Journal of Research in Forestry, Wildlife & Environment Vol. 12(2) June, 2020
E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe
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ISBN: 2141 – 1778
Imarhiagbe and Aigbokhan, 2020

STUDIES ON *Thonningia sanguinea* VAHL. (BALANOPHORACEAE) IN SOUTHERN NIGERIA: III. DISTRIBUTION, HABITAT CHARACTERISTICS AND PHYTOSOCIOLOGY

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ABSTRACT

Apart from the recognition of Thonningia sanguinea as a root parasite of forest trees, information on other aspects such as the nature of its population, habitat preference and distribution range in Nigeria has not been reported. Hence to delineate its presence and current distribution ranges, reconnaissance surveys were carried out across selected forested areas in Southern Nigeria. Records on habitat characteristics comprising host type, elevation, GPS location/orientation, companion plant species, and soil types were collected from sampling sites habouring the plant. This study reports the presence of T. sanguinea in the following locations with an accompanying number of population: Cross River National Park (13), Ehor Nu Wire Forest (3), Okokhuo Forest (3), Okour Forest (2), Iyanomo Forest (2), Okomu National Park (12), Idanre Forest Reserve (2), Ofosu Forest Reserve (3), Oba Hills Forest Reserve (2), IITA Forest Reserve (5), and Omo Forest Reserve (2). Analysis of its habitat features revealed its preference for disturbed habitats, particularly those along forest margins and nature trails, where sunlight reflection reaches the ground. T. sanguinea habitats were characteristically ferrallitic or ferruginous soil. Phytosociological analysis of T. sanguinea habitats showed a regular association with secondary forest indicator species such as* Cercestis *sp, Harugana madagascariensis, Anchomanes difformis, Musanga cecropioides, Strombosia grandifolia, Icacina trichantia, Myrianthus arboreus. Thus, based on habitat preference,* T. sanguinea *can best be described as a species that avoid a highly disturbed environment but show a preference for areas with minimal disturbance in a forested environment. Consequently, T. sanguinea could be a potential bio-indicator in predicting environmental degradation in a forested ecosystem.

Keywords: Habitat characteristics, bioindicator, phytosociology, parasitic plant.

INTRODUCTION

The distribution pattern and habitat characteristics are key aspects of the ecology of parasitic plants. Parasitic plants are an intriguing group of species, essentially, by the partial or complete undermining of their fundamental photosynthetic role as independent plants to become dependent on other plant species for survival (Heide-Jørgensen, 2008; Santos *et al.*, 2017). Owing to the specialized habitat requirements of parasitic plants, their distribution among plant communities is largely influenced by host availability, host quality, host resistance to parasitism, and parasite preference (Garcia-Franco and Rico-Gray, 1996; Norton and Carpenter, 1998; Norton and Lange, 1999; Press and Phonex 2005). Although most authors postulate that host species are the key determinant of the distribution pattern of parasitic plants (Watson, 2009; Joel *et al.*, 2013), other environmental conditions might affect such a synchronous distribution pattern. According to Zhang *et al.* (2018), the distribution of a parasitic plant synergistically results from an interaction between biological (i.e., dispersal vector and host availability) and environmental factors (i.e., altitude, area, longitude, and latitude). Therefore understanding the host-parasite interaction in relation to habitat features is key to proper

understanding of the ecology of parasitic plants and this has often been a challenge for conservation biologists (Marvier and Smith 1997; Santos *et al.*, 2017).

Thonningia sanguinea Vahl. of the Balanophoraceae, is an obligate parasitic flowering plant, notable for its unusual development and obscure affinities. It is a fleshy dioecious herb that grows from an underground yellow tuber that extends horizontally through the soil and forms a bulb-like swelling at the points where it attaches to the roots of its host plants (Imarhiagbe and Aigbokhan, 2019). The stem is coated with spirals of scale-like leaves that lack chlorophyll; hence, it obtains its nutrients solely from the hosts. The flowering stem emerges from the ground to produce a bright red or pink inflorescence. Although commonly considered as a weed especially in rubber plantations (Idu *et al.,* 2002), *T. sanguinea* is highly revered for its medicinal properties (Olanya and Eilu, 2009; Imarhiagbe, 2020). A number of studies have been carried out on other aspects of the plant. Amongst these are, its gall anatomy (Idu *et al*., 2002), its pollination system (Goto *et al.*, 2011), and its ethnobotany (Imarhiagbe, 2020). *Thonningia sanguinea* has also been reported to possess antibacterial activity (N'guessan *et al.,* 2007), antioxidant activity (Gyamfi *et al*., 1999) and according to Ouattara *et al*. (2007), *T. sanguinea* may potentially harbor the healing properties to treat HIV and AIDS infection.

