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FRUITS/SEEDS WEIGHTS, FLIGHT PATTERNS AND DISPERSAL DISTANCES OF SOME NIGERIAN RAINFOREST TREE SPECIES

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ABSTRACT

Fruits/seeds weights, flight patterns and dispersal distances of 17 plant families consisting of 30 tree species and 180 individuals were studied at the rainforests at Umudike and Oban Forest Reserve, Nigeria. The weight was measured using the Ohus Scout sensitive weighing balance; while the length and width of 30 fruits and 30 seeds of each tree species were measured using Digital Mitutoyo Japan Caliper. Cup anemometer was used in measuring wind speed. The flight pattern was observed using Audubon Swift binocular. A total of 33.33 percent of the tree fruits/seeds had dispersal appendages. Dust fruits/seeds were not observed. *Ceiba pentandra* had the furthest dispersal distance of 95.63 m because of it's possession of the silk cotton. *Pterocarpus soyauxii*, *Terminalia superba* and *Hildegardia barteri* had 89.70, 56.99 and 56.88 m, respectively. Weight of fruit/seed had a lot of adverse effects on the dispersal of plant fruits/seeds. A negative co-relationship existed between the dispersal distance and the weight of fruits observed. The plant species producing drupe fruits had a weight range of between 2.02 and 106.88 g. The drupe fruits dropped vertically down. Plant species having samara/capsule fruit types had a weight range of between 0.23 and 83.77 g. The weight and the position of the seed such as those of the genera *Entandrophragma* favoured helical trajectory at the general wind speed of between 0.1 and 3.0 $ms^{-1.}$ It was observed that many fruits such as those of *Milicia excelsa* have no dispersal appendage and dropped vertically down. It was observed that such a drupe, berry and achene fruits clustered under the crown of the dispersing tree. Such fruits depended on gravitational force, bats and animals for dispersal. These vertebrate animals were not frequently seen feeding on the fruits and most of the fruits fell vertically down due to gravitational force. Their entry to adequate microsites for seed germination and seedling establishment depended on chance. Most seedlings of the dispersing tree species under the crown of dispersing tree rarely establish and grow to pole size. There is the need for man to assist in the selection of adequate microsite best for each plant species' seed germination and seedlings' establishment or these plants species could become listed as endangered or rare. If the tropical rainforest is to survive, potential sources of desirable seeds are required for plant colonization of abandoned areas.

Keywords: fruits, seed, weight, flight pattern, dispersal appendage, helical trajectory, seed cluster.

INTRODUCTION

Many fruit bearing rainforest tree species produced flowers at least once in 15 months (Frankie, *et al*; 1974; Appanah, 1990; Dike, 2001). Some of these flowers were pollinated mainly by numerous bees, ants, butterflies, and other arthropods resulting in mass production of viable seeds. These mature seeds were dispersed in several directions. The dispersal distances depended mainly on the height of the tree, possession of adequate dispersal appendage, the direction of wind; the obstacles on the flight path; the weight of the seed and the architectural pattern of the branches (Ridley, 1930; Burrows, 1975; Dike, 2000). In spite of the numerous viable seeds produced and dispersed periodically, several authors have reported that the tropical rainforest of Nigeria is disappearing at alarming rate of between 3.0 and 4.0 percent per annum (Okali, 1979; Okojie, 1998) and many plant species were about to be lost (Okafor,1993). Janzen (1970) reported attacks on seeds by herbivores and, Dike (1992) reported that pangolins (*Manis* spp) fed on the seeds of the genera *Entandrophragma*. However, numerous seeds always escaped the attack and germinated while some failed to germinate and remained as soil seed bank.

