

Research Article

An Assessment of Nypa Palm (*Nypa fruticans* Wurmb) Stand Dynamics in the Douala-Edea National Park, Littoral Region, Cameroon

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Abstract

Nypa palm (*Nypa fruticans* Wurmb) is a monotypic monocot genus belonging to the family Palmae or Arecaceae that grows in the soft muddy banks of brackish tidal portions of rivers; and forms the transition between mangrove and freshwater swamps. The purpose of this study is to investigate the distribution and stand density of Nypa palm categories in the study area. Geographic locations and elevations of the selected sample sites were obtained in the field and used as a reference material for the production of a geo-referenced sample location map from where the samples were collected. ESRI Arc GIS version 10.1 Software were used for this process. Ropes were used to establish square plots of 20 m X 20 m established on a selected stratum. Another subplot of 10 X 10 m was established inside the 20 X 20 m plot. Within the subplot of 10 X 10 m, another subplot of 5 X 5 m was established. Four 1 X 1 m plots will then be establish at the extremes of the 10 X 10 m plot. The number of Nypa palm present within the plots were counted and number of fronds per palm within the plots were also counted and recorded by the team for all 15 plots. Classification was based on frond numbers and four developmental stages. The study reveals that Nypa palm populations were found in the more brackish mangrove forest strips, situated further inland and away from the direct exposure to pure seawater. The results revealed higher amounts of seedlings individuals. It competes and poses a threat the indigenous mangrove species in the area. Hence, the spread of this palm should be checked due to its negative impact on native's mangroves and adverse effect it poses to climate change.

Keywords

Classification, Distribution, Nypa, Stand, Structure

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1. Introduction

The genus *Nypa* is monotypic with *Nypa fruticans* being its only species. It is one of the most ancient angiosperms and probably the oldest species of palm [20]. It can grow up to 10 m tall, and differs from most palms in that it lacks an upright stem. Instead, it has a thick, prostrate, rhizomatous stem that branches dichotomously underground. New plants grow vegetatively from each branch, often creating dense monospecific stands. The terminal shoot supports a cluster of erect, pinnate leaves, of which the alternating leaflets are lanceolate and numerous (30-40 per leaf). It is monoecious and the flowers are dimorphic. The female inflorescence is globular while the male inflorescence is catkin-like. Flowers develop into fibrous chestnut-brown fruit that form large drooping spherical infructescences [20].

Nypa is a monocious and pleonanthic palm; it also exhibits viviparous germination [22] as in many other mangrove species. The leaves of *Nypa* palm can grow up to 10 m, and arise from a dichotomously branched underground rhizome that grows to about 50 cm in length [20]. The species lacks a visible upright trunk, and the leaves appear from the ground. The diameter of the cluster could be up to 75 cm and a single leaf may attain a height of 8 m. The mature crown may contain 6 to 8 living leaves and 12 to 15 bulbous leaf bases at a time [19]. It grows along coastlines and estuarine habitats in the Indian and Pacific Ocean. It is a stem-less palm with tall erect fronds and underground rhizomatous stem [23] possessing an extensive root system, well suited to resist swift running water [24].

According to UNEP-WCMC/UNEP, (2007) the *Nypa* palm (exotic species) which was introduced from Asia has colonized several areas and competes to a significant degree with the indigenous mangroves such as *Rhizophora* spp. It is native to Singapore and was introduced in Nigeria in 1906 to control erosion is reported to have spread across extensive areas replacing native *Rhizophora* as observed by [4, 6-10, 12, 25].

Nypa palm (*Nypa fruticans* Wurmb. *Arecaceae*) is an important component of the East Asian mangrove vegetation. It is one of the oldest living palms [26, 27]. In Bangladesh, the natural distribution of *Nypa* Palm is restricted to the 'Sundarbans', the largest single continuous tract of mangrove forest in the world [28, 29].

Compared with soils under mangrove species, *Nypa* soils have higher bulk densities [30-34] which impair penetration of the soil by roots, thereby limiting propagation to the rhizomes of the *Nypa* while other species are excluded. *Nypa* saplings, being more vigorous in growth than mangrove propagules, eventually dominate the secondary succession and take over the former mangrove habitat. In this way *nypa* becomes ecologically more important, and has achieved dominance due to the low taxonomic diversity of the Nigerian mangrove swamps and also the species ability to deal with continually changing salinities [30, 32].

