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Common Flora of Walls, Cracks and Crevices in Benin City, Nigeria

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Abstract:
Context: *The study of Benin City, Nigeria revealed that the flora of the urban environment is composed of taxa that are vigorous, adaptable and well-equipped to seize a quick foothold and thrive in habitats where other plants cannot effectively inhabit.*
Aims: *The study aims to provide an inventory of plants that grow on walls, cracks and crevices in Benin City, identifying the dominant species, identifying any adaptive features, and determining their frequency.*
Methods and Material: *Random surveys conducted in 2010 divided the city into 4 major sectors, visually inspecting each section to identify and inventory vegetation found on walls, cracks and crevices.*
Results: *The most important details are that 75 vascular plants, 51 bryophytes and 23 lichens were recorded, with 36 (24%) species occurring on one wall and 21 (14%) species on only two walls. 39 plant taxa were recorded from crevices, 21 from cracks and 14 from walls. Mosses were the most common plants on walls, with Tortula muralis and Bryum argentums being the most common. Peperomia pellucida was the most predominant in cracks and Chromolaena odorata had the least common in crevices. The numbers of plant taxa at the different sites appear to reflect their respective degree of competitiveness.*
Conclusions: *Weeds are caused by disturbance of the natural ecosystem by Man's activities.This study is important to help industries select materials that are suitable for moist tropical environments and to enable builders to choose building materials more carefully to reduce the frequency of occurrence of weeds on walls.*
Keywords: *Taxa, Flora, Wall, Crevices, Cracks.*
Key Messages: *Plant residue buildup can obstruct storm water runoff and provide a substrate for the growth of new weeds. They can make traffic indicators less visible at road edges, which can lead to accidents. In addition, weeds are unsightly and are often seen as signs of a failing city because they cover the sidewalks and streets.*

1. INTRODUCTION

Human activities such as construction of buildings, roads and agriculture modify the natural ecosystem (Chi, Zhang, Xie, & Wang, 2020). Weeds germinate more often in open spaces present, for instance joints and cracks, and can result in damage to the hard surfaces by breaking up asphalt and the edge of the road seal or enlarging cracks and thereby shortening their lifetimes (Li, 2020). Weeds are considered problematic since they compete, crowd out or restrict light to more desirable plants, harbor and spread pathogens that infect and degrade crop plants, have thorns and prickles that are injurious to human, and have chemicals or produce chemicals that cause skin irritation or may be hazardous when eaten. Weeds have adapted to grow and proliferate in human disturbed areas such as agricultural fields, lawns, roadsides and construction sites (Fracchiolla, Lasorella, Cazzato, & Vurro, 2022). Due to the constant development of urban settlement caused by population explosion in Nigeria, there is a constant replacement of natural vegetation either by construction of houses, roads or for cultivation purposes.

Benin is a city in Edo state, Nigeria, located between longitude 06004'E and 06043'E and latitude 05044'N and 07034'N. It has a population of 2, 159, 848 and occupies a land area of 17,802sqkm. Edo state has a tropical climate characterized by 2 distinct seasons and an average rainfall ranging from 150cm – 250cm (Orhorhoro, 2018).

Urbanization is a central component of land transformation process worldwide and one of the leading causes of species extinction (Cao, Kong, Zhang, & Ouyang, 2021). The urban environment has a unique flora composed of relatively few taxa which are vigorous, adaptable and well-equipped to seize a quick foothold and thrive where other plants cannot effectively compete (Verma, Kumar, & Bussmann, 2007). The habitat of these species can be found in sidewalks, cracks, crevices that occur on streets and walls of buildings (Santamour, 1983). In many ways, walls provide an extreme environmental condition for plant life which may include the availability of space for settlement, the hardness and alkalinity of the substratum, the lack of soil and humus, the inclination, the increased temperature, and the decreased humidity. Woodell (1979) observed that plant species found on walls are few, small, and include lower plants such as mosses and ferns. Wall vegetation is frequently disturbed because walls basically serve as temporary habitat, resulting in a wide range of species composition (He & Monaco, 2018). Pollution is not an important factor in determining the composition of flora since higher plants are much less affected by pollution than lichens and bryophytes (Heinrichs et al., 2019). A greater diversity of vascular and total species, but not bryophytes and lichens, is associated with increasing wall width (Heinrichs et al., 2019; Löbel, Dengler, & Hobohm, 2006; Frahm, Specht, Reifenrath, & León Vargas, 2000).