Two types of ecological groups of plant species, the climax and the pioneer species have been classified (Swaine and Whitmore, 1988). Seeds of climax plant species germinated under closed forest canopy and most of the resultant seedlings remained as seedling banks. Most of such seedling banks remained without any appreciable height growth until a gap is formed above them. Oldeman (1978); Whitmore, (1983) and Dike, (1992), reported that many climax plant seedlings would remain for several years as seedling bank. During that period, many would die (Oldeman, 1978). Stone, *et a*l (1985) reported that seeds that germinated very close to the dispersing tree species would suffer for competition between each other and the parent plant for light and minerals. Seeds of most pioneer plant species often remained under closed forest canopy as soil seed bank awaiting the formation of adequate gap size above them to enable seed germination to occur. Dike (1992) working at the Strict Nature Reserve, at Etemi Oke in Omo Biosphere Reserve, Nigeria recorded simultaneous colonization in large gaps by seedlings of both climax and pioneer plant species. He observed that several plant species adopted different mechanisms for survival within large gaps. The plant species that are at the best microsites for establishment have high probability of occupying the gap. It appears that possession of adequate fruits/seeds dispersal appendage could assist the migration of tree species fruits/seeds into both the central portion of large tree fall gaps and different parts of abandoned farmlands.

There is the need to identify desirable economic tree species (Lancaster, 1961) that needed help during fruit/seed dispersal. Presumably, if assistance is rendered by introducing seeds at adequate microsite for germination and seedling establishment, their low adult density and uniform dispersion would not occur. This paper reports the effect of fruit/seed types on the dispersal patterns of some Nigerian rainforest tree species. The result will be useful to foresters and researchers who are interested in the regeneration potentials of some rainforest tree species away from the mother trees and some latent functions performed by forests such as carbon sink, transpiration of water vapour into the atmosphere and climate change.

MATERIALS AND METHODS

Study area

The study was carried out at the rainforests at the University of Agriculture, Umudike, Nigeria and the Oban Forest Reserve in Cross River State of Nigeria. Umudike lies between latitudes 5^0 27^1 and 5^0 32^1 N and longitudes 7^0 32^1 and 7^0 35^1 E. Oban Forest Reserve with an area of 3743 km^2 lies between latitudes 5^0 15^1 and 5^0 32^1 N and longitudes 8^0 14^1 and 8^0 34^1 E. These areas are in southeastern Nigeria. The climate is of the equatorial type. The temperature ranges between 19^0C and 34^0C. There are two seasons: a wet and a dry season. Each year, the wet season starts from mid-March and ends in mid-November. The dry season continues till the mid-March of the following year. The vegetation is the tropical rainforest (White, 1983). Most of the original rainforest areas have been logged and reduced to the status of secondary forest regrowths in various degrees of degradation. The abundant tree species are *Anthonotha macrophylla*, *Dialium guineense*, *Dactyladenia barteri*, *Elaeis guineensis* and *Piptadeniastrum africanum*. The soil is sandy loam and the soil parent material is the Pre-Cambrain basement complex.

METHODOLOGY

Thirty tree species were selected at the rainforest at the University of Agriculture, Umudike. The same thirty tree species were selected at Oban Forest Reserve (Table-1). Three fruit bearing individuals of each tree species were selected at both Umudike and Oban Forest Reserve. Each of the 180 individual tree species was marked with a numbered plastic tag. During the fruit/seed dispersal period, the flight pattern of the fruits and seeds were observed as they fall using Audubon Swift binocular, model no.804. For each tree species, the length and width of 30 fruits and 30 seeds were measured using a Digital Mitutoyo, Japan caliper. The length and width of each dispersal appendage were measured. The individual weight of 30 fruits and 30 seeds were measured with electronic sensitive weighing balance, Ohus Scout Pro, Model No. 402, Serial No. 7123071201. The dispersal distance was measured using a tape. Measurement was done from the dispersing tree to the point the fruit or seed fell on the ground. Any additional distance the fruit or the seed did by sliding was not included. Wind speed was measured using cup anemometer. The maximum and minimum wind speed per hour was recorded.

