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Archidium acanthophylum (Moss) and *Cyanotis lanata* (Succulent monocot) Succession model: Inselberg Indicators in Southwestern Nigeria

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ABSTRACT

Succession progression on an Inselberg, an insular rock with its peculiar microclimate, and vegetation was monitored quarterly for three years. Lichen (Buellia canescens), moss (Achidium acanthophyllum), and succulent monocot (Cyanotis lanata) formed major vegetation on the rock, and the three plants were zero in for study. Quadrat method was use to measure the density of the target plants. Operational succession models accessed. Density cover of B. canescens remained constant throughout the year, while C. lanata and A. acanthophyllum coexist. C. lanata density increased and A. acanthophyllum decreased from March to September, while the A. acanthophyllum and C. lanata decreased from September to December. Measure of pH value of the substrate on the rock in December was significantly higher than any other month (7.3 ± SE 0.12, $p < 0.05$). Temperature of the substrate increased significantly (39.6 ^{o} C ± SE 0.56, $p < 0.05$) in December. Relative humidity above vegetation on rock surface increased significantly (78.78 ±SE 0.90, $p \leq 0.05$) in June and September. B. canescens exhibited inhibition model of succession while the coexisting C. lanata and A. acanthophyllum exhibited facilitation model. Tolerance model was not visible among the rock vegetation. Inselberg was established as indicator of C. lanata and A. acanthophyllum.

Keywords: *Archidium acanthophyllum, Cyanotis lanata,* facilitation model, indicator, inhibition model, inselberg, succession.

INTRODUCTION

Succession is a directional, non-seasonal cumulative change in the type of plants that occupy a given habitat over time. It involves the processes of colonization, establishment, and extinction of the participating plant species. According to [1]. Succession is a reflection of interaction between edaphic factors and the changing types of plant species. This interaction establishes stable, climax vegetation. In the absence of disturbance (fire, logging, cultivation) pioneer succession vegetation develops through directional change in species composition through time and end with climax community.

There are three types of successions, primary, secondary, and allogenic succession. Allogenic succession is a change in environmental conditions, which subsequently, influence the composition of plant species in a habitat over time. The secondary succession is the inversion of plants in a habitat that was once vegetated, but lost its vegetation through natural or human disturbances. The primary succession is the formation of pioneer plants on land that has not been previously vegetated.

According to [2] there were three models of succession mechanisms, facilitation model, tolerance model, and inhibition model. The latter model imply when all species resist inversion of competitors. Nevertheless, when killed by local disturbances (extreme physical conditions or predation) then the incoming species gradually replace the early colonists. In tolerance model, the incoming species tolerate low nutrient levels and edge out the early species in competition and grow to maturity. In contrast to either the tolerance or the inhibition model, facilitation model proceed by changes in biotic environment caused by the developing plant community. This means that the condition for the incoming species depends on earlier species preparing the habitat. Individualistic concept of [3] states that there is a relationship between coexisting species because of similarities in their requirements and tolerances. This concept properly explains the reverse succession, which [4] concept of succession did not explain earlier in 1916. Rather, [4] holistic principle states that the action of the whole community of organisms is greater than the sum of its parts. According to [5], auto-succession is originally described in the Alpine cryptogamic vegetation in Scandinavia. Several other authors working in the temperate region made similar observations [6, 7]. A more dynamic cyclic succession revealed by analysis of lichen community on a rock side in the Rocky Mountains [8].

In the tropical guinea savanna zone of Nigeria, the present author made a casual observation of coexisting species of succulent monocot (*Cyanotis lanata*), and moss mat (*Archidium acanthophyllum}* on inselbergs. Both facilitation and inhibition model of successions were suspected. However, the succession development on inselberg is latent, and very slow, thus receives little or no attention. The main objective was to apply ecological models of succession to the event happening on Baasi inselberg, specifically, to find out the active ongoing processes of succession on the study rock.

