

Analyzing the Distribution Patterns of Nutmeg (*Myristica* spp.) in Busama Forest Area Using Quadrat Size Technique

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Abstract Trees in natural forests are scattered across and along altitudinal gradients. The mode of dispersion varies within a natural forest and is influenced by natural translocation phenomena of biotic and abiotic factors acting on the environment. It is understood that dispersion in a natural forest can be in random, uniform or clumped and assumed to be in random at a certain degree. This study was carried out in Busama forest area in a permanent sampling plot to describe the distribution pattern of trees within the forest area with *Myristica* spp. used because of its dominance within the forest. The index of dispersion technique was used to assess and analyze the distribution patterns of *Myristica* spp. where quadrat sizes are increased from 1m² to 2,500m² using Microsoft EXCEL to generate subplots within the PSP and f – test was used to test the significance of the departure or closeness of the distribution to randomness at $F_{0.01} \geq 1.36$ (at 1% level of significance). It was found that as the quadrat size increase the distribution pattern of *Myristica* spp. becomes random and also the population density increases but it is predicted that it will become random but in clumps ($F_{0.01} \geq 1.36$), as the quadrat size increased to about 200m² and above, there is a significant departure from the randomness of closeness. However, the distribution pattern of *Myristica* species in this case is general and can be applied to other tree species in other locales.

Keywords Random, Uniform, Clumped, Index of Dispersion, Quadrat Size, Permanent Sampling Plots

1. Introduction

In natural forests, the pattern of distribution is not consistent as different species are translocated through many methods including dispersal by people, wind, water and animals. Biogeographers have tried to understand the factors determining species distribution and they found that the dispersion and distribution of trees are affected by biotic factors, abiotic factors and social factors. “Biotic factors

includes any non – living chemical or physical factors in the environment, abiotic factors include climate which consists of sunlight, atmosphere, humidity, temperature, salinity and the social factors which includes land use and water availability”[1]. For the past 40 years, the ecologists have paid much attention to the problem of spatial distribution of individuals in a population and Morisita [17] published his technique of the analysis of the distribution pattern using the quadrat size as the sampling device. Scientists over the years have found that trees are distributed in different distribution patterns. The patterns include: random, uniform and clumped. Through the use of quadrat technique, “many indices which express the degree of aggregation or departure from randomness of distribution of individuals have been proposed” [5,9, 10,14,and 17]

“It is well known that statistical characteristics of the distribution of a given population may often be different when size of quadrat used is different” [10]. A large quadrat size reflects greater distribution away from randomness whereas a small quadrat size reflects a distribution close to randomness and clumped. According to Morisita [17], “such effects of quadrat sizes upon index values may have an influence due to: 1. the effect caused by the change of the average number of individuals per quadrat, 2. the effect of combining or splitting the clumps due to the increase or decrease of quadrat size.” The first effect is due to the influence of mean population density per unit area and the latter is due to the structure of the spatial distribution of individuals.

The method of using the quadrat size has been used as the sampling technique to the studies of plant distribution with the uses of indices. Many scientists have used this method to study the distribution pattern of plants and animal populations. However, there was one problem identified: Iwao [9] argued that “the index method was not applicable to animal population as it was seen that many insect and animals lay eggs in clusters and not singly and the larvae emerged tend to be either restricted in their mobility or gregarious to a certain extent.” Among those proposed

indices method, Morisita's [17] method was seen as a suitable way of measuring aggregation tendency because it is not affected by mean density [9]. In the plant population, the use of quadrat size relative to population mean is applicable as plants are subjected to different environmental gradients which affect their distribution pattern over time. The plants can be distributed either randomly, contagiously, uniformly or clumped. According to Abrahamson [1,2], "the individuals of a species can be randomly distributed across a community or they might be singly and regularly distributed throughout the community or they may be clumped."