RESULTS AND DISCUSSIONS

All of the 30 tree species studied produced fruits and seeds whose length, width and weight could be measured easily. No dust seed (Burrows, 1975) was observed (Table-1). The fruit types were Capsules,(13.3%); Samaras,(23.4%); Legumes (13.3%); Follicles (16.7%), Drupes(13.3%); Berries (6.7%); Achenes (6.7%); Sorosis (3.3%) and Schizocarp (3.3%). The sizes of fruits and seeds varied. Trees having long fruits were *Pentaclethra macrophylla*, *Cola gigantea*, *Entandrophragma angolense*, *Mammea africana*, and *Hildegardia barteri* having 426.41, 198.13, 154.40, 128.75, and 77.15 mm, respectively. Trees having wide fruit width include *Cola gigantea*, *Pterocarpus osun*, *Mammea africana*, *Pentaclethra macrophylla and Entandrophragma angolense* having 161.54, 119.91, 117.74, 78.10, and 55.17 mm, respectively. The observation is similar to those of Dike, (2009). He recorded that *Pentaclethra macrophylla* had fruit length range of between 435.22 and 508.52 mm; fruit width range of between 70.97 and 78.21 mm and seed length and width ranges of 36.06 and 80.82; 30.31 and 47.70, respectively. Seeds of *Pentaclethra macrophylla* had a weight range of between 10.46 and 14.34 g. Within the same pod, seeds having small surface area would have lesser resistance than seeds with larger surface area. If the same force is used in dispersing seeds within a pod, seeds with smaller surface area would be dispersed further.

Within the tree species that have capsule fruits, *Ceiba pentandra* had the highest seed dispersal distance of 95.6 m and a mean of 60.53 ± 35.10 m. It was observed that the capsule of *Ceiba pentandra* exploded exposing several seeds each embedded in a silk-cotton. The silk-cotton enabled the seed having a weight range of between 0.05 and 0.09 g to float in the air. Sometimes, few silk-cottons were seen floating above the dispersing tree. However, all the observed silk-cottons that were soaked with water, dropped vertically down. The floating of the silk-cotton was not in any direction in wind speed less than 2.0 $ms^{-1.}$ However, in wind speed greater than 7.0 ms^{-1}, the silk-cottons were mainly floating towards the northeastern direction. Such a violent squall was observed by Swaine and Hall (1983) at Atewa Range Forest Reserve, Ghana. They reported that some silk-cottons were liberated into the air for a kilometer or more. Presumably, these were from several *Ceiba pentandra* trees. Capsules of *Entandrophragma angolense* and *E. cylindricum* exploded exposing winged seeds. It was observed that fruits of *E. angolense* did split at the base but remained joined at the apex. Consequently, many seeds were not released after the split. Some of the remaining seeds were gradually detached from the central column while some fell vertically down with the central column. The seeds that got detached performed a helical trajectory more especially at the prevailent wind speed of less than 3.0 ms-^{1}. At wind speed greater than 3.0 ms^{-1} spiral trajectory was observed. The maximum distance a seed of *E. angolense* was dispersed was 26.89 m while that of *E. cylindricum* was 21.37m (Table-1). In the northeast, northwest, southeast and southwest directions, there was no significance difference (p>0.05) in the dispersal distances of fruits/seeds of *E.angolense; E. cylindricum; Daniellia ogea* and *Hildegardia barteri* (Table-2), because for each plant species the seed was located at one end of the dispersal appendage (Hutchinson and Dalziel, 1954 - 72), Dike (2001) working at Oban Forest Reserve, Nigeria observed a similar poor flight pattern in the fruits of *Triplochiton scleroxylon* and the seeds of *Nesogordonia papaverifera* due to the location of the seeds. Seedlings of *Triplochiton sceroxylon* were abundant under the crown but very rare 30 m away from the edge of the crown. The capsule of *Hevea brasiliensis* exploded and the maximum dispersal distance was 13.44 m (Table-1). The distance is less than 50.0 m which was recorded for *Hura crepitans* (Swaine and Beer, 1977) presumably because of the relative heavier seeds of *Hevea brasiliensis* which ranged between 2.83 and 3.46 g with a mean of 3.14 g (Table-1).