Plants growing in man-made stone work have to adapt to conditions of stress. Limestone, travertine and sandstones are the most porous materials and are easily colonized more readily than compact materials like siliceous rocks (Bozhko, Lapunova, & Kozlov, 2018; Helman, Lensky, Yakir, & Osem, 2016). The primary cause of the global decline in biodiversity is the fragmentation and loss of habitat brought on by anthropogenic pressure on natural ecosystems (Malavasi, Bartak, Carranza, Simova, & Acosta, 2018). Urbanization is the most damaging, persistent and rapid form of anthropogenic pressure (Ding & Chen, 2022). The study aims to answer the following questions: what plants grow on walls, cracks and crevices in Benin City, which families constitute the most plants, and in what proportions they manifest in different scenarios.

The assumptions proposed are that some plants are poor competitors and have adapted to growing in areas where few plants survive, and that plants that survive in cracks and crevices do not have direct contact with soil water and depend solely on water from condensation in humid air. The objectives of the study were to provide an inventory of plants that grow on walls, cracks and crevices in Benin City, determine the dominant species in each

category, identify any possible adaptive features that makes them survive in conditions present in cracks and crevices, and determine in what frequency they are encountered on walls, cracks and crevices in Benin City.

2. MATERIALS AND METHODS

2.1 Reconnaissance surveys

In 2010, a number of surveys, both random and opportunistic, were carried out across the metropolitan area of Benin. The city was divided into four major sectors, and walk-through inspections were performed in each section. An inventory of the vegetation that was discovered on walls, cracks, and crevices was carried out, and the rate of occurrence of each species was determined. A wall was described as anything that was constructed out of stone, brick, plaster, or wood and was used to partition off or enclose something, or as any side of a room or building. On the basis of the width of the openings, cracks were differentiated from crevices. Cracks are considered to be narrow slits between hard surfaces that measured less than 2 millimeters in diameter, while crevices were recognized to be spaces that were wider than 2 millimeters and typically contained some visible soil deposition inside. Each of the species that were discovered in each location was noted as either being present or absent. Fungi and lichens were not included because, contrary to common belief, they are not properly classified as plants.

3. RESULTS

The entire city of Benin was used as the focus of this particular research study. Records were gathered from the Oluku region of Benin all the way down to Ikpoba hill in the north, which then extended west toward Ekehuan. The fieldwork was conducted from May 2010 until October 2010, and the areas were divided into four different sites: Uniben, Ugbowo, Benin Metropolis, and Benin Outskirts (Table 1).

Table 1: Areas within the metropolis of Benin City and outskirts surveyed.

Study area	Area covered
Site A	University of Benin precinct
Site B	Ekosodin, Uwasota, Isihor, Oluku, Adolor and Uwagboe
Site C	Ring road, Airport road, Ekewan, Sapele road and G.R.A
Site D	New Benin, Upper mission, Upper Lawani, Sakponba and Ikpoba

The majority of the plants that were discovered in Site A's cracks and crevices were also discovered in other sites with very little variation. However, the species that were discovered on the walls were found to be repeated, but more species (new) were also recorded.

Although the mosses predominated, there were also some liverworts and a few species of higher plants among the species that were discovered on the walls. The plant species that were discovered at each of the locations were extremely diverse. They included indigenous, non-indigenous, as well as some invasive plant species. The plants that were discovered were primarily sedges, herbs, shrubs, grasses, and woody trees. (Table 2)