Several studies have been carried out to find the distributional patterns for plants and animal populations. Lutes [13] summarized his findings that each of the distribution arises due to different population acting on individuals. Little [12] used Maps of ranges of tree species in North America where the maps were digitized for use in United States Geological Survey (USGS) vegetation-climate modelling studies and Shresta and Tokola [24] used cluster sampling techniques where they integrated the data from National Inventory, Aerial photographs and Thematic Mapper Satellite to compare different cluster designs. They used precision (sampling error) and efficiency (time and cost) technique as criteria to compare the cluster designs. Shresta and Tokola [24] found that the optimal distance between the plots within the cluster was much longer than in the present clusters (25 m), in which the 3 - plot cluster provided little additional information in comparison with a one - plot sample unit. Palmer [18] gave an overview of the ordination method where he stated that "quantitative community ecology is one of the most challenging branches of modern environmetrics." He argued that "community ecologists typically need to analyze the effects of multiple environmental factors on dozens (if not hundreds) of species simultaneously, and statistical errors (both measurement and structural) tend to be huge and ill behaved." Ricklefs [22] presented a report where the purpose of their field lab was to investigate how patterns of tree dispersion vary with size structure and species identification and how these patterns change with spatial scale.

The Myristicaceae family comprises about 19 genera including the *Myristica* genus with 400 known species and is native in Indonesia including Papua New Guinea. It has been widely cultivated in southern Asia, the West Indies, and Brazil for its seeds, which yield various spices, and for its timber. The fruit is a yellow drupe having a diameter of about 5 cm, popularly called the nutmeg apple, which splits into two halves, thereby revealing the seed surrounded by a fleshy outer coating. The most common nutmeg tree (*Myristica fragrans*) grows to a height of about 15 meters [24]. Apart from the uses of spice and timber production, the *Myristica* species are also used in oil, wax and soap productions [4].

This study contributes to the previous work done by Morisita [17] in dealing with non-random distribution, theoretically implying that "even if the individuals are distributed non-randomly over an area, the area may be

divided into small sub-areas of various sizes on each of which the individuals occurred therein are distributed randomly or uniformly" [17]. The research is fundamental to the ecological perspective, biogeography's perspective as well as forestry. It revises and extends the knowledge of ecologists in understanding spatial distribution and creating a further understanding to the biogeography's knowledge. In forestry, this study can be done for the volume of sawlogs (*i.e.*, 50cm diameter and above) to find how merchantable logs are distributed in the forest of commercial value for timber exploitation so that the interest parties concerned knows how the merchantable logs are distributed. Moreover, in the past years, forestry students have done research on the Busama forest area but they were more concerned with the timber volume. This report will analyze the distribution patterns of individual trees of *Myristica* species population, because in Busama Forest Area in terms of tree population density, it was documented from previous studies by Peki and Veisami [20] and forestry students in 2011 (through their FD 365 field trip) that *Myristica* species are the dominant species in terms of tree population density in the Busama Forest Area with the occurrence of *Myristica chalmersii*, *Myristica hollrungii*, *Myristica horsfieldia*, *Myristica irya*, *Myristica womersleyii* while a great proportion (approximately 82%) of the species of the *Myristica* species were not identified down to the species level.

This paper will specifically concentrate on *Myristica* species distribution, and it will set a benchmark for other researchers pursuing the same research to improve in later researches. Furthermore, will be using the data of tree positions collected from the 1 hectare Permanent Sampling Plot (PSP) established in 2010 in Busama Forest Area, the position of tree was used to describe the spatial distribution of *Myristica* species in the Busama Forest Area using the quadrat size technique as proposed by Morisita [17]. This research intends to document whether the increase or decrease in quadrat size will affect the index of dispersion by using different subplot sizes to analyze the distribution pattern of *Myristica* species. The methods and analysis of this study can also be used by forestry department to assess the distribution of volumes of tree species if further research is conducted into the distribution of all commercial species in a forest dividing them into sawlog and pulp log. Hence this kind of study also helps to understand the distribution patterns of any tree species, in a given forest area, e.g. in Busama Forest area, in terms of volume per hectare, it is dominated by *Pometia* species, but, in terms of individual tree population, it is dominated by *Myristica* species and this species is not logged, because the *Myristica* species does not grow to 50 cm and above, however, there are exception.