Description of study site

Baasi inselberg rock (N08^{o} 20’ 11.8”, E003^{o} 23’ 39.5”,) located 286 m above sea level, about 25 m away from a highway, 40 km south of Shaki (N05^{o} 51’ 58.9”, 004 ^{o} 08’ 32.9”alt. 390 m). The flat top rock consists of elongated, narrow crevices, and depressions with or without soil. The dominant vegetations on the rock include crustose lichen (*Buellia canescen*) which gives the rock rough grayish-black appearance. Major species occurring together in a shallow soil in rock depressions are moss (*Archidium acanthophyllum* Snider), and succulent monocot (*Cyanotis lanata* Benth.). The major source of disturbance to plant growth and development on the rock are rapid bush fire and grazing by cattle.

Climatological data about Baasi inselberg area from 2007-2009 are available from the Federal Meteorological station, Oke-Iho located a few kilometers southwest of the inselberg. Climate, characterize by a dry season from November until March, and a rainy season from April to October. Mean annual rainfall was 1240 mm. During December-February (period the harmattan), northeasterly trade-wind that bringing dry air from the Sahara drops the relative humidity below 20% with daytime temperatures above 40 ^{o}C

Minimum temperature during the dry season sometimes falls below 20 ^{o}C *with* dew in the morning hours. The climate of Baasi inselberg is relatively dry. Temperatures on the bare rock exceed 50 ^{o}C (caused by high radiation of over 1000 W/m^4 while the relative humidity is falling below 30%. Like many inselbergs, Baasi inselberg, is an arid habitat complex, that is strongly differs from the surroundings.

MATERIALS AND METHODS

Monitored succession processes within a marked area of 70 m x 50 m. Non-random quadrats (0.5 m x 0.5 m) positioned in two marked areas [9]. consisting of target species for study. The northwestern side (aspect > 20^{o}) was dominated by coat of Lichen (*Buellia canescens*) while the southeastern (aspect <20^{o}) was dominated by both succulent monocot (*C. lanata*) and moss (*A. acanthophyllum*). Since the target species cannot easily be counted in this study, because the edges of each plant are not immediately obvious. Instead, the local percent cover of each plant was calculated in each quadrat. Total covers of these plants were estimated quarterly (Mar, Jun, Sep, and Dec) for three years, according to the established scale of [10]. The recommended cover abundance scale: 5 ≥ 75-100% cover, 4 = 50-75% cover, 3 = 25-50% cover, 2 = 5 – 25% cover, and 1<5% cover. The species density was calculated by formula: *Species density= percent cover/Quadrat area(m).* Also measured alongside were substrate pH, temperature, and light incidence (percentage of full deflection of meter scale) close to the substrate surface.

Statistical analysis

Species density, substrate pH, temperature, and relative humidity data of the micro vegetation collected on the inselberg were subjected to one-Way ANOVA using SPSS 11.5 package.

RESULTS AND DISCUSSION

The density of the target species on the studied inselberg showed varied pattern of growth over the year. According to Braun Blanquet scale *B. canescens,* ranked between the scale 5 to 3 (very abundant, abundant, and frequent). *A.acanthophyllum and C.lanata,* ranked from 5 to 1 (very abundant, abundant, frequent, few and, rare).

(a)

(b)

Figure 1. Free rock surface covered by (a) Monocot (*C. lanata*) and Moss (*A. acanthophyllum*) beneath in June. (b) Mat of moss exposed in December