Table 2: A check list of plant found on walls crack and crevices in Benin City

Family	Weeds	Common name	Habit	Life form
Acanthaceae	*Asystasia gangetica*	-	Herb	Annual
Amaranthaceae	*Alternathera pungens*	Khaki weed	Herb	Perennial
	Amaranthus spinosus	Thorny pig weed	Herb	Annual
	Gomphrena celesoides	Bachelor's button	Herb	Annual
	Pupalia lappacea	-	Shrub	Annual
Asteraceae	*Ageratum conyzoides*	Goat weed	Herb	Annual
	Aspiliabussei	Haemorrhage plant	Herb	Annual
	Chromolaena odorata	Siam weed	Shrub	Perennial
	Emilia coccinea	Yellow tassel flower	Herb	Annual
	Synedrellanodiflora	Star weed	Herb	Annual
	Tridax procumbens	Coat buttons	Herb	Annual
	Vernonia cinerea	Little iron weed	Herb	Annual
Cleomaceae	*Cleome rutidosperma*	Fringed Spider Flower	Herb	Annual
Commelinaceae	*Commelina benghalensis*	Wandering Jew	Herb	Perennial
Convolvulaceae	*Ipomoea involucrate*	Morning Glory	Herb	Annual
Cucurbitaceae	*Momordica charantia*	African Cucumber	Herb	Perennial
Cyperaceae	*Kyllingra pumila*	-	Sedge	Perennial
	Mariscus alternifolius	-	Sedge	Perennial
	Mariscus flabelliformis	-		
Euphorbiaceae	*Euphorbia heterophylla*	Spurge weed	Herb	Annual
	Euphorbia hirta	Snake weed	Herb	Annual
	Phyllanthus amarus	-	Herb	Annual
Fabaceae	*Centrosema pubenscens*	Centro weed	Shrub	Perennial
	Desmodium ramosissimum	Petite roglisse	Herb	Perennial
	Desmodium triflorum	-	Herb	Annual
	Indigophera spicata	Hairy indigo		
	Leuceana leucocephala	-	Shrub	Perennial
	Mimosa diplothrica	Giant sensitive plant	Shrub	Perennial
Lamiaceae	*Solenostemon monostachyus*	-	Herb	Annual
Loganiaceae	*Spigella anthelmia*	Pink weed	Herb	Annual
Malvaceae	*Sida acuta*	Broom weed	Shrub	Perennial
Moraceae	*Ficus compensis*	-	Tree	
	Ficus exasperate	Sand paper plant	Tree	
Poaceae	*Axonopus compressus*	Carpet grass	Grass	Perennial
	Eleucine indica	Bull grass	Grass	Annual
	Eragrostis tenella	Feathery love grass	Grass	Annual
	Panicum maximum	Guinea grass	Grass	Perennial
	Setaribarteri	Foxtail grass	Grass	Annual
	Sporobollus pyramidalis	Cat tail grass	Grass	Perennial
Portulacaceae	*Talinum triangulare*	Water leaf	Herb	Perennial
Piperaceae	*Peperomia pellucid*	Worm bush	Herb	Annual
Rubiaceae	*Oldelandia corymbosa*	-	Herb	Annual
Utriaceae	*Laportea aestuans*	Tropical nettle weed	Herb	Annual

The number of different plant species that were found in cracks and crevices was counted to determine the frequency of the plant taxa that was discovered in these areas. According to the findings, various plant species predominated at each location. In cracks, crevices, and on walls, found *Commelina benghalensis, Eleucine indica, Peperomia pellucida, Solenostemon monostachyus,* and *Sporobolus pyramidalis. Agerarum conyzoides, Amaranthus spinosus, Axonopus compressus, Emilia coccinea, Euphorbia hirta, Ficus compensis, Gomphrena celesoides, Phymatodes scolopendrea, Pteridium togoensis, Sida acuta, Synedrella nodiflora* and *Tridax procumbens* occurred both in cracks and crevices.

Cleome rutidosperma, Phyllanthus amarus, Platecerumsp, Pteridium togoensis and *Vernonia cinerea* occurred both in crevices and on walls. *Spigella anthelmia* occurred only in cracks while *Alternathera pungens, Aspiliabussei, Asystasia gangetica, Centrosema pubenscens, Chromolaena odorata, Desmodium triflorum, Eragrostis tenella, Euphorbia heterophylla, Indigophera spicata, Ipomoea involucrata, Kyllingra pumila, Laportea aestuans, Leuceana leucocephala, Mariscus alternifolius, Mariscus flabelliformis, Mimosa diplotricha, Momordica charantia, Oldelandia corymbosa, Panicum maximum, Pupalia lappacea, Setaribarteri* and *Talinum triangulare* occurred only in crevices.