1.1. Objectives

The main objective of this research is to determine the distribution pattern of *Myristica* species in Busama Forest Area. Indirectly, the study will determine if the influence of

quadrat size upon index of dispersion have any influence on the distribution pattern of species and specifically looking at the following two effects:

- a) The effect caused by the change of the average number of individual per quadrat and;
- b) The effect of combining or splitting the clumps due to the increase or decrease of the quadrat size

2. Methodology

2.1. Study Site

The study was conducted in the Busama Forest Management area in the Salamaua Local Level Government (LLG) in Morobe Province, PNG. The eastern boundary is the coastline from the mouth of Buang River (coordinates 147° 50' 11" south, and 146° 50' 23" east of Buasi River) that extends from the mouth of the river ascending west to the narrowest part of the river to coordinates 147° 50' 14" south and 146° 50' 6" east, and there it extends south via a creek onto the main ridge. It links up a creek that flows down to Buasi River at coordinates 147° 50' 25" south and 146° 50' 11" east. From that point the southern boundary is the Buasi River which flows east into the Solomon Sea [21].

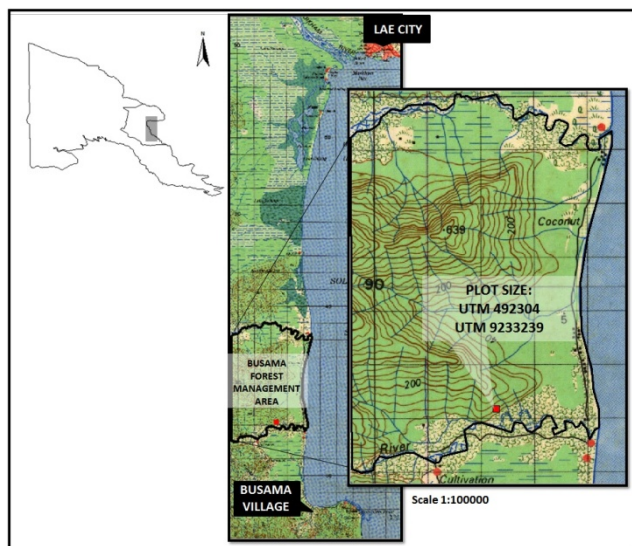


Figure 1. Map of Morobe Province showing location of Busama village and study site

The climate is moist, warm and fluctuating which is mainly caused by the topography of the area. The wet season starts from June to August and the dry season starts from September to January with April and May having a mixed season of both wet and dry periods. The area is a natural forest with slight disturbance due to human activities such as gardening and small scale logging. Due to these, there are few signs of canopy openings. The topography is hilly and steeply dissected (16 – 30%) with slope position from lower to mid slope and in rare cases some areas are very steep (30+ %) but it is accessible from the lower elevation area to

where the mid slope ends. The parent material is made up of sedimentary rocks (3 – 15%) [16].

The management area extends in elevation from 30 – 1,200 meters above sea level and covers approximately 5, 424 hectares. The study site itself located is 96 meters above sea level. From the data collected, *Myristica* spp., *Celtis* spp., *Protium* spp., *Pimeleodendron amboinicum*, *Dysoxylum* spp., *Endiandra* spp. and *Gnetum gnemon* dominated the forest area (about 67.1%/ha) with other tropical species across the forest. The sampling area was established where it had not been subjected to logging practices with no immediate land use plans by landowners and it will be easily accessible for future monitoring purpose. Over the past years, other researches were also carried out at the same site for forest mensuration and resources by the students from the Forestry Department of the Papua New Guinea University of Technology. The permanent sampling plot (PSP) showed minor signs of disturbance mostly due to subsistence activity.