Based on the present narrative, it is evident that a fundamental aspect relating to sustainable survival in the wild has not been looked into. *Thonningia sanguinea* is restricted to the humid inland forests where it uses various tree roots as host. Recent reports indicate that these forested habitats are being faced with escalating high rates of degradation (Bani *et al.,* 2006; Piratelli *et al.,* 2008; Leimu, 2010), resulting in potential loss of host plants, thereby impacting negatively on the parasite population. More so, considering the current limited knowledge on the germination mechanism of *T. sanguinea* which up till now, remains elusive among scientists, the only viable option is to identify with current wild populations and proffer ways of conserving the plant in situ. Therefore, an understanding of its distribution, host species, and habitat features become an important prerequisite step necessary for making informed conservation management decisions. Hence, the present study was conducted based on the following objectives: (i) delineate the scope of the distribution (ii) identify its host species and (iii) determine its habitat preferences in Southern Nigeria.

MATERIALS AND METHODS

Description of study sites

Thonningia sanguinea populations are not randomly distributed but restricted to forested environments comprising a suitable host. Therefore, forested locations in Southern Nigeria, comprising National Parks, Forest Reserves and community-managed secondary forests, habouring *T. sanguinea* was mapped out and used as study sites. A brief description of the sites is given below.

The Okomu National Park, Edo State is located between longitude 5^{o} E and 5^{o} 30' E and latitude 6^{o}N and 6^{o}N, about 75 km west of Benin City, Nigeria. The park has a forest habitat that spans an area of 1,082 km^2 and it is further divided into different segments of about 1.6km^2 each. The climate has a well-marked rainy and dry reasons. The mean annual rainfall and temperature are 2,100 mm and 30.2 ^{o}C respectively. The relative humidity is usually not less than 65 percent during the day in any month of the year (Olaniyi *et al.,* 2015).

Oba Hills division of the Cross River National Park is 2,800 km^2 in area, centered on coordinates 5°25′0″ N 8°35′0 E″. The division shares a long border with Korup National Park in the Republic of Cameroon, forming a single protected ecological zone. It has a rugged terrain, rising from 100 m in the river valleys to over 1,000 m in the mountains. The soils are highly vulnerable to leaching and erosion. The rainy season normally starts from March to November, with an annual rainfall of over 3,500 mm. The forest remains largely untouched in the less accessible areas, but around the margins, it has been considerably degraded by human activity. The Park is divided into the buffer zone and the main park.

Akure Ofosu Forest Reserve is situated in Southwest Nigeria and with a land cover of over 394 km^2. It is located between latitude 5° 12´ and 5°30´N, longitude 50´and 7° 05´E, in the humid,

tropical rainforest zone of Ondo State, Nigeria (Ogunjemite and Oates, 2011). The forest has two distinct seasons (rainy and dry), with an annual rainfall (March to November) ranging from 1,500 to 2,000 mm and mean annual temperature between 30°C and 32°C while the mean daily humidity is 70%. Akure Ofosu Forest Reserve is currently experiencing a decrease in the vegetation cover due to anthropogenic activities, especially from logging and conversion of Forestlands to cocoa farms through forest encroachment.

IITA Forest Reserve is located in Ibadan, between Ojoo and Moniya town. The forest reserve covers about 350 hectares. It lies in the transition zone between equatorial rainforest to the south and savanna to the north. The Forest is a dry semi-deciduous rainforest. There is a pronounced dry season beginning in November and lasting until March. The average rainfall is 1301.6 mm with average monthly rainfall being lowest in January (1.6 mm) and highest in July (189.7 mm) (Bown, 2013).

