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Occupancy of *Azadirachta indica* A. Juss. by fungus and termites in Port Harcourt: Implications for integrated protection strategies

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Abstract: *Azadirachta indica used as avenue trees are facing combined local fungus and termites attacks as the trees lifetime progresses in University of Port Harcourt (UNIPORT), Nigeria. Studies of the co-occupancy of these wood degrading pests on ornamental woody trees are rare in Nigeria. Therefore, Ganoderma lucidum fungus and termites infestations on the 36-year old A. indica trees were surveyed along the Delta major road main gate to the Ofrima/senate roundabout of UNIPORT between January and December, 2014. G. lucidum was considered as the principal primary occupant pest found in all the 212 trees while termites mainly Amitermes evuncifer was recognized as the secondary occupant pest found in only 62 trees. Their co-occupancy indicated that they were not antagonists of each other but their co-infesting activities were greatly inimical to the trees survival resulting in average annual loss of 4 trees. The results demonstrated that G. lucidum and Amitermes evuncifer actively contributed to the decline of the tree species. Significance of trees in the landscape was recognized in the University as a whole but strategies to guide the trees management and ensure their protection for future generation were inadequate. Selections of trees should consider first the reputed tolerance ability of the species to the peculiar environmental conditions.*

Keywords: *Avenue trees, co-occupancy, institutions, suitability study, wood protection*

I. Introduction

Trees represent important component of landscape systems providing many amenities for University community, yet perceptions of community value may not incorporate all the scientifically confirmed global goods and services of trees pertaining to its management and protection. The order of growth and developmental stages of trees include: (a) planting, (b) canopy opening, (c) canopy lightly closed, (d) canopy moderate (e) canopy dense, (f) canopy degrading, (g) canopy broken and (h) death. However, trees like other living organisms are inherently endowed with varied specific lifespan but can be altered by human-induced modified environments. Plant species grown as avenue trees are mostly considered desirable at canopy-dense stage and this stage is expectedly to be relatively longer than any other stage for the species to satisfy purpose of management as avenue trees. The suitability of chosen species for any object of management often reduces the vulnerability of the trees to pests' interactions and infestations.

Many inter-specific interactions have been considered parasitic which in turn impaired the host species fitness against their object of management especially in human-modified environments. Anthropogenic forest modifications often alter pest-host interactions and could change the persistence of host populations [1] yet species suitability is usually grossly ignored in the course of trees' selection in many Nigerian institutions. Added to this, are the low research studies about the pest's situations on the ornamental trees which could have provided background information of the possibility of future damages and cost to rate payers. Although, reference [2] pointed that there was no suitably perfect tree but selection criteria should fit in to environmental tolerances, functional requirements, and aesthetic/design needs. Moisture (precipitation) is a ubiquitous abiotic factor stress within mangrove forest zones or habitats. Soil in the cities can be saturated with moisture for weeks or months due to the incessant downpour of rainfall, increased anthropogenic soil pores blockage systems installations, and low vegetation cover.

Avenue trees are crucial in environmental conservation and the landscaping of institutions' environments. In the University of Port Harcourt: Palm spp., *Casuarina equisetifolia, Delonix regia, Mangifera indica, Terminalia* spp., *Azadirachta indica* etc were popular species grown as avenue trees along the major roads. The selection of these species were believed to be predicated upon preference but not quality (suitability). Persistent wide spread of pest infestations were among the consequences. So far, no available species suitability research efforts have been reported. Recently, the decline of the *Azadirachta indica* was linked with *G. lucidum* and some abiotic factors [3]. Hence, study of the host range species to predict the spatial occurrence of *G. lucidum* on general ornamental trees, and incidence and severity of termites' infestations on *A. indica* in

UNIPORT were initiated, but co-occupancy effect of the fungus and termites on *A. indica* have not been reported. *A. indica* in the University landscape continue to fall victim to combine fungal and termites' attacks. Considering the emerging annual decline of the institution trees especially avenue trees, co-occupancy of *G. lucidum* and termites on the *A. indica* along the most popular road was surveyed with a view to recommending integrated strategies for the protection of the ornamental trees.

II. Materials and Methods

The study area and data collection

The study was carried out along the Delta major road main gate to the Ofrima/senate roundabout (Latitude 40 54' 6.14'' and 40 54' 23.26''N and longitude 60 54' 24.63'' and 60 55' 8.98'' E) of UNIPORT between January and December, 2014. UNIPORT falls within humid region characterized with two seasons, the dry season (November to March) and wet season (April to October). The rainfall distribution is nearly all year round though its intensity is seasonal and variable. The monthly mean maximum temperature ranges from 28^{o}C to 33^{o}C while the monthly minimum temperature ranges from 17^{o}C to 24^{o}C [4].