2.2. Plot Design and Data Collection

Plot designs followed the standard PSP plot establishment and remeasurement strategy. Detailed information can be obtained from PSP plot establishment standards and procedures outlined by Romjne [23], A PSP Program to predict growth and yield in previously logged forest, Parts A – E. A 1 hectare (100m x 100m) permanent sampling plot was established at the study site with sides running along cardinal bearing. Each plot was subdivided into 25 quadrats of 20m x 20m each; with a numbering system to identify each (Fig. 2)

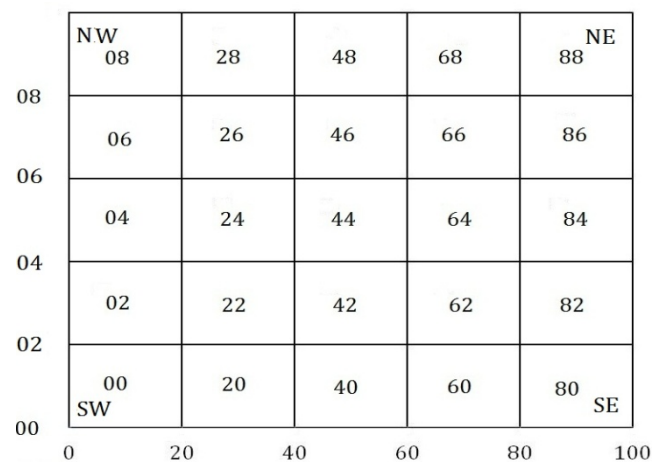


Figure 2. Design layout of the plot establishment(Source: [23])

Data collection included species identification, tree diameter, tree height, stem form, crown form, and their respective directional position (tree positions) coordinates (*i.e.*, easting and northing) within plot from south-west corner of the plot. Of the total number of species identified, *Myristica* spp. was analyzed because it was found to be dominant species in the study site. Tree positions were identified in each quadrat (25m x 25m) and their position

relating to their direction (*i.e.*, easting and northing) in the plot was added with their distance from zero at starting point going east and north at right angle from the plot boundary (Fig. 3).

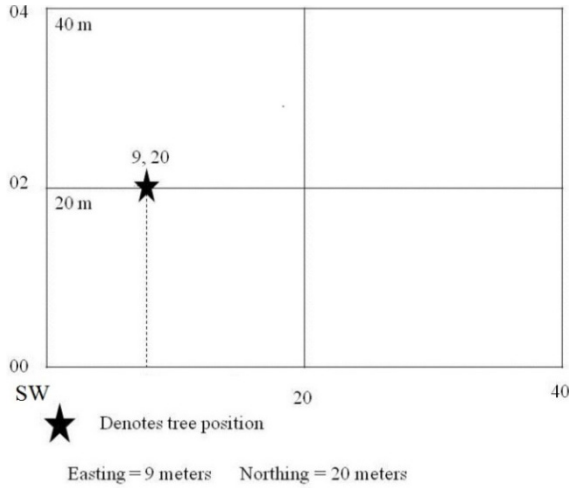


Figure 3. Tree position coordinates system

2.3. Data Analysis

2.3.1. Distribution of the number of tree species

Data collected in the field using the field data were entered into the Microsoft EXCEL worksheet and sorted according to the frequency of the occurrence of each species from the most dominant to least dominant on a per hectare basis.

2.3.2. Diameter distribution of *Myristica* spp

The distribution of diameter classes of *Myristica* spp. was divided into 10cm class interval with each midpoint at 0 and 20.49cm for diameter class of 10 -20cm, 20.5 – 30.49cm for diameter midpoint of class 21 – 30cm, 30.5 and greater for class of 31cm and above.

2.3.3. *f*- test values and the Dispersion of *Myristica* spp. at Different Spatial Scales

The data analysis followed previous published papers. A more detailed Index of Dispersion ($I\delta$) computation techniques can be found in Morisita [17]. The use of Microsoft EXCEL analysis techniques and *f*- test was used to document the level of distribution and significance of *Myristica* spp. using a standard table as shown in table 1 with formulas that follow.

The test for randomness of the individuals of *Myristica* spp. is assumed to follow a Poisson series (*i.e.*, n_1, n_2, n_3, n_q) therefore it is assumed to have a χ^2 - distribution with $(q - 1)$ degrees of freedom approximately.