In Uniben, the percentage of plant species found in cracks and crevices was 34% and 66% respectively. In the area of Ugbowo, the percentage of plant species that were found in cracks and crevices was 38 and 62%, respectively. The percentage of plant species that were found in cracks and crevices ranged from 36 percent in Benin Metropolis to 64 percent in Benin Outskirts, but the percentage of plant species that were found in cracks and crevices ranged from 40 percent to 60 percent in Benin Outskirts.

More plant taxa and numbers were recorded from crevices and the least number of plants were recorded on walls. The number of plant taxa found in a decreasing order was as follows: walls < cracks < crevices. Lower plants, primarily mosses, were the most common on walls. *Peperomia pellucida* was the most prevalent species in cracks, while *Chromolaena odorata* was the most prevalent species in crevices (Fig. 1, 2, & 3).

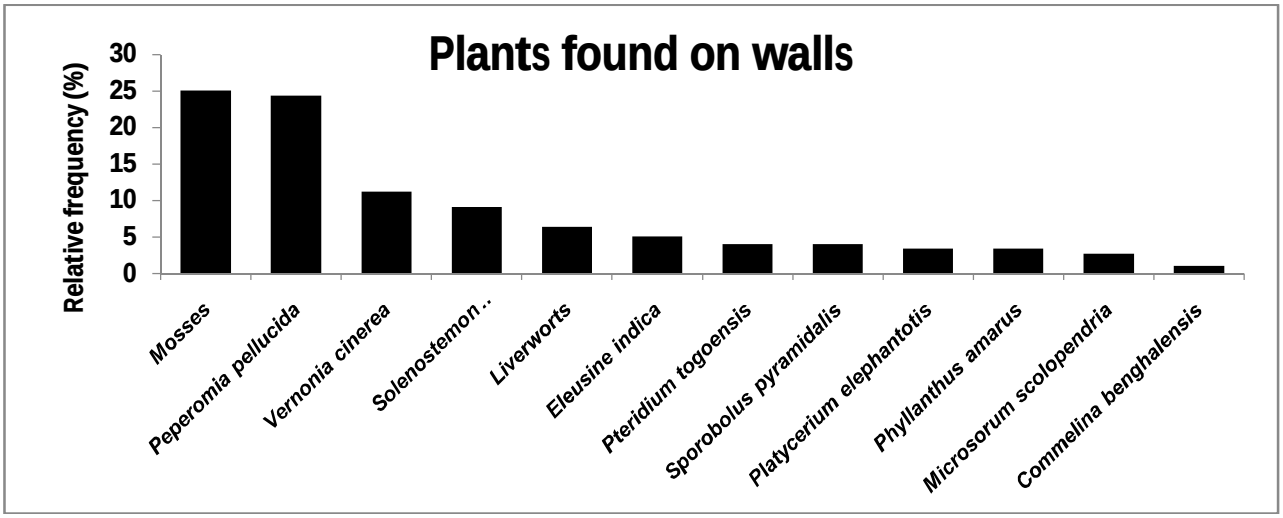

Figure 1: Percent relative frequency of occurrence of plants (inset) found on walls in Benin City in 2010.