Idanre Forest Reserve has been deeply encroached by anthropogenic activities, resulting in a single patch of natural forest at its Centre. The eastern side of the forest reserve has been converted to teak plantations and farms. There are many camps on this side of the reserve, indicating a high human population. The size of the remaining forest could not be quantified but it is probably less than 50 km^2.

Oba Hills Forest Reserve is situated in Osun State, Nigeria. The vegetation covers an area of about 52 km^2 of hilly terrain. Presently, the forest reserve is faced with degradation as almost all of the reserves have been converted to plantations and farms.

Omo Forest Reserve is a preserved area of tropical rainforest in Ogun state, Nigeria. The reserve covers an area of 130,500 hectares (322,000 acres) with mixed vegetation types. In the northern part, the vegetation consists of a dry evergreen moist, deciduous forest, while in the south, it is a moist, mixed, semi-deciduous forest. The average rainfall is around 2,000 mm. Recent reports indicate that a large portion of the reserve have been significantly disturbed, with the felling of the original trees and the establishment of plantations (Ojo, 2004)

Iyanomo rubber plantation is situated in the Rubber Research Institute of Nigeria (RRIN), Edo State. It is the only agency in the country mandated to conduct research into the production and development of *Hevea brasiliensis.* To complement the National Parks and Forest Reserves, some community forests were also visited. They include Ehor Nu Wire Community Forest, Okokhuo Community Forest, Okuor Community Forest, all in Edo State.

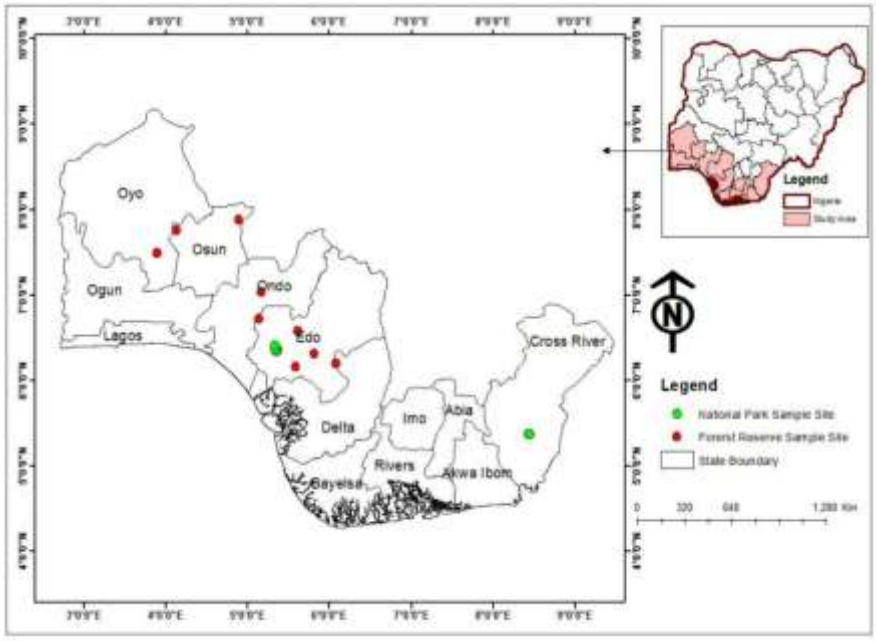

Figure 1. Map of Nigeria (Inset) Showing Study Sites in Selected Southern States

Experimental Design

To plot the distribution range of *T. sanguinea* populations, two reconnaissance studies by road were conducted to delineate the current distribution and identify its presence and absence across these locations (study sites). Supplementary information from historical records on *T. sanguinea* including ethnobotanical information was obtained from oral interviews of indigenous people living around the study sites and this was used to complement visual observations. A distribution map was drawn with the ArcGIS software (ver. 1.6) using geo-reference data collected. The habitat characteristics of *T. sanguinea* were observed and recorded using descriptors such as host species, nature of habitat (sunny or shaded), elevation and GPS location/orientation, nature of soil (data on the nature of soil were espoused from the characterization of the forest of Southern Nigeria according to Hall (1977). A vegetation survey was conducted to check plant species that appeared more often in plots with *Thonningia sanguinea*. Plant species found growing within the vicinity of 10 m × 10 m of the quadrat surrounding where *T. sanguinea* stands were spotted and identified, recorded and subjected to phytosociological analysis. Vegetative analysis parameters such as relative values of frequency, density, abundance and the importance value of each species were analyzed according to the methodology outlined by Kuchler *et al*. (1976). Identification of host and associated plant species was carried out using plant identification guides e.g Hutchinson and Dalziel (1968); Applequist (2001); Steentoft (2008); Aigbokhan (2014); Akobundu *et al. (*2016).