Equation (1) was used to calculate the Index of Dispersion value;

$$I\delta = \frac{\sum_{i=1}^q ni(ni - 1)}{N(N - 1)} \quad (1)$$

Where $I\delta$ is a measure of dispersion of individuals where δ corresponds the unbiased estimation of Simpson’s measure of diversity, λ ; q is the observed number of quadrats; ni is the

individual *Myristica* spp. (*i.e.*, ni , where $i = 1, 2, 3, q$); N is the total number of *Myristica* spp. and is assumed to take a fixed value on average independently on δ ; and n is the number of individuals of *Myristica* spp.

Equation (2) was used to test for the significance of the departure or closeness to random distribution;

$$F_o = \frac{I\delta(N - 1) + q - N}{q - 1} \quad (2)$$

The significance of the departure or closeness from randomness of the distribution of *Myristica* spp. in the study site was tested by the comparison of F_o value with the value of F_{α}^{q-1} , where the value is equal to 1.36 at 99% confidence limit. If the F_o value is greater than the F value at 1% level of significance (*i.e.*, 1.36), then there is a significant departure, but, if the value of F_o is less than 1.36, then there is no significant departure.

Table 1. An example of the frequency distribution of individuals of *Myristica* spp. and the computation of the index of dispersion values for 1m x 1m plot size (Source: [17])

| Number of individuals (<i>n</i>) | Observed number of quadrat (<i>f</i>) | <i>fn</i> | <i>n</i> ² | <i>fn</i> ² |
|------------------------------------|---|-----------------|-----------------------|------------------------|
| 0 | 9932 | 0 | 0 | 0 |
| 1 | 67 | 67 | 1 | 67 |
| 2 | 1 | 2 | 4 | 4 |
| 3 | 0 | 0 | 9 | 0 |
| 4 | 0 | 0 | 16 | 0 |
| 5 | 0 | 0 | 25 | 0 |
| 6 | 0 | 0 | 36 | 0 |
| 7 | 0 | 0 | 49 | 0 |
| 8 | 0 | 0 | 64 | 0 |
| 9 | 0 | 0 | 81 | 0 |
| 10 | 0 | 0 | 100 | 0 |
| 11 & over | 0 | 0 | 0 | 0 |
| Total | 10,000 (<i>q</i>) | 69 (<i>N</i>) | | 71 ($\sum n^2$) |

Table 2. Frequency Distribution of the tree species in Busama Forest Area

| Family | Genus species | No. of trees/ha | % of trees/ha |
|---------------|----------------------------------|-----------------|---------------|
| Myristicaceae | <i>Myristica</i> spp. | 68 | 14.81 |
| Ulmaceae | <i>Celtis</i> spp. | 42 | 9.15 |
| Palmaceae | Palm spp. | 34 | 7.41 |
| Euphorbiaceae | <i>Pimeleodendron amboinicum</i> | 32 | 6.97 |
| Burseraceae | <i>Protium</i> spp. | 29 | 6.32 |
| Meliaceae | <i>Dysoxylum</i> spp. | 25 | 5.45 |
| Lauraceae | <i>Endiandra</i> spp. | 23 | 5.01 |
| Gnetaceae | <i>Gnetum gnemon</i> | 22 | 4.80 |
| Lauraceae | <i>Cryptocarya</i> spp. | 17 | 3.70 |
| - | <i>Medusanthera</i> spp. | 16 | 3.49 |
| Other Family | Others | 151 | 32.90 |
| Total | | 459 | 100 |

3. Results and Analysis

3.1. Distribution of the Number of Tree Species

Out of the 459 tree species, it was found that *Myristica* spp. was the dominant species among other species with a total percentage of 14.81% (table 2). Hence, the data for *Myristica* spp. was retrieved from the spreadsheet and tabulated separately from the whole data.

3.2. Diameter Distribution of *Myristica* spp

The majority of the *Myristica* spp. (about 62.32%) consists of diameters between the ranges of 10 – 20 cm diameter class, approximately 23.19% of the *Myristica* spp. population is from diameter class of 21 – 30cm and a considerable 14.49% consists of *Myristica* spp. of diameter class 31cm and above as shown in table 3.