Within the trees having samara fruits, the fruits of *Pterocarpus soyauxii* had the highest dispersal distance of 89.70 m. There is no significant difference (P> 0.05) in the distribution of fruits/seeds of tree species having samara fruits in the northeast, northwest, southeast and southwest directions (Table-3). The distance of 50.0 m recorded for *Terminalia ivorensis* at Atewa Range Forest Reserve, Ghana (Swaine and Hall, 1983) is similar to 56.99 m observed for *Terminalia superba* and 45.23 m for *Terminalia ivorensis* (Table-1). At wind speed less than 3.0 ms-^{1}, the location of the seed controls the flight. The fruit weight of *Terminalia* ranged between 0.21 and 6.63 g while the seed weight ranged between 0.07 and 1.01 g. Helical trajectory was observed. The tree species having legume fruits, most of the dried fruits exploded except those of *Distemonanthus benthamianus*. The fruits of D. *benthamianus* had the furthest dispersal distance of 52.11 m because the trees were bent. Although a loud noise was made when the fruits of *Pentaclethra macrophylla* exploded, it was only 28.19 m that the furthest seeds were thrown to (Table-1). A similar observation was recorded for *Bussea occidentalis* tree at Atewa Range Forest Reserve, Ghana. The heavily lignified pods exploded violently dispersing its seeds of about 4.0 g between 30.0 and 35.0 m away (Swaine and Hall, 1983). The seeds were not thrown at a specific direction (Table-4). It was observed that, in some exploded fruits of *Pentaclethra macrophylla* between 0.00 and 75 percent of the seeds remained attached to the fruits. Such remaining seeds fell vertically down because the seed has no dispersal appendage. The fruits weight ranged between 0.89 and 325.39 g while the seed weight ranged between 0.03 and 19.11 g. Although some rodents such as *Cricetomys gambianus* fed on these seeds, many seeds remained under the parent tree. These viable seeds germinated. The observation agreed with that of Janzen (1970); Dike, (1992) who recorded that some animals such as *Manis gigantean* and *Cephalophus* spp fed on seeds of the genera *Entandrophragma* and fruits of *Milicia excelsa*, respectively.

In tree species that produced follicle fruits, the farthest dispersed seed was that of *Pycnanthus angolensis* which was dispersed 16.59 m. It was observed that follicle fruits open from one side exposing their seeds. In some mature follicle fruits, such as those of *Sterculia rhinopetala*, each seed was attached to the fruit with a threadlike substance. It was mainly when the threadlike substance broke that the seed could fall. It was observed that in follicle fruits, the seed dispersal distance was often the horizontal distance from the centre of the plant to where the fruit was formed. Consequently, the range of the seed dispersal distance was between 8.11 and 16.59 m (Table-1). The distance was upto 16.59 m in some seeds that fell on other branches before falling on the ground. There was no significant difference (p>0.05) in the distribution of the seeds in the northeast, northwest, southeast, and southwest directions (Table-5). The fruit weight ranged between 3.02 and 216.0 g while the seed weight ranged between 0.16 and 3.79 g. In plant species producing any of these fruits, drupe, sorosis, berry, achene and schizocarp fruits, the fruits dropped vertically down because of lack of developed dispersal appendage. At Makokou, out of 172 plant species studied, it was only 13.95 percent that had winged fruits/seeds (Hladik and Miquel, 1990). In this study, it was only 33.3 percent of the tree species that had dispersal appendage. The maximum fruit dispersal distance of *Canarium schweinfurthii, Trilepisium madagascariensis, Xylopia aethiopica and Milicia excelsa* were 14.95, 15.02, 16.49, and 17.41 m respectively. Athough few bats and some duikers (*Cephalophus maxwelli, Cephalophus spp*) fed on the fruits of *Milicia excelsa*; many fruits were seen under the crown of the tree. It is also very difficult for a bat to fly away having a fruit in it's mouth. The observation agreed with that of Hladik and Miquel (1990). They recorded that animals formed 67.44 percent of the dispersal agent in an African rainforest. Gautier-Hion *et al*; (1985) working at Makokou also recorded that 40 vertebrate animals fed on fruits/seeds of 122 plant species. Swaine and Hall, 1983 recorded that plants having fleshy or arillate fruits which were dispersed by bats and birds formed 64 percent of 757 tree seedlings enumerated in their study at Ghana. These bats and birds are no longer as frequent in abandoned farmlands because of attacks by poachers; and the use of modern chemicals and traps. Dike (1992) working at Etemi Oke, in Omo Biosphere Reserve Nigeria observed that the droppings of these animals such as elephants (*Loxodonta africana cyclotis*); monkeys (*Cercopithecus* spp; *Cercocebus* spp) and birds (*Treron australis*) contained many seeds which germinated and the resultant seedlings competed with each other. He observed that these seeds although they were dispersed by these animals and have germinated, the resultant seedlings being clustered, rarely survived more especially during the drier periods of the year. Also, those fruits/seeds that adhered to the large birds and animals fell mainly where the animals were resting or hiding from poachers. Some birds were seen on branches of large trees such as *Ceiba pentandra*. Their droppings tend to be concentrated under the crown of each tree. Fruits of *Milicia excelsa* and *Nauclea diderrichii* must decay to release the seeds. The distribution of seeds in northeast, northwest, southeast, and southwest directions was not significant ($p>0.05$). However, there was significant difference between the species (Table-6). The tree species have different architectural patterns. Consequently, the horizontal distances from the point the fruit was attached to either the twig or the branch to the centre of the tree varied between plant species. A negative corelationship was observed between the dispersal distance and the weight of fruits recorded.