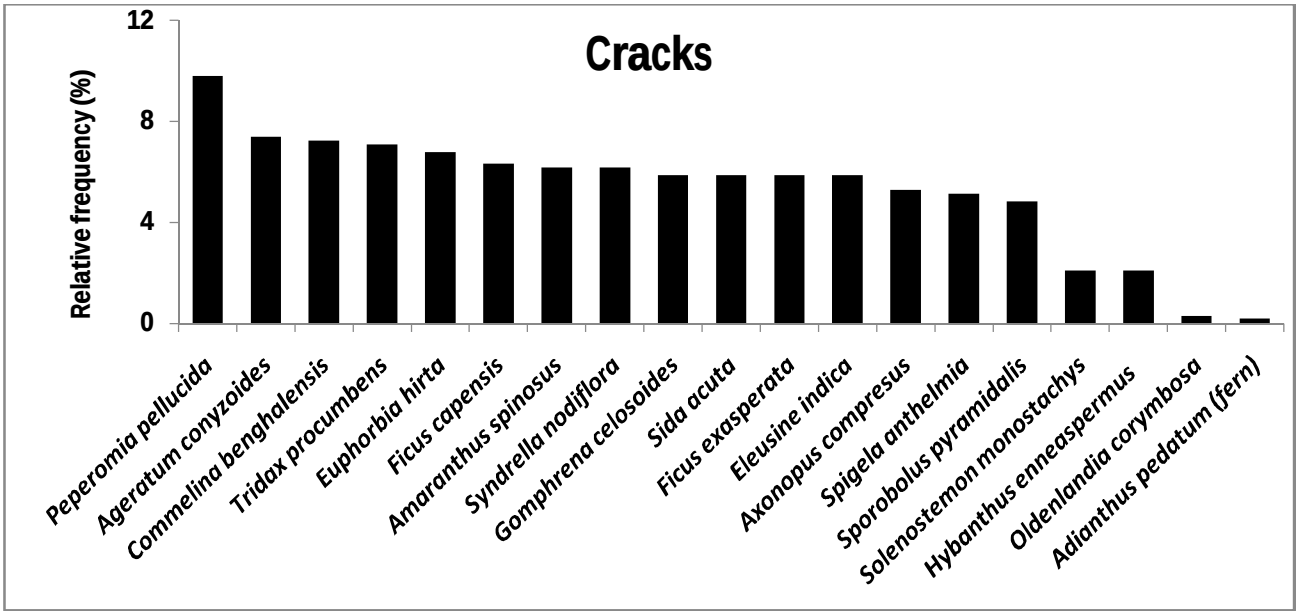

Figure 2: Percent relative frequency of occurrence of plants (inset) found in cracks in Benin City in 2010.

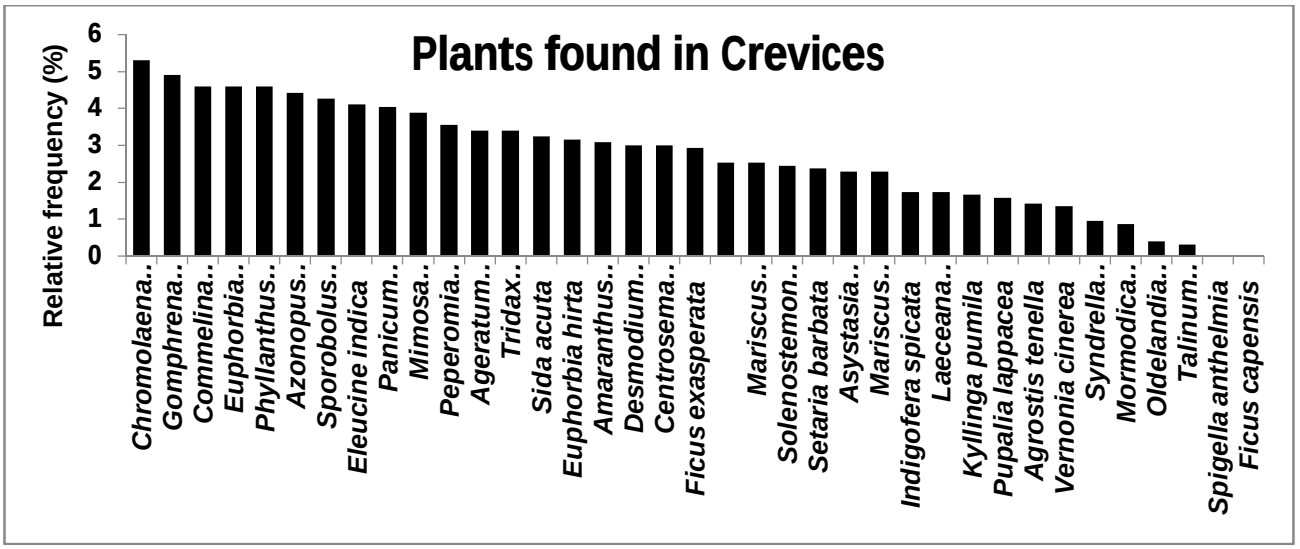

Figure 3: Percent relative frequency of occurrence of plants (inset) found in crevices in Benin City in 2010.