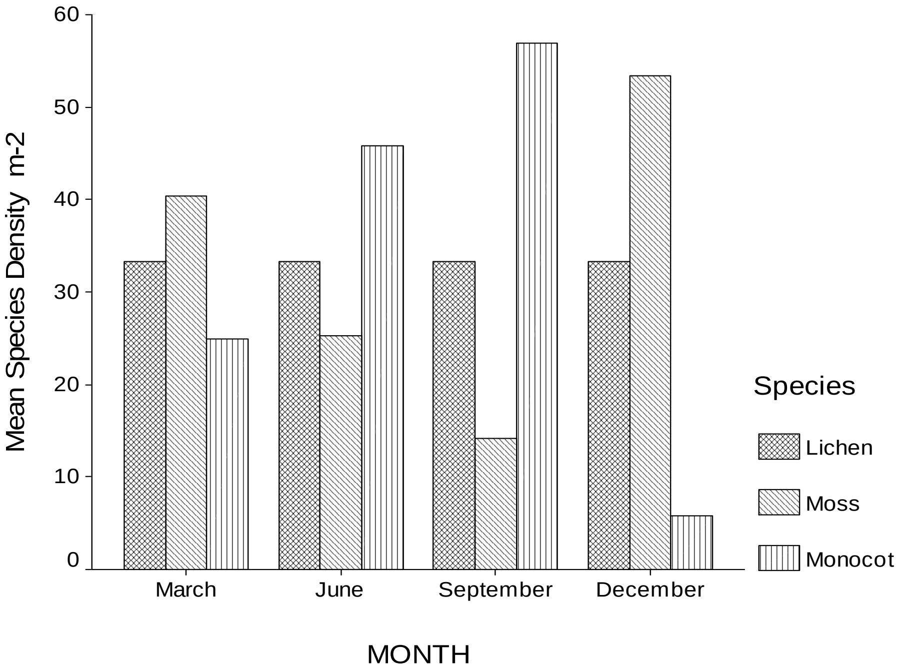

Figure 2. Density of dominant plants calculated quarterly on the Baasi inselberg. Lichen (*Buellia canescens*), succulent monocot (*C. lanata*), and moss (*A. acanthophyllum*)

Figure1a shows that *C.lanata* (monocot seedlings) grew on the mat of *A.acanthophyllum* (moss) from February to matured plants in June, and die back (few to rare) in December when mat of *A.acanthophyllum* (Figure1b), once again exposed to the direct sunlight. Figure 2 shows that density cover of *B. canescens* remained uniformly throughout the year. The moss density cover decreased steadily from March to September, under full shade of *C. lanata* leaves, but sharply increased in December, while the latter *d*ensity cover sharply dropped from September to December.

Figure 3 shows that pH value of the *B. canescens* substrate remained fairly constant round the year. But for the substrate on which both the *A.acanthophyllum* and *C.lanata* pH decreased from

March to September and sharply increased in December. pH in December was significantly higher (7.3 ±SE 0.12, $p \leq 0.05$) than any other month.

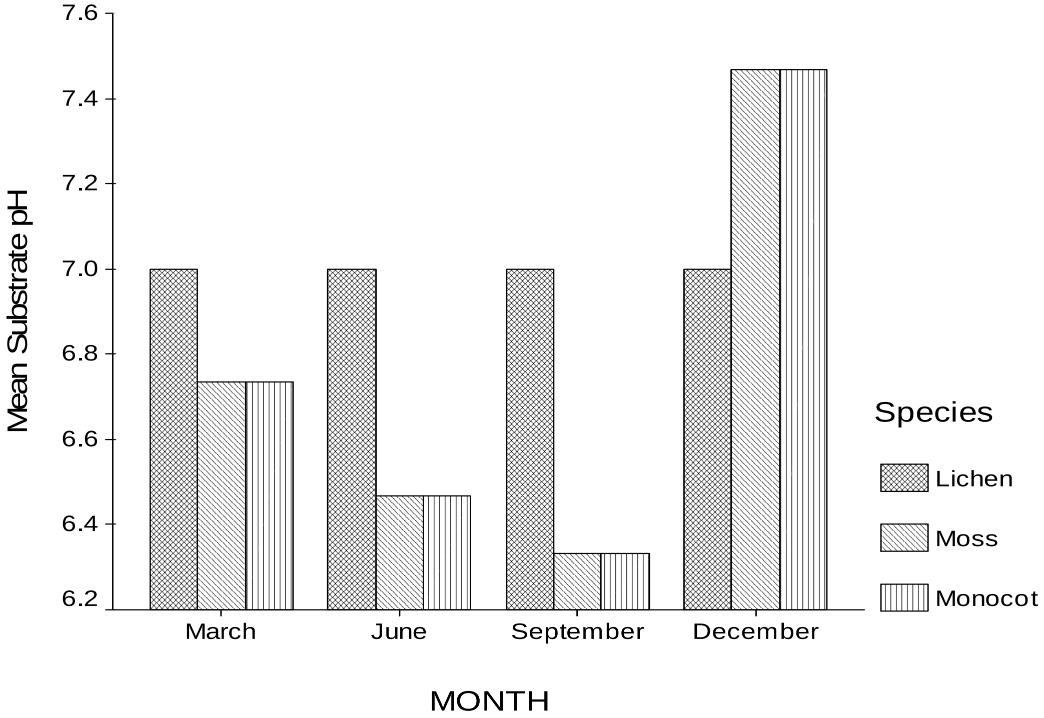

Figure 3. pH of substrate of dominant plants measured quarterly on the Baasi inselberg. Lichen (*Buellia canescens*), succulent monocot (*C. lanata*), and moss (*A. acanthophyllum*).