Table 3. Distribution of the Diameter Classes of *Myristica* spp. in Busama Forest.

| Species | Diameter Distribution (% of trees/ha) | | |
|-----------------------|---------------------------------------|-----------|-------|
| | 10 - 20cm | 21 - 30cm | 31cm+ |
| <i>Myristica</i> spp. | 62.32 | 23.19 | 14.49 |

3.3. *f*- test Values and the Dispersion of *Myristica* spp. at Different Spatial Scales

The *f*- test values of all *Myristica* spp. of diameter class 10 -20cm are less than the F_o value at 1% level of significance.

Since the *f*- tests values are less than the value of F_o at 1% level of significance, it can be said that there is no significant departure from random expectation and the distribution is said to be at random. The *f*- test values of all *Myristica* spp. of diameter class 21 -30cm are less than the value of F_o at 1% level of significance from 1m² to 100m². Hence, it can be said that there is no significant departure from random expectation and the distribution is said to be again at random. However, at quadrat size 200m² to 400m², the *f*- test value was greater than the value of F_o at 1% significance level hence from 200m² to 400m², there is a significant departure from random expectation. At 2,500m², the *f*- test value decreased dramatically to less than the value of F_o at 1% level of significance that there is no significant departure

from random expectation and the distribution is said to be at random again. The *f*- test values of *Myristica* spp. of diameter class 30cm and above are less than the F_o value at 1% level of significance from 1m² to 80m². However, at 100m², 200m² and 400m², the *f*- test values of *Myristica* spp. was greater than the value of F_o at 1% significance level. However, at 2, 500m², the *f*- test value of *Myristica* spp. decreased to below 0. Since the *f*- test values of *Myristica* spp. are less than the value of F_o at 1% level of significance from 1m² to 80m², it can be said that there is no significant departure from random expectation and the distribution is said to be at random. However, from 100m² to 400m², there is a significant departure from random expectation. At 2,500m², there is no significant departure from random expectation and the distribution is said to be at random again. For the overall result of *Myristica* spp., the distribution was at random as the *f*- test values of *Myristica* spp. was smaller than the value of F_o at 1 percent level of significance and as the subplot sizes increased from 50m² upwards, the distribution departs from random expectation as the *f*- test values of *Myristica* spp. was larger than the value of F_o at 1 percent level of significance. At 2500m², the distribution is at random again as the *f*- test value is smaller than the value of F_o at 1 percent level of significance (table 4)

For diameter class 10 – 20cm and 31cm and above, they showed distribution patterns at 8m² and above. For diameter class 21 – 30cm, the *Myristica* spp. individuals showed distribution patterns at 25m² and above. Generally, for the three different diameter classes (*i.e.*, 10 – 20cm, 21 – 30cm and 30+cm) that were analyzed, they all showed contagious distribution with large intra – clump distribution in uniform at some point when the quadrat size increased. Overall, the values of the $I\delta$ for all *Myristica* spp. were large when the subplot size was small at 1m². As the subplot sizes increases, the $I\delta$ value decreased approaching unity. It can be said that the distribution of the individuals of *Myristica* spp. is at random with intra-clump distribution as the $I\delta$ values for various quadrat sizes showed a contagious distribution with large intra - clumps (fig. 4a and b)..