Figure 2: A closeup of *Thonningia sanguinea* inflorescence at the Okomu National Park, Edo State. (A) Male plant (B) Female plant (C) & (D) Aggregated nature of the population.

RESULTS

Figure 2 depicts the potential and confirmed distribution of *Thonningia sanguinea* in Southern Nigeria**.** The study revealed its presence in the following locations with accompanying number of populations: Cross River National Park (13), Ehor Nu Wire Forest (3), Okokhuo Forest (3), Okour Forest (2), Iyanomo Forest (2), Okomu National Park (12), Idanre Forest Reserve (2), Ofosu Forest Reserve (3), Oba hills forest Reserve (2), IITA Forest Reserve (5), and Omo Forest Reserve (2). These populations were supported by the following host species *Hevea brasiliensis*, *Theobroma cacao*, *Guarea cedrata*, *Lophira alata*, *Musanga cecropiodes*, *Myrianthus arboreus*, and *Ricinodendron heudelotii*, within the distribution range.

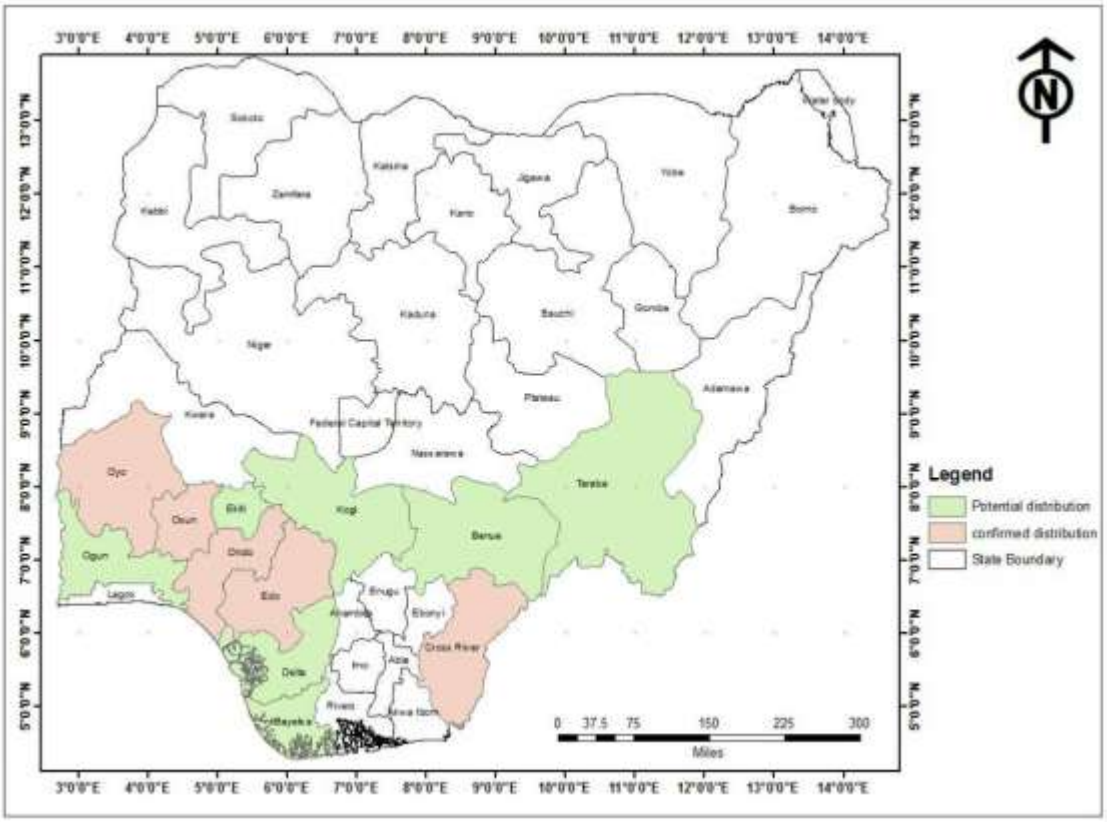

Figure 3: Potential and confirmed distribution of *Thonningia sanguinea* in Southern Nigeria

Table 1: Host Species and Habitat Characteristics of Sites Harbouring *Thonningia sanguinea* in Southern Nigeria

Study Sites	State Located	Altitude (m)	Coordinates	Habitat Characteristics/ host plants	Soil Type of Source/Parent Rocks*
Okomu National Park	Edo	51.40 - 102.6	06°24.113" 005° 19.440"E 06°21.381" 005°19.889" E 06°20.937" 005°20.685" E 06°20.135" 005°20.470" E 06°21.062" 005°21.398" E 06°21.656" 005°21.587" E	Common along forest trails and edges where sunlight penetrates to the ground. Host species include *Myrianthus arboreus, Musanga cecropiodes Guarea cedreta, Ricinodendron heudelotii*	Ferrallitic soils-western sub-group. Cenozoic sands
Cross River National Park	Cross River	123.6 - 167.6	05°21.863″ 008°26.438″ E 05°22.172" 008° 26.182" E 05°21.863" 008° 26.438" E 05°21.925" 008°26.350" E 05°21.863" 008°26.438" E	Abundant in disturbed portion of the forest, especially along the forest walk way. Sunlight reflection also observed. Host species include *Lophira alata* and *Musanga cecropioides*	Ferrallitic soils. Soil particles highly compact. Basement complex