Most fruits and seeds were relatively heavy and fell vertically down. It is very difficult for many seeds to fly easily into the central portion of large gaps. The poor flight of fruits and seeds showed that seeds cannot even fly into distant abandoned farmlands. Many fruits/seeds within the rainforest are not easily transported by water because of their weight and tangles in the forest floor. The observation supports the report of Okafor (1993) that many plant species were about to be lost. Also it supports the finding of Oguntala *et al*., 2000; Meregini, 2005 who reported that between 30 and 115 Nigerian rainforest plant species were endangered. The observation also supports the report that most of the rainforest area are land capable of bearing forest but in various degrees of degradation (Okali, 1979).

CONCLUSIONS AND RECOMMENDATIONS

Except seeds of *Ceiba pentandra*, the fruits and seeds observed have poor dispersal appendages. Fruits and seeds were rarely dispersed for up to 100 m away from the center of the dispersing tree. The absence of dust fruits and seeds and the presence of low wind speed of between 0.1 and 3.0 ms^{-1} at 50 cm above the ground contributed to the difficulty of fruits/seeds of any of the observed tree species being blown up again once it has fallen on the ground.

It is recommended that adequate attention should be given to experiments on natural regeneration by universities and schools of Forestry. Assistance by trained foresters must be given to all tree species especially the emergent and upper canopy tree species in the dispersal of their seeds to proper micro-sites for seed germination and seedlings establishment. Animals rarely disperse these fruits/seeds adequately and timely. Many silvicultural experiments carried out in Nigerian rainforest such as the Group Method (Dike, 1992) failed to achieve their major objectives because of the delay in waiting for seeds to fly into the opening created. Consequently, seeds stored in the soil germinated and their seedlings occupied the opening. The undesirable plant seedling had the chance of competing with the desirable tree seedlings. If the seeds of the desirable plant species eventually fly in when a closed canopy has been formed, some of the seedlings of the desirable plant species would be forced to form seedling banks.

The idea that Forestry is a Swiss cheese should sink into oblivion if the tropical rainforest would survive and perform its functions satisfactorily. It is recommended that stated number of hectares should be planted up each year through natural regeneration and plantation methods. Moreover, urban Forestry should be encouraged in all countries but not by planting trees such as *Elaeis guineensis* and *Gmelina arborea* very close to road camber as it is presently being done in some developing countries.

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Table-1. Fruit/Seeds dispersal distances. Lengthens, widths and weight at the rainforest at Oban forest reserve, Nigeria.