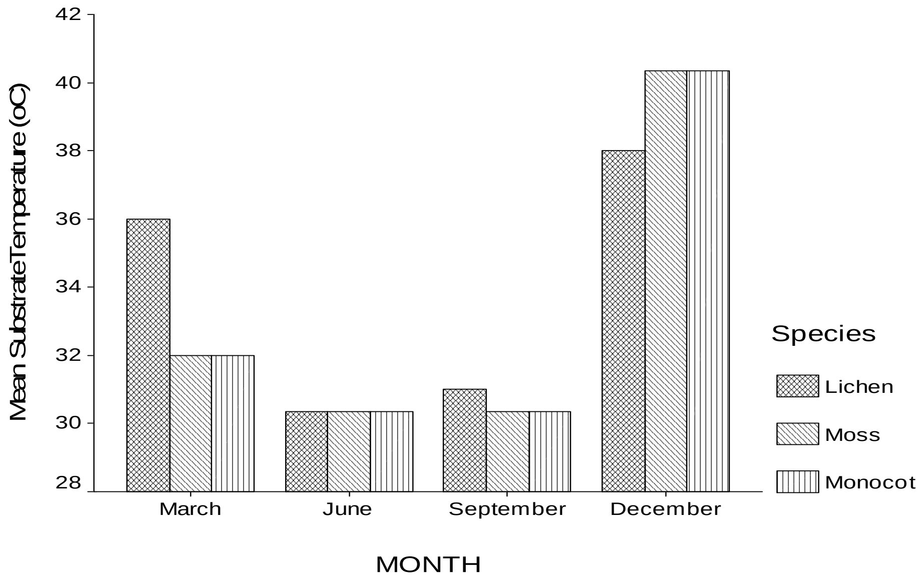

Figure 4. Temperature of substrate of dominant plants measured quarterly on the Baasi inselberg. Lichen (*Buellia canescens*), succulent monocot (*C. lanata*), and moss (*A.acanthophyllum*).

Figure 4 shows that substrate temperature varies throughout the year. Substrate temperature decreased sharply from March to June and remained steadily until September when it suddenly increased in December (39.6 ^{o} C ±SE 0.56, $p \leq 0.05$).

Figure 5 shows that the micro vegetation relative humidity increased significantly in June and September (78.78 ±SE 0.90, $p \leq 0.05$).