Table 4. *f*- test of values of *Myristica* spp. in Busama forest

| Distribution of <i>Myristica</i> spp. Popu.(cm) | Quadrat size (m ²) | | | | | | | | | | | | |
|---|--------------------------------|------|------|------|------|------|------|------|------|------|------|------|-------|
| | 1 | 2 | 4 | 8 | 16 | 20 | 25 | 50 | 80 | 100 | 200 | 400 | 2500 |
| 10 – 20 | 1.00 | 1.00 | 0.99 | 0.98 | 1.05 | 1.13 | 1.12 | 0.89 | 1.09 | 1.04 | 1.00 | 1.35 | 0.74 |
| 21 – 30 | 1.00 | 1.00 | 0.99 | 0.98 | 1.13 | 0.97 | 0.96 | 1.13 | 1.13 | 1.35 | 1.46 | 1.42 | 0 |
| 31+ | 1.00 | 1.00 | 1.00 | 1.00 | 1.31 | 1.18 | 1.18 | 1.16 | 1.13 | 5.56 | 1.84 | 1.67 | -0.01 |
| Overall | 1.02 | 1.04 | 1.03 | 1.10 | 1.12 | 1.18 | 1.09 | 1.39 | 1.15 | 1.16 | 1.42 | 1.70 | 0.79 |
| F at 1% Level of significance = 1.36 | | | | | | | | | | | | | |

their growing character in which Minderovic [15] found that it could only reach a height of 20 meters at the age of 8 and bear fruit indicates the *Myristica* spp. to be an adult tree at an early stage which might have affected Peki and Veisami's [20] results in terms of volume per hectare. Since *Myristica* spp. is suited from lowland forest to mid montane forest, this could be the likely reason that *Myristica* spp. is dominant in Busama forest. Parthasarathy [19] also found that *Myristica* spp. is generally found in great density in primary forest that is not subjected to logging; however, the specific estimation of the density is not stated. In general, this can reflect the greater number of *Myristica* spp. in Busama forest which is a primary forest not subjected to logging activities.

4.2. Diameter Distribution of *Myristica* spp.

From PSP plots established by FRI, it was found that not all *Myristica* spp. reach 50cm or above [21], hence, the *Myristica* spp. is abundant from 10 – 20cm in diameter and decreased dramatically as the *Myristica* spp. grows older. Within the natural forest, other tree species grow as well among each other hence it may be due to the competition among other tree species for light and nutrients. The conversion of forest to sustainable agricultural activities sustains the livelihood of the locals may have also influenced the growth of the *Myristica* spp. trees. In the event of clearing the forest, *Myristica* spp. individuals may have been felled. Harvesting of trees for building material is another likely factor that may have contributed to the fall in population of *Myristica* spp. in their late growth stage. From data collected, the study area is evidenced to show slight disturbance due to human activities such as gardening and small scale logging. Due to the action of dispersion modes, the diameter classes (*i.e.*, 10 – 20cm, 21 – 30cm and 31+cm) were dispersed widely in large clumps. Studies done by Minderovic [15] found that *Myristica fragrans* reach heights of about 20 meters and bears fruit at the age of 8 years. The tree (*Myristica fragrans*) itself is found to be a spice. Her study can relate to this study that at the height of 20m and the age of 8 years, it is already a matured tree hence the diameters from 10 – 20cm is so abundant and only a few select managed to go beyond 31+cm in diameter. As a source of food spice, they may have been destroyed for spice extraction.

4.3. *f*- test Values and the Dispersion of *Myristica* spp. at Different Spatial Scale

The *f*- test values and the index of dispersion for diameter distribution of *Myristica* spp. indicates that random distribution was achieved when the subplot sizes were large. As the plot sizes increased, the distribution tends to be contagious with intra-clump distribution in uniform for each diameter class (*i.e.*, 10 – 20cm, 21 – 30cm and 31+cm). However, at the largest subplot size possible, the distribution tend to be random again, however, still distributed contagiously in large clumps.

As with the *f*- test values of the individuals of *Myristica*

Figure 4. a; A graph representing the Index of Dispersion values of *Myristica* spp. in the Busama Forest Area; b, Schematic representation of the individuals of *Myristica* spp. in the 1 hectare permanent sampling plot.