Idanre Forest Reserves	Ondo	196.6	07°01.954" 005°09.868" E	Secondary forest type, found growing amidst *Theobroma cacao* plantation.	Ferruginous tropical soil- wet subgroup. Basement complex
IITA Forest Reserves	Oyo	214.5	07°29.820" 003°53.530" E	Secondary forest type. *T. sanguinea* common along the disturbed portion of the forest especially along the forest walk way, with much sunlight reflection to the ground. Host unknown.	Ferruginous tropical soil-Dry sub soil group. Basement complex
Ofosu Forest Reserves	Ondo	188.6	06°43.278" 005°07.852" E	Secondary forest type, common along forest walkway. Found parasitizing *Musanga cecropioides.*	Ferruginous tropical soil-Dry sub soil group. Basement complex
Oba hills forest Reserves	Osun	253.3	07°45.275" 004°07.752" E	Secondary forest type. Disturbed portion of the forest. Found along the forest walk way, with much sunlight reflection to the ground. Host unknown.	Ferruginous tropical soil-Dry sub soil group. Basement complex
Omo Forest Reserves	Ogun	??	??	Secondary forest type. Disturbed portion of the forest. Found along the forest walk way, with much sunlight reflection to the ground. Host *Ficus* sp	Ferruginous tropical soil-Dry sub soil group. Basement complex

				?.	
Ehor Nu Wire Forest	Edo	99.1	06°18.342" 005° 48.598" E	Plantation forest, with attributes of a forest re- growth physiognomy, comprising predominantly of *Hevea brasiliensis*. Host species observed was *H. brasiliensis*	Ferrallitic soils-central sub-group less compact soil particles. Cenozoic sands.
Okokhuo Forest	Edo	25.3	06°34.909" 005° 36.415" E	Plantation forest, with attributes of a forest re- growth physiognomy, comprising predominantly of *Hevea brasiliensis*. Host species observed was *H. brasiliensis*	Ferrallitic soils-central sub-group. Cenozoic sands
Okour Forest	Edo	148.6	06°11.962" 006° 04.928" E	Plantation forest, with attributes of a forest re- growth physiognomy, comprising predominantly of *Hevea brasiliensis*. Host species observed was *H. brasiliensis*	Ferrallitic soils-central sub-group Coarse litter, with relatively un-decomposed plant materials. Cenozoic sands
Iyanomo Forest	Edo	35.3	06°09.746" 005°34.898" E	Found in large patches among stands of the host species-*H. brasiliensis*.	Ferrallitic soils-central sub-group less compact soil particles. Cenozoic sands