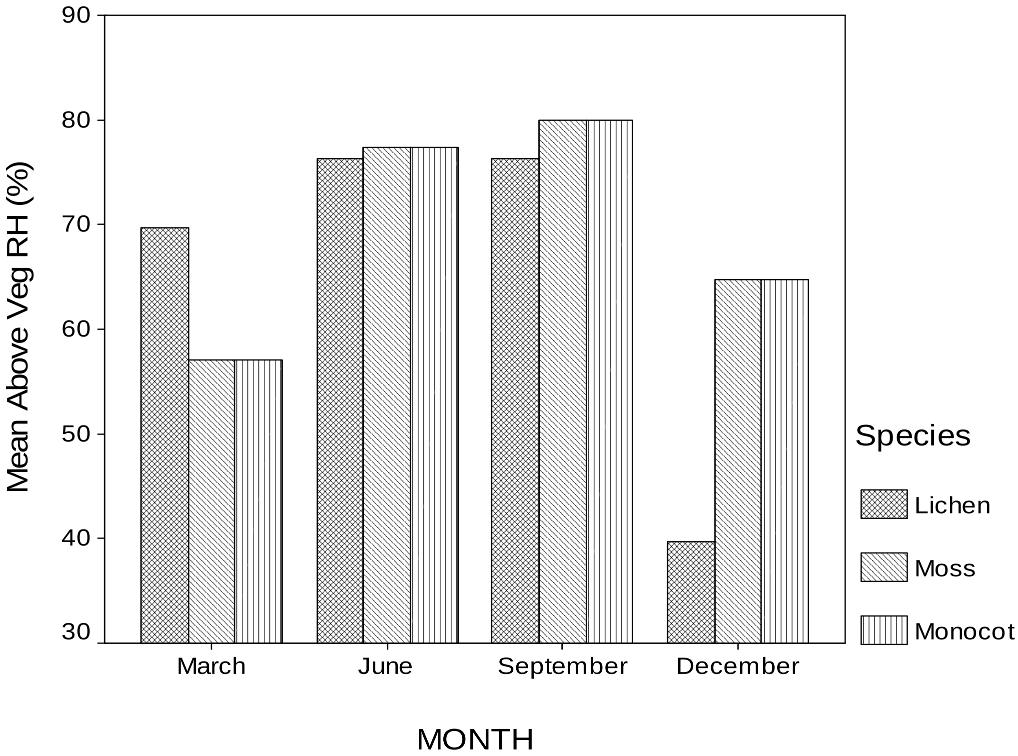

Figure 5. Relative humidity above substrate of dominant plants measured quarterly on the Baasi inselberg. Lichen (*Buellia canescens*), succulent monocot (*C. lanata*), and moss (*A. acanthophyllum*).

DISCUSSION

Inselbergs are isolated inverted "saucer" shaped rock with insular attributes (i.e. special substrate, climatic, and floras). They provide suitable models for studying biogeographical and ecological phenomenon. According to [1], the succession progression of any vegetation is supposed to modify the edaphic and microclimate conditions that favored incoming species with which the initial plants are unable to compete. The condition on the studied inselberg is quite different. The succession on Baasi-Inselberg is a process by which dominant plants species successfully occupy, disappear, and reappear over time following a disturbance. This is in accordance with [4] definition of succession as predictable, directional, and inevitable process. The succession events on the inselberg could be either auto or cyclic succession depending on the rock aspect and the dominating species of plants. Auto succession pattern with evidence of little or no competition or displacement of one stage by another is restricted to steep areas of the rock. This observation corroborates [5] that auto succession as one consisting of a single stage in which pioneer and climax species are the same. It often occurs where the severity of climate restricts the number of species and displacement fails to occur. Thus, inselberg with its unique microclimate provides special ecological models for auto and cyclic succession.

On one part of the rock, the constant density of B. *canescens* suggests substrate constant pH (7.0 ±0.1), and temperature (36 to 38 ^{o}C) in March and December respectively, and high relative humidity (70 to 80%) from March through June to September. In the present study, the only lichen (B. canescens) actually not modifying the rock, since there was no evidence of other plant growing from the gaps created by the dead fragments over the years. Although [1] noted that bryophytes and lichens are commonly involve in auto succession in the temperate region, but it is not clearly true in the present study. Instead, succession on this part of the rock follows proposed model of inhibition of [2]. The model of succession could not be facilitation or tolerance, because the same species of lichen persist year round. Thus, persistence of lichen on the rock round the year is a reflection of inhospitable external factors.

On the other part of the rock, pattern of development was cyclic in which case, *C. lanata,* and *A.acantophyllum* coexist. *A. acanthophyllum* formed the pioneer species and often persist throughout the year. The annual death of the *C. lanata* enhances high density of *A. acanthophylum* in December because of exposure to full light. Coexistence of *C. lanata and A. acanthophyllum* suggest facilitation model of [2].

In cyclic succession process, the *A.acanthophyllum* competes favorably with *C.lanata*. In addition, since cryptogams generally and always modify habitat conditions, the colonization of *A. acanthophyllum* is expected. Furthermore, mild alkaline substrate combined with high temperature (over 40 ^{o} C) and high relative humidity (over 60%) seems to enhance the higher density of A. *acanthophyllum* than the co-plant, *C. lanata* in December. *A. acanthophyllum* could survive the high temperature by the shade created by the canopy of *C. lanata*. Mild acidic substrate combined with moderate temperature (32 ^{o}C) and high relative humidity favored seedlings of *C. lanata* in the mat of *A. acanthophyllum,* in March. Thus, a change in coexisting plants is an indication of facilitation model.

In conclusion, it is evident that the two models of succession process operating on the Baasi inselberg. The lichen follows inhibition model while the co-existing C. *lanata* (succulent monocot), and the A. *acanthophyllum* (moss) follows the facilitation model. The tolerance model was not visible.

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