The survey covered the occupancy of 212 *A. indica* trees by *G. lucidum* and two termites' species from January to December. The two rows of 36 year old trees were spaced 7m apart and had attained Diameter at Breast Height (DBH) range between 40.90cm and 73.18cm. The trees were classified as severely and more severely infested based on the individuals and or combination of occupants. Those that were occupied by fungus only were being classified as severely infested while those occupied by both fungus and termites were under more severe class. The ultimate end stage (death) of the trees was also recorded within the year. The trees were investigated for tree-inhabiting *G. lucidum* and termites by examining the individual tree for fungus fruiting bodies, decay and infestations of termites on the stem trunk from the base to the crown.

III. Results

Climatic aspect

Generally, the weather oscillates from dry to rainy season. The monthly air temperature peaked at 28^{o}C and 33^{o}C and minima of 17^{o}C and 24^{o}C was previously reported [4]. The rainfall distribution in the study year was all year round but monthly quantity, frequency and intensity varied. Prevailing weather conditions appeared to be relatively favourable for the vulnerability of middle-age and old trees to fungi infestations and growth of *G. lucidum*. Therefore, the main prerequisite responsible factor for occupancy of the species by fungus and termites was the anaerobic soil moisture conditions.

Decline of the trees

Occupancy of the avenue trees by *G. lucidum* and termites mainly *Amitermes evuncifer* translated to annual loss of 4 trees and high net loss in trees canopy areas. 146 trees were severely infested by *G. lucidum*, 66 were more severely co-infested by *G. lucidum* and *Amitermes evuncifer* while 4 mortalities were recorded during the study as indicated in table 1. The two level of severity or occupancy corresponded with canopy degrading and canopy broken growth stages of the trees.

Table 1: Monthly declining of the trees due to fungus and termites attacks during the year 2014

Months	Fungus attack (Severe)	Fungus/termites attacks (more severe)	Death	Total
January	146	66	-	212
February	146	66	-	212
March	146	64	2	210
April	146	63	1	209
May	146	62	1	208
June to December	146	62	-	208

Trees inhabiting fungus and termites

As shown in Fig.1, 208 trees had varying degree of fungal and termites infestations. The chronology of occupancy apparently indicated fungus as primary occupant and termites as secondary occupant. *Amitermes evuncifer* and *Macrotermes bellicosus* were the termites species found in the 62 trees but *Amitermes evuncifer* was dominant over *Macrotermes bellicosus* which was found only in 4 trees. The fruiting bodies of G. lucidum were found on the trees floor, the trees butt and exposed lateral roots (Fig. 2 and 3) causing rots and cracks. The evidences of termites' infestations were observed through their tunneling, nesting and plastering (Fig. 4) activities on the dead stem bark, heartwood and dead branches.

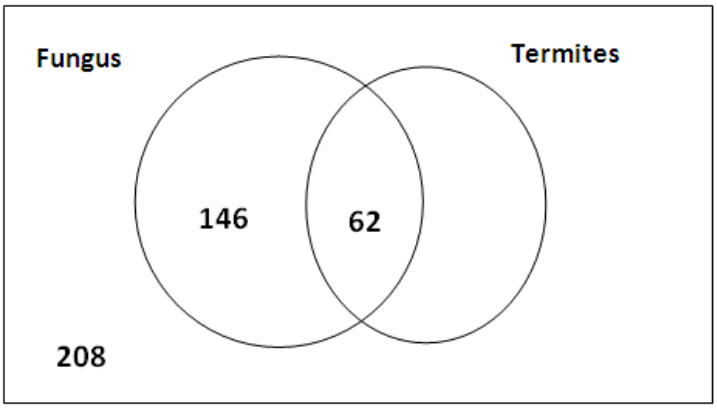

Fig. 1: Frequency of *A. indica* trees occupancy by fungus and termites

Fig. 2: Fruiting bodies *G. lucidum* on the tree floor and butt

Fig. 3: Fruiting bodies *G. lucidum* on the exposed lateral branches causing rots and cracks

Fig. 4: Plastering of the dried stem bark by *Amitermes evuncifer* termites

IV. Discussion

Understanding the ecological requirements of specific tree species could aid their best utilization for landscaping. This is very crucial especially in zones that are constantly experiencing high intensity of rainfall. *A. indica* also known as neem is a popular species grown for landscaping purposes across Nigeria. But the species could not specially adapt to Port Harcourt anaerobic soil conditions beyond the middle-age of 35 years before succumbing to primary pest infestations. This was in agreement with the submission of reference [5] that Neem does not tolerate seasonally or permanently waterlogged (poorly drained) soils. The result was further corroborated with those of references [6 and 7] that neem's natural habitat is 'seasonally dry in India and Pakistan. The higher DBH and longevity of *A. indica* trees observed in forest dry zone of Ibadan, Savanna zone of Imeko, Nigeria was also an attestation to confirm the better adaptability of this species to drained soil conditions. Therefore, soil moisture condition apparently contributed to the species vulnerability to primary fungus pests' infestations. The evidence of the role of soil moisture as precursor of fungus and termites' infestations to the decline of the species is of environmental concern for the management of shade in the most popular main road of the University.