Family/Sub-family			**Dispersal distance**		**Fruit**			**Seed**	**Dispersal appendage**	
			Maximum (m)	**Mean** (m)	**Length** (mm)	**Width** (mm)	**Weight range** (g)	**Weight range** (g)	**Length** (mm)	**Width** (mm)
Bombacaceae	Ceiba pentandra	capsule	95.63	60.53±3510	85.64	32.47	10.32-18.16(15.49)	0.05-0.09(0.07)	8.76	27.32
Euphorbiaceae	Hevea brasiliensis	capsule	13.44	9.60 ± 3.84	28.15	48.40	16.55-23.81(19.81)	2.83-3.46(3.14)	explosive	
Meliaceae	Entandrophragma angolense	capsule	26.89	18.00 ± 8.90	143.09	34.49	28.38-43.56(38.77)	0.12-0.63(0.48)	4.80	21.23
	Entandrophragma cylindericum	capsule	21.37	15.12 ± 6.26	154.40	55.17	64.35-80.20(78.82)	24-0.51(0.41)	60.44	21.08
Combretaceae	Terminalia ivorensis	samara	45.23	28.29 ± 16.95	34.91	12.03	0.18 -0.28(0.23)	0.07-0.11(0.09)	18.84	11.24
	Terminalia superba	samara	56.99	39.10 ±17.90	19.64	10.25	0.21-0.27(0.23)	0.07-0.13(0.78)	22.35	20.2
Caesalpiniodea	Daniellia ogea	samara	22.44	16.71±5.73	69.84	33.64	1.25-2.15(1.86)	0.61-0.83(0.78)	70.68	28.88
Fabaceae	Pterocarpus osun	samara	43.35	28.6±14.75	113.73	119.91	1.65-6.63(3.62)	0.25-1.01(0.49)	54.48	51.05
	Pterocarpus soyauxii	samara	89.70	61.70±28.01	64.68	83.89	0.32-0.87(0.54)	0.09-0.18(0.14)	41.57	34.10
Sterculiaceae	Hildegardia barteri	samara	56.88	33.06±23.82	77.15	19.77	0.47-0.56(0.51)	0.36-0.43(0.40)	50.34	23.48
Verbanaceae	Tectona grandis	samara	9.33	7.96 ± 1.38	27.34	17.46	0.66-0.80(0.74)	0.20-0.63(0.45)		
Caesalpiniodea	Brachystegia eurycoma	legume	32.14	23.55±8.59	117.12	39.46	16.39-20.05(17.67)	0.43-0.63(0.53)	explosive	
	Distemonanthus benthamianus	legume	52.11	33.28±18.83	110.70	36.97	0.89-1.55(1.08)	0.03-0.06(0.05)		
Mimosoideae	Pentaclethra macrophylla	legume	28.19	20.45±7.75	426.41	78.10	274.83-325.35(297.88)	13.42-19.11(15.63)	explosive	
	Albizia lebbeck	legume	14.44	11.73±2.72	144.25	40.92	0.74-2.96(1.72)	0.06-0.11(0.08)	explosive	
Fabaceae	Pterocarpus santalinoides	follicle	41.36	10.66±3.70	42.81	31.93	4.02-6.07(5.00)	0.65-1.82(1.33)		
Myristicaceae	Pycnanthus angolensis	follicle	16.59	12.20±4.39	36.36	21.09	3.28-5.22(4.33)	0.72-1.74(1.05)		
Sterculiaceae	Cola gigantea	follicle	14.58	11.52±3.06	198.13	161.54	35.50-216(90.77)	1.77-3.79(2.86)		
	Sterculia rhinopetala	follicle	9.81	8.66±1.15	57.57	28.10	3.02-3.84(3.09)	0.16-0.29(0.24)		
	Sterculia tragacantha	follicle	8.11	6.54±1.58	72.90	34.61	3.51-7.86(7.86)	0.65-1.82(1.25)		
Burseraceae	Canarium schweinfurthii	drupe	14.95	11.28±3.68	33.07	16.53	7.07-9.65(8.15)	2.05-2.50(2.27)		

Guttifera	Mammea africana	drupe	6.63	5.24±1.39	128.73	117.74	93.96-121.17(106.88)	7.38-32.75(17.61)
Guttifera	Garcinia kola	drupe	8.42	6.82±1.60	103.29	97.74	74.87-120(97.74)	3.80-6.04(4.93)
Simaroubaceae	Hannoa klaineana	drupe	14.50	11.67±2.84	20.02	13.67	2.51-2.88(2.86)	1.35-1.74(1.54)
Moraceae	Milicia excelsa	sorosis	17.41	13.69±3.72	65.57	16.29	6.11-10.79(7.19)	0.06-0.15(0.11)
Rubiaceae	Nauclea diderrichii	berry	9.08	7.36±1.73	55.5	89.65	13.86-23.85(16.55)	
Annonaceae	Xylopia aethiopica	schizocarp	16.49	12.42±4.07	59.68	6.40	0.35-0.69(0.51)	0.02-0.06(0.04)
Caesalpiniodea	Dialium guineense	achene	13.17	11.46±1.72	24.38	14.50	0.83-1.29(1.04)	0.11-0.59(0.40)
Moraceae	Trilepisium madagascariensis	achene	15.02	10.64±4.38	20.88	12.34	1.08-2.78(1.64)	0.43-1.25(0.85)
Loganiaceae	Anthocleista djalonensis	berry	12.09	10.42±1.68	28.96	23.29	5.71-13.36(7.24)	

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Table-2. The dispersal of tree fruits/seeds in different directions at Umudike, Nigeria.