4. DISCUSSION

The colonization of walls, cracks, and crevices by plants is typically limited to moist environments and is an essential part of primary succession (Dakskobler & Martinčič, 2020; Santamour, 1983). Pavements, road verges, walls, and railway embankments are just some of the different ecological niches that can be found in an urban environment (Wrzesień & Denisow, 2016; Tikka, Koski, Kivelä, & Kuitunen, 2000). Within each of these niches, there are certain species that are particularly well-suited to surviving in their respective environments. According to Johnson et al. (1974), the average temperature in cities is typically higher than in the countryside that surrounds them, giving rise to the term "heat island."This leads to an increase in the number of species that are capable of engaging in C4 photosynthesis in urban areas with a warm climate (Sage, Wedin, & Li, 1999). Furthermore, aridity is a characteristic of masonry corners, small fissures between paving blocks, and pavement cracks which encourages the growth of xerophytes. (Benvenuti, 2004). Pavement cracks can be found in both residential and commercial settings. As walls get older and there is less of an impact from humans on them, they eventually become covered with a select group of plant taxa that are able to colonize this unusual habitat. When given enough time, walls that have been colonized by plants will begin to disintegrate. This will result in the production of fine grain rubbles that have a variable nutrient content. These rubbles will then accumulate in cracks and crevices, providing a substrate that will allow early succession of other types of vegetation.

This is the first survey conducted to identify the plant that grows on walls, in cracks, and in crevices in Benin City. The result showed that plants of the Asteraceae family were the most predominant with 7 species followed by the Poaceae and Fabaceae with 6 species each while the families *Acanthaceae, Cleomaceae, Commelinaceae, Convolvulaceae, Cucurbitaceae, Lamiaceae, Loganiaceae, Malvaceae, Piperaceae, Portulacaceae, Rubiaceae* and *Utriacaceae* with one plant species each. Benin City has a similar urbanized ecosystem to that of Kampala (Mosango, Maganvi & Namanganda, 2001), in which the natural vegetation has been predominantly altered by human activities, resulting in several man-made habitats where a different kind of vegetation has taken over. This consists primarily of invasive weeds that spread quickly.

Some of the plants that were discovered growing in cracks and crevices on the walls during the period of this research are very likely to be the types of plants that would play active roles in primary succession in the Benin City area. According to Andersen & Macmahon, (1985), several of the plants, including *Asystasia gangetica* and *Solenostemon monostachys*, were among those that were involved in the primary succession following a volcanic eruption in the Cameroons in 1922. Plants that were a part of this study have the possibility of being categorized as possible primary succession agents in Benin City. More plants were discovered in crevices at the University of Benin site, with *Commelina benghalensis* being the species that was found the most frequently. Benin's outskirts had the most plants found in cracks, with *Axonopus compressus* occurring more frequently than the others. Benin's metropolis, on the other hand, had more plants on walls, with Bryum sp appearing more frequently than the others.

When walls age, and with low human impact, they become covered with a limited number of plant taxa that are able to invade this peculiar habitat. As the walls disintegrate, fine grain rubbles with a variable nutrient content are produced. These rubbles then accumulate in cracks and crevices, providing a substrate that enables the early succession of other types of vegetation. The disintegration of the walls and wall joints was probably caused by climatic erosion by wind, rains, and the effect of the vegetation itself. This may have been responsible for the accumulation of fine grain rubble in crevices, which in turn allowed for further development of vegetation, which explains the occurrence of more plants in crevices than on the walls and cracks (Duchoslav, 2002). At the Uniben site, Bryum species and Marchantia species were found on the walls more frequently, particularly on the