Trees had various degrees of fungus and termites infestations. Fruiting bodies of *G. lucidum* were found on 146 trees while 62 were concurrently infested by *G. lucudum* and termites. The termites were strictly inhabiting or occupying the dead parts of the species ranging from the stem bark to crown branches. The severely and more severely infested degrees corresponded with canopy degrading and canopy broken growth stages of the trees respectively. This chronological order of occupancy indicated *G. lucidum* fungus as primary pest and termites as secondary insect pest occupants. The result was in congruity with assertion of [8] that primary pests usually invade first and principally affect the health of the tree, and secondary pests, which have a less important influence and usually affect trees already weakened by a predisposing factor. Severity of fruiting bodies on the tree floors and lateral roots corresponded with the increasing rainfall. This was in consonant with those of [9] that fungal infection is very responsive to environmental factors, and a strong correlation exists between moisture content around the root collar and mycelial growth of roadside trees in Japan. Appearance of fruiting bodies was the first active evidence of the pathogenic *G. lucidum* causing notable roots and stem butt rots on the trees. At advanced stage, the stem bark became dead, thus provided suitable substrate for termites nutrition. Though the trees had fluctuating occupancy severity of *G. lucidum* but lateral root rots levels corresponded with the levels of die back of the crown branches. The fungus infesting the root systems strongly indicated that *G. lucidum* was the ultimate cause of the species decline as its infestations impaired tree chemistry and obviously accompanied by root rots, dead of phloem, and die back of the branches. This was in consonance with submission of reference [10], that roots are essential for the uptake and translocation of water and nutrients are the synthesis site for certain hormones; any factor that limits overall root development will limit the extent of shoot growth. It might be difficult to gauge the extent of internal damages caused by *G. lucidum* fungus on 146 trees that had not been attacked and occupied by termites. However, this study has shown it as possible negative indicators of trees declining.

Further occupancy of the dead parts of weakened trees by termites was an indication that the dead wood of *A. indica* had no extractives of fungal and insect protection values. The association of the fungus and termites suggested that both were not antagonists of each other but termites were dependent on fungus. Though,

the termites' tunnels were sparingly observed closed to *G. lucidum*, but the fungus serving as termite's diet was not clear. This was because; there was no obvious evidence of termites' mouth part on the contact fungus part. Growing numbers of termites were found infesting heavily on the dead parts from the stem bark to the crown causing gradual upward death of the stem bark through their feeding, tunneling, plastering and nesting activities. *Amitermes evuncifer* drywood feeder termites were the dominants in all the 62 infested while insignificant activities of *Macrotermes bellicosus* were observed in only 4 trees during the rainy season. This suggested that *Macrotermes bellicosus* might be more of damp wood feeder. This result was similar to those reported by reference [11] that *Macrotermes bellicosus* and *Odontotermes* sp. destroyed the neem tree (*Azadirachta indica*) used as poles for electric power transmission in Zaria, Nigeria. The more severely infested trees did little to shade enhanced their surrounding landscapes, death of trees created undesirable voids in the landscape canopy. The weakened conditions and 4 mortalities of trees recorded indicated the ecological and economic loss caused by combined occupancy of fungus and termites.

Implications

Significance of trees in the landscape was recognized in the University as a whole but strategies to guide the trees management and ensure their protection for future generation were inadequate. The study suggested that the useful life expectancy of *A. indica* may not exceed 40 years in Port Harcourt. The biggest challenge probably was caused by the factors that rendered the trees vulnerable to primary pathogenic *G. lucidum* infestation. Considering the relevance of trees in environmental conservation, the task of proper implementation of tree protection must commence with the selection of suitable species and systematic replacement of not only *A. indica* but other severely affected ornamental species notably *Casuarina equisetifolia*, *Delonix regia* etc., possibly selecting cultural, ecological or historical trees of landscaping importance. This study and other studies can be used as background information in strategic political effort to ensure that adequate resources are allocated for planning and onward management of ornamental trees.

V. Conclusion

It was clear that 36-year old *A. indica* trees used as avenue trees in UNIPORT were vulnerable. The study revealed *G. lucidum* fungus and mainly *Amitermes evuncifer* termite species as the specific pests (occupants) that actively posed serious threat to *A. indica* in the University of Port Harcourt, limiting its fullest usefulness as avenue tree species. Undoubtedly, soil moisture was the abiotic stress responsible for the vulnerability of the tree species. The study suggested that the useful life expectancy of *A. indica* may not exceed 40 years in Port Harcourt. The study recommended site assessment on its potentiality to meet tree species needs or requirements should be given priority, indigenous tree species of ornamental significance that have proven water tolerance should be retained and selected, fund should be released for ornamental trees related researches, destruction of the ornamental trees by humans in form stem bark harvesting for medicinal purposes should be stopped. This study has provided an insight on how soil moisture conditions (abiotic), and combined fungus and termites (biotic) factors influenced the decline of *A. indica* used as avenue trees. Hence, intensified effort should be made for good management of ornamental trees in the University as a whole.

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