		NE	SE	SW	NW	Mean
Entandrophragma angolense	capsule (samara)	9.10	16.45	11.75	12.56	13.97
Entandrophragma cylindricum	capsule (samara)	18.29	9.65	15.47	17.63	15.26
Daniellia ogea	samara	19.43	12.49	22.44	20.77	18.78
Hildegardia barteri	samara	19.65	29.54	23.94	15.96	22.27
Mean		16.62	17.03	19.90	16.73	17.57
F - LSD (0.05)						
Species	7.952					
Flight direction	7.952					

Table-3. The dispersal of fruits/seeds having samara fruits in the rainforest of southern Nigeria.

		NE	SE	SW	NW	Mean
Terminalia ivorensis	samara	14.76	18.54	45.23	20.76	24.82
Terminalia superba	samara	35.53	29.50	23.99	37.47	31.62
Pterocarpus osun	samara	15.05	23.65	35.65	24.15	24.63
Pterocarpus soyauxii	samara	34.67	46.30	42.42	33.80	30.30
Mean		25.00	29.50	36.82	29.05	30.09
F - LSD (0.05)						
Species	14.30					
Flight direction	14.30					

Table-4. The distribution of fruits/seeds having legume or capsule fruits at Oban forest reserve.

		NE	SE	SW	NW	Mean
Pentaclethra macrophylla	legume	19.79	14.56	28.19	20.09	20.66
Brachystegia eurycoma	legume	25.68	14.46	17.85	32.14	23.03
Distemonanthus benthamianus	legume	25.94	18.62	16.99	19.22	20.19
Albizia lebbeck	legume	9.01	10.16	14.44	11.18	11.20
Hevea brasiliensis	capsule	10.01	5.76	13.44	6.11	8.83
Mean		18.09	13.11	18.18	17.75	16.78
F - LSD (0.05)						
Species	7.28					
Flight distance	6.51					

Table-5. The dispersal of seed of some follicle fruits in different directions at the rainforest at Umudike, Nigeria.

		NE	SE	SW	NW	Mean
Cola gigantea	follicle	8.46	14.58	13.64	11.86	12.14
Sterculia rhinopetala	follicle	8.30	9.58	8.35	8.36	8.65
Sterculia tragacantha	follicle	8.05	5.86	7.70	6.46	7.01
Pycnanthus angolensis	follicle	6.59	9.85	11.58	11.37	12.35
Pterocarpus santalinoides	follicle	9.10	9.35	7.79	10.22	9.12
Mean		0.10	9.84	9.81	9.64	9.85
F - LSD (0.05)						
Species	3.29					
Flight direction	2.94					

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Table-6. The dispersal of nine fruits in different directions at the rainforest at Umudike and Oban forest reserve, Nigeria.

		NE	SE	SW	NW	Mean
Milicia excelsa	sorosis	14.10	10.49	10.87	17.07	13.13
Hannoa klaineana	drupe	9.49	12.44	11.69	10.89	11.13
Canarium schweinfurthii	drupe	9.12	8.93	7.88	10.28	9.05
Nauclea diderrichii	berry	7.60	8.69	9.08	8.58	8.49
Trilepisium madagascariensis	achene	12.22	6.26	9.64	14.29	10.60
Xylopia aethiopia	schizocarp	1.07	9.20	11.12	16.49	12.20
Garcinia kola	drupe	5.75	7.05	5.56	6.98	6.34
Dialium guineense	achene	11.25	12.16	9.86	9.78	10.76
Anthocleista djalonensis	berry	11.04	9.19	10.17	9.69	10.02
		10.29	9.37	9.54	11.56	10.19
F - LSD (0.05)						
Species	2.72					
Flight direction	1.81					

NE represented northeast
SE represented southeast
SW represented southwest
NW represented northwest