walls that had not been painted. Since higher plants are more likely to be affected by pollution than lichens and bryophytes, pollution is not considered to be an important factor in determining the composition of the flora, as stated by Presland (2008). It is possible that Uniben is less polluted than the other sites due to the greater number of bryophytes that were found on the walls in that location. According to Gemal, Green, Cary, & Colesie (2022), Bryum sp are commonly found growing on walls but not on hard strata. Therefore, the presence of Bryum sp can be explained by the use of soft stones as building materials for the walls, despite the fact that the composition of the walls was not taken into account. Furthermore, the fact that they were found growing on all of the walls that were studied in Benin provides evidence that they are quite cosmopolitan. The plant species discovered were primarily weeds, some of which were invasive, while others were cosmopolitan and included shrubs, sedges, grasses, herbs, and woody trees. The observations made on the growth pattern and occurrence of plants revealed a number of similarities, some of which include the substratum on which the plants grow and the characteristics of the environment in which they are found. The majority of plants found in cracks and crevices are commonly referred to as weeds due to their ability to rapidly colonize an area, persist, and produce and disperse large quantities of seeds (Araj & Wratten, 2015). In accordance with Janick and Jules's (1979) definition, their capacity to colonize a region enables them to grow and adapt in any environment, regardless of how extreme the conditions are. According to Segal (1969), the majority of plants that are found in crevices have both mesophytic and xerphytic properties. This allowed them to survive even in dry conditions when there was a limited supply of water, even though they appeared less luxuriant during dry spells. However, pre-existing plant cover may also encourage the growth of other specimens by providing protection against evaporation and sun exposure, thereby regulating relative humidity. Crevice plants lose the majority of their leaves, which then form mulch at their bases and help retain water content in the soil.

There were fewer plants found to be colonizing wall surfaces, and they seem to be vertically stratified, occupying primarily the lower bottom half of the wall, with little to no presence at the top and at the ground level. It is highly likely that the absence of plant species at the top of the walls was caused by desiccation and exposure to harsh climatic elements. On the other hand, plant species were present at the lower part of the wall because of high humidity and low competition. However, plant species were not present at the basal ground level because of high levels of competition from other plants. According to an indication of ecological conditions based on vascular plants, differences in light and moisture exist between wall tops and vertical surfaces. Wall tops were found to be drier and gained more incident radiation than vertical surfaces (Mustafa & Vagif, 2006).

Establishment of flora on walls is influenced by a wide variety of ecological factors, including topography, access, edaphic conditions, and climate (He, Li, Wang, Xie, & Ye, 2021). Plants have the potential to colonize walls in particular areas depending on their ability to adapt and develop on the volume and types of substrata, as well as the effectiveness of their reproductive mechanism and their capacity to colonize their environment (Merget et al., 2019). Since Benin City is in a moist tropical rainforest zone, there is a significance occurrence of flora found on the walls and in crevices. The majority of wall-dwelling plants were herbaceous and non-vascular, whereas shrubs and grasses dominated in cracks and crevices, likely due to a greater amount of substratum present in crevices than on walls.

In general, *Peperomia pellucida* was found to occur in all of the investigated sites, albeit at varying levels of frequency depending on the location. Although it was the most common in cracks and the second most common on walls (after mosses, which makes it the most common angiosperm on walls), it was a distant 12th place among the most common plants in crevices. Mosses were the most common on walls. This suggests that as the environment becomes more stable and hospitable to support more plant growth, certain species, such as *P. pellucida*, begin to become extinct, most likely because

they are unable to successfully compete with other organisms for the limited space and nutrients that are abundant in crevices. This proved that *Pepromia pellucida* is a poor competitor and that it has adapted to grow in areas that are less hospitable, such as walls and cracks, because the majority of plants and other potential competitors are unable to thrive in such areas.

5. CONCLUSION

Most of the plants found on walls, in cracks and crevices are majorly weeds comprising bryophytes and angiosperms so it is not an attribute peculiar to some particular plant families since the availability of substratum and climatic factors together with Man play a major role influencing growth of plants on walls, cracks and crevices.

From this study, it is evident that with the constant disturbance of the natural ecosystem by Man's activities plants will keep occurring on walls and with time, there will be an increase especially in tropical countries with high humid conditions of the world thus reducing the aesthetic value of urban infrastructure.

This study is important to assist industries like paint and real estates in selecting materials that would be suitable for very moist tropical environment so that painted buildings would be durable and thus reduce the cost of renovation, to also enable builders to choose building materials more carefully to reduce the frequency of occurrence of the weeds on walls. Plant residue build-up can obstruct storm water runoff and provide a substrate for the growth of new weeds. They can make traffic indicators less visible at road edges, which can lead to accidents. In addition, weeds are unsightly and are often seen as signs of a failing city because they cover the sidewalks and streets (Popay et al., 1992; Benvenuti, 2004).

6. CONFLICT OF INTEREST

There is no conflict of interest among authors.

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