Today, *Nypa* has colonized large areas along the coastline

of the Bight of Biafra, particularly in brackish and sheltered tidal areas such as river deltas - areas where the dicotyledonous mangrove species are more commonly found. The species has now established itself as far south as the Wouri Estuary near Douala, Cameroon and westwards to Lagos. Unfortunately, this colonization has considerable ecological implications. It has been observed that *Nypa* is a highly opportunistic species and the dense monospecific stands that the species forms are out-competing the indigenous mangrove vegetation. This opportunism is exacerbated by the fact that much of the mangrove forest of Nigeria and Cameroon is being felled to provide fuel wood for smoking fish for commercial sale. The resulting exposed mudflats are ideal colonization areas for *Nypa*, and the indigenous mangroves are unable to re-colonize the areas [17, 18, 35].

It is considered native to China (Hainan region), the Ryukyu Islands, Bangladesh, India, Sri Lanka, Andaman and Nicobar Islands, Myanmar, Cambodia, Thailand, Vietnam, Borneo, Java, Maluku, Malaya, the Philippines, Sulawesi, Sumatra, the Bismarck Archipelago, New Guinea, the Solomon Islands, the Caroline Islands, Queensland, and the Australian Northern Territory. It is reportedly naturalized in Nigeria, the Society Islands of French Polynesia, the Mariana Islands, Panama, and Trinidad, Japan's Iriomote Island and its neighboring Uchibanari Island are the most northern limit of the distribution [5].

Nypa was introduced into West Africa in the early 1900s, specifically, Oron 4.8°N 8.2°E (Nigeria) in 1906 and Calabar (Nigeria) in 1912. It has now spread westwards along the coast down to latitude 4°E. By the early 1990s, *nypa* had been recognized as a serious invasive 'weed' [33, 34, 36].

In Cameroon, *Nypa* has colonized large areas along the coastline of the Bight of Biafra, particularly in brackish and sheltered tidal areas such as river deltas areas where the dicotyledonous mangrove species are more commonly found. The species has now established itself as far south as the Wouri Estuary near Douala, Cameroon and westwards to Lagos [1]. The purpose of this study is to investigate the distribution and stand density of *Nypa* palm categories in the area.

2. Method

2.1. Description of Study Area

The Douala-Edo National Park is situated Latitude (3°14' 3°50'N) and longitude (9°34'10°03' E). Some 75 km south west of Douala in the Districts of Mouanko and Manoka in the Littoral Region within the Douala-Kribi basin of the coastal Atlantic Ocean and it stretches for 100 km along the Cameroon coastline [38]. The climate of the park is the equatorial type characterized with four seasons. The park has a bi-modal climate type. There is abundant rainfall ranging from about

3000-4000 m and generally high average monthly temperatures ranging from 24-29 °C and generally very high humidity [38].

Located in the coastal plain, it extends from the Atlantic coast to a maximum distance of 35 km, its eastern limit following the Dipombe River. The park is made up of two unequal parts: the largest, in the South, is between the mouths of Sanaga to the North and Nyong to the South; the other extends along the northern coast of Sanaga to Souelaba Point and is bounded on the east by Kwa Kwa Creek. Mouanko is a town and community in the Sanaga maritime area, lying on the north bank of the Sanaga River in the Littoral Region of Cameroon [37].

80% of the park is covered by tropical lowland equatorial forest and 15% by Atlantic mangrove forests. The Park between the Sanaga and the Wouri estuary holds about 15,000 hectares (37,000 acres) of mangrove forests [40].

The Douala-Edéa national park is lowland with a complex creek-crossing drainage system. The biggest water surfaces are river Sanaga, river Kwa-Kwa, river Lote, river Mouaha and Lake Tisongo. The average altitude is 0-50 m above the sea level and rarely above 100 to 120 m. [38]. Soils are alluvial rich in silt from river Sanaga and associated origin [37]. The main activities of the coastal populations and along the rivers are the fishing and arable crop production [39].