**Soil types and parent material characterization adopted from Hall (1977)*

Figure 4: The regular nature-trail habitat preference of *Thonningia sanguinea*; parasitizing host trees along the forest trails (sites identity: A- Okomu N. P.; B- Okokhuo C.F; C- Ofosu F. R.; D- IITA F.R.; E- Cross River N. P.).

***Legend: N.P* (*National Park*), *C.F.* (*Community Forest*), *F.R.* (*Forest Reserves*)**

Table 2: Importance value index (IVI) of plant species growing at *Thonningia sanguinea* sites in Southern Nigeria

Associated Plant Species with *Thonningia sanguinea*	Relative Frequency (R.F.)	Relative Density (R.D.)	Relative Abundance (R.A.)	Important Value (I.V.)
Hevea brasiliensis	2.56	7.01	3.63	13.20
Cercestis sp.	3.84	6.63	2.57	13.04
Harugana madagascariensis	4.23	5.69	1.96	11.88
Theobroma cacao	1.28	3.79	3.92	8.99
Rinorea braviracemosa	1.67	3.79	2.94	8.40
Anchomanes difformis	2.17	3.22	1.99	7.38
Musanga cecropioides	2.96	2.65	1.18	6.79
Strombosia grandifolia	2.96	2.46	1.09	6.51
Icacina trichantia	1.67	2.46	1.91	6.04
Adenia lobata	1.28	2.27	2.35	5.90
Smilax anceps	2.17	2.27	1.41	5.85
Myrianthus arboreus	2.56	2.08	0.88	5.52
Alchornea cordiflora	1.28	2.08	2.15	5.51
Cleistopholis patens	2.17	2.08	1.18	5.43
Pteris togolensis	1.67	2.08	1.61	5.36
Periploca sp.	0.89	1.7	2.64	5.23
Trema orientalis	0.89	1.7	2.64	5.23
Acanthus montanus	1.67	0.76	2.35	4.78
Albizia lebbeck	2.17	1.52	0.94	4.63
Clerodendrum sp.	1.67	1.52	1.18	4.37
Leea guineensis	1.28	1.52	1.57	4.37
Funtamia elastic	2.17	1.33	0.822	4.32
Lophira alata	2.17	1.33	0.822	4.32
Acacia ataxacantha	0.89	1.33	2.05	4.27
Macaranga barteri	1.28	1.14	1.76	4.18
Costus afer	1.28	1.9	0.98	4.16
Allanblankia floribunda	1.67	1.52	0.94	4.13
Megaphrynium sp.	0.89	1.33	1.91	4.13

Associated Plant Species with *Thonningia sanguinea*	**Relative Frequency (R.F.)**	**Relative Density (R.D.)**	**Relative Abundance (R.A.)**	**Important Value (I.V.)**
Carapa procera	1.67	1.33	1.03	4.03
Alchornea laxiflora,	1.28	1.33	1.37	3.98
Laportea aestuans	0.89	1.14	1.76	3.79
Ricinodendron heudelotii	1.67	1.14	0.88	3.69
Voacanga Africana	1.67	1.14	0.88	3.69
Memecylon spatada	1.28	1.14	1.18	3.60
Trichilia monadelpha	1.28	1.14	1.18	3.60
Nauclea latifolia	0.89	0.94	1.47	3.30
Alstonia boonei	1.28	0.95	0.98	3.21
Cola millenii	1.28	0.95	0.98	3.21
Uapaca guineensis	1.28	0.95	0.98	3.21
Barteria fistolosa	1.28	0.76	0.88	2.92
Artocarpus altilis	0.89	0.76	1.18	2.83
Parkia bicolor	0.89	0.76	1.18	2.83
Cola heterophylla	1.28	0.76	0.78	2.82
Manniophytun fluvum	0.39	0.57	1.76	2.72
Pycanthus angolensis	0.89	0.38	1.18	2.45
Sterculia tragacantha	0.89	0.38	1.18	2.45
Pentaclethra macrophylla	1.28	0.57	0.58	2.43
Triplochiton scleroxylon	1.28	0.57	0.58	2.43
Strophanthus hispidus	0.89	0.32	1.18	2.39
Albizia zygia	0.89	0.57	0.88	2.34
Ancistrophyllum sp..	0.89	0.57	0.88	2.34
Anthocleista vogelii	0.89	0.57	0.88	2.34
Ceiba pentandra	0.89	0.57	0.88	2.34
Cola gigantean	0.89	0.57	0.88	2.34
Desplatsia dewevrei	0.89	0.57	0.88	2.34
Elaeis guineensis	0.89	0.57	0.88	2.34
Palisota hirsute	0.89	0.57	0.88	2.34
Sphenocentrum jollyanum	0.89	0.57	0.88	2.34
Treculia Africana	0.89	0.57	0.88	2.34