4. Discussion

4.1. Distribution of the Number of Tree Species

According to Eddowes [6], *Myristica* spp. is generally distributed all over Papua New Guinea from lowland flood plains and lowland hills to mid montane forest. A study done by Karnataka [11] on the characterization of soil properties from fresh water swamps and adjoining evergreen forest area found that swamp forest are also a good environment to shelter *Myristica* spp. Asgarpanah and Kazemivash [3] also found *Myristica* spp. to be a spreading aromatic evergreen tree usually growing to about 5 to 13 m high, occasionally 20 m. Previous study done by Peki and Veisami [20] in Busama forest also found *Myristica* spp. to be the second dominant species after *Pometia* spp. in terms volume per hectare, however, it could be possible that the increase in the volume of *Pometia* spp. is due to them being able to grow into large diameters, hence, there could be less number of *Pometia* spp. trees per hectare, however, there will be a significant number of *Myristica* spp. exceeding the *Pometia* spp., but, due to

spp., the trend indicates that quadrat size affect the distribution pattern. When the sizes of quadrats were small, individuals of *Myristica* spp. were distributed randomly or close to random expectation at least approximately. As the quadrat size increases, the spacing between the distributions of the individuals became large therefore affecting the distribution pattern. It was, however, at the largest quadrat size possible that the individuals of *Myristica* spp. were at random. As argued by Morisita [17], the larger the quadrat become, the more the index of dispersion value approaches unity, regardless of whether they are in clumps is supported in this research. As can be seen above (figure 4a and b), the pattern is more or less a negative sigmoid curve or at least it shows for the overall *Myristica* spp. distribution. This shows that the distribution of *Myristica* spp. individuals approaches random distribution as the quadrat size increases and supports the two effects that the mean population density in each quadrat area is changed when the quadrat sizes are increased or decreased and the effect of combining or splitting the clumps resulted in a random distribution where as the sizes increase, the *Myristica* spp. individuals were distributed in large clumps contagiously, but, in random.

5. Conclusions

In this study, *Myristica* spp. dominated the Busama Forest Area by approximately 14.8% (table 2) consisting mainly of *Myristica* spp. population of diameter class 10 – 20cm in great abundance (62.32%) (table 3). The f – test values showed a trend especially in diameter classes 21 – 30, 31+cm and also the overall population of the *Myristica* spp. individuals. Random distribution was achieved when the quadrat size was small. Midway at some point in the increase of quadrat size (from 200m² to 400m² for 21 – 30cm, 100m² - 400m² for 31+cm and 50m² - 400m² for the overall *Myristica* spp. population), the distribution departs from random expectation and at the largest quadrat size possible (*i.e.*, 2, 500m²), random distribution was achieved again. However; the diameter class 10 – 20cm showed random distribution from the smallest quadrat size possible (1m²) to the largest quadrat size possible (2, 500m²) (Table 4). The usefulness of the quadrat size technique was not effectively demonstrated practically as the distribution was not as expected at random, but, was intra-clumped due to the individuals of *Myristica* spp. being contagiously distributed in large clumps (Fig. 4a and b). When the *Myristica* population was divided into diameter classes (*i.e.*, 10 – 20cm, 21 – 30cm and 31+cm), they all showed contagious distribution in uniform and in large intra – clump at some point in the increase of quadrat size (*i.e.*, 10 – 20cm and 31+cm showed distribution patterns at 8m² and 21 – 30cm showed distribution patterns 25m²). Combined together, they still showed contagious distribution in large intra – clumps, however, in random distribution (Fig. 4a and b). This may have resulted from this study using only one species (*i.e.*, *Myristica* spp.) to analyze the spatial distribution. However, as previously mentioned in the

objective, this research was intended to document the distribution patterns of *Myristica* spp. in Busama Forest Area and random distribution of *Myristica* spp. was, however, achieved.

Acknowledgements

The authors would like to thank unanimous people for the invaluable critics, advice and the reviewing and editing of the manuscript. The authors would also like to extend their gratitude to the Forestry Department for the release of funds for the FD 365 field trip for data collection in 2011, and staff of the department who assisted in this trip includes late Mr. Eric Asari, Mr. Artis Vinas and Mr. Leonard Wana for the mentoring and supervising, the locals of the Busama village for providing guiding assistance during the course of the field trip and the 3rd year forestry class of 2011 who helped in the set up of the permanent sampling plot (PSP) and data collection.

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