and altitude most suitable for the colonization of *Aerangis biloba*. It is essential that continuous management and conservation of the phorophytes in the field gene bank should be undertaken to ensure the survival and sustenance of the epiphytic orchids and their complex ecological relationship with other biotic components of the community. Especially since the selective nature of *A. biloba* for a specific type of phorophyte might be the major factor responsible for their distribution within the gene bank.

From literature studies, it could be noted that over-collection of wild orchids for sale and deforestation are the greatest risk factors for the survival of wild orchid populations (Koopowitz et al. 2003). Therefore, cultivation of orchids should be encouraged, in order to reduce the pressure on the wild collections and at the same time, be a source of income generation and self-employment for interested people, especially the youth, since there is a ready market for orchids and the capital involved is relatively small.

It is also strongly recommended that research attention be given to Nigerian orchids, to conduct a comprehensive survey on their natural distribution, population, the phorophytes of the epiphytic orchids, samples taken and cultures created of their mycorrhizae symbionts and their conservation status.

Conclusion and Recommendation

Aerangis biloba, like many other orchids, is an important component of a complex ecosystem, and members of its populations as producers of nectar, are fundamental to some complex food webs. This study has revealed that the abundance and conservation of epiphytic orchids, such as *A. biloba* is dependent on the abundance and population of the phorophytes and the natural presence of the mycorrhizae associated with the phorophytes. Therefore, felling of the phorophytes for this orchid will reduce the population of the orchid and threaten its survival.

Research attention needs to be focused on the study of many of the other highly diverse Nigerian orchid flora for their phorophyte specificity, effects of altitudinal gradients, mycorrhizal associations and habitat preferences, among other environmental factors, in order to preserve, understand and enjoy these unique Nigerian orchid species.

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