Associated Plant Species with *Thonningia sanguinea*	**Relative Frequency (R.F.)**	**Relative Density (R.D.)**	**Relative Abundance (R.A.)**	**Important Value (I.V.)**
Zanthoxylum sp.	0.89	0.57	0.58	2.04
Klainedoxa gabonensis	0.39	0.38	1.18	1.95
Maesobotrya barteri	0.39	0.38	1.18	1.95
Tetracera alnifolia	0.39	0.38	1.18	1.95
Annickia chlorantha	0.89	0.38	0.58	1.85
Anonidium mannii	0.89	0.38	0.58	1.85
Baphia nitida	0.89	0.38	0.58	1.85
Ceitis zenkeri	0.89	0.38	0.58	1.85
Diospyros mespiliformis	0.89	0.38	0.58	1.85
Guarea cedreta	0.89	0.38	0.58	1.85
Pausinystalis johimbe	0.39	0.19	0.58	1.16
Ancistrocladus korupensis	0.39	0.19	0.58	1.16
Bridelia ferruginea	0.39	0.19	0.58	1.16
Entadrophragma angolense	0.39	0.19	0.58	1.16
Ficus sp.	0.39	0.19	0.58	1.16
Holarrhena floribunda	0.39	0.19	0.58	1.16
Lovoa trichilioides	0.39	0.19	0.58	1.16
Microdesmis peribula,	0.39	0.19	0.58	1.16
Monodora myristica	0.39	0.19	0.58	1.16
Monodora tenuifolia	0.39	0.19	0.58	1.16
Oeceoclades maculate	0.39	0.19	0.58	1.16
Paristolochia goldiena	0.39	0.19	0.58	1.16

DISCUSSION

The study established a relatively wide range of distribution for *T. sanguinea*, detecting the presence of nineteen populations in the following locations Ehor Nu Wire forest (Edo), Iyanomo forest (Edo), Okour forest (Edo), Okokhuo forest (Edo), Okomu National Park (Edo), Cross River National Park (Cross River), Idanre Forest Reserve (Ondo), Ofosu Forest Reserve (Ondo), Oba Hills Forest Reserve (Osun) Omo Forest Reserve (Ogun) and IITA Forest Reserve (Oyo). However, ethnobotanical investigations carried out attested to its potential presence in Bayelsa, Ogun, Delta, Kogi, Benue, and Taraba States. At first notice in the forest, *T. sanguinea* are found in aggregated patches, clustered around the vicinity of the host plant (figure 2d). Such a contagious pattern of distribution is expected of species that are associated with specific resources, in this case, the host species. However, there are some implications to such distribution pattern as stated by Santos *et al.* (2017), that impaired vegetative growth and reduced seed dispersal may be associated with a clumped distribution of this nature and this could further result in interference of resource use and interspecific interactions among generated forms of aggregated individuals. On a broad scale, it appears that the general distribution pattern of *T. sanguinea* in Nigeria corresponds to areas where forest vegetation is still present. Meaning that the rate of forest degradation which is currently on the rise may likely have a negative effect on the present distribution of *T. sanguinea*. Consequently, the absence of *T. sanguinea* in places such as Enugu, Imo, Anambra, and Ebonyi States is attributed to the depleted nature of the forests, thereby creating a partial savannah-like environment that is not habitable to *T. sanguinea* (figure 3).

Another interesting finding was that the presence or absence of host plant in a forest habitat was not a major determinant of the occurrence of *T. sanguinea* because even with the presence of host species, *T. sanguinea* was markedly absent in some areas. For instance, no account of *T. sanguinea* was noticed in the Ogba Zoo and Nature Park, a wet tropical lowland rainforest in Edo State, despite the abundance of common host species like *Myrianthus arboreus* and *Musanga cecropioides* in the Park. Such a pattern of occurrence suggests that host plants appear not to be critical in the prevalence of *T. sanguinea* and also reflect the heterogeneity of the forest habitat as a whole. However, most *T. sanguinea* habitats were observed to possess good drainage with a moist-soft soil texture which allows for the upward growth of the inflorescence. *Thonningia sanguinea* population were found on several forest soil types in Southern Nigeria, comprising: dry sub group ferruginous tropical soil, wet subgroup ferruginous tropical soil, western sub-group ferralitic soil, central sub-group ferralitic soil, and southern sub-group ferralitic soil.

Sites habouring *Thonningia sanguinea* were marked by disturbances and hence they were always found growing on forest path or trails, forest edge, and secondary forests brought about by the conversation of the original forest vegetation to plantations. The recurrent incidence on forest edges and nature trails was constant in all locations and it reveals the preference of *T. sanguinea* for disturbed areas of the forest preferably, areas along forest margins with much sunlight penetration to the ground. Analysis of its phytosociology shows that the following plant species namely *Hevea brasiliensis, Cercestis* sp., *Harugana madagascariensis, Theobroma cacao, Rinorea braviracemosa, Anchomanes difformis, Musanga cecropioides, Strombosa grandifolia, Icacina trichantia, Adenia lobata, Smilax anceps, Myrianthus arboreus, Alchornea cordifolia,* and *Cleistopholis patens* were regularly found growing around the vicinity of *T. sanguinea*. Plant species association with respect to a particular species of interest can give insightful clues to the nature of the habitat. Most of the above listed associated species of *T. sanguinea* are "sun-loving" secondary forest indicator species (Martin 1991; Aubréville and Bossanyi, 2015; Oluwokudejo and Oyetola, 2016). Hence, this corroborates the earlier observed preference of *T. sanguinea* for disturbed areas of the forest environment. Ecroyd (1996) reported a similar pattern of habitat preference for *Dactylanthus taylorii* (Balanophoraceae) in New Zealand. The generalization of this unique pattern of habitat preference for members of Balanophoracae can only be affirmed in due course when the habitat characteristics of other members of Balanophoraceae are revealed.

CONCLUSION

The study has evaluated the distribution, habitat characteristics, and phytosociology of *Thonningia sanguinea* in Southern Nigeria. A total of 49 *T. sanguinea* populations were found parasitizing *Hevea brasiliensis*, *Theobroma cacao*, *Guarea cedrata*, *Lophira alata*, *Musanga cecropioides*, *Myrianthus arboreus*, and *Ricinodendron heudelotii*. Analysis of its habitat features indicated its preference for disturbed habitats along forest margins and nature trails. The phytosociological analysis revealed its close association with species such as *Cercestis* sp, *Harugana madagascariensis*, *Anchomanes difformis*, *Musanga cecropioides*, *Strombosia grandifolia*, *Icacina trichantia*, *Myrianthus arboreus*. The consistent presence of *T. sanguinea* along footpaths, the disturbed portion of the forest, and preference for key secondary forest re-growths species such as *Musanga cecropiodes* and *Myrianthus arboreus* as host, suggest it as a potential bio-indicator in predicting environmental degradation in a forested ecosystem.

Acknowledgments

This work was completely funded by the TETFUND 2017-2018 (Batch 12th) Research Project (RP) Intervention. The authors are grateful to the invaluable assistance provided by the management of the various National Parks and Forest Reserves. We also appreciate the efforts of Park Rangers that assisted in field sampling and data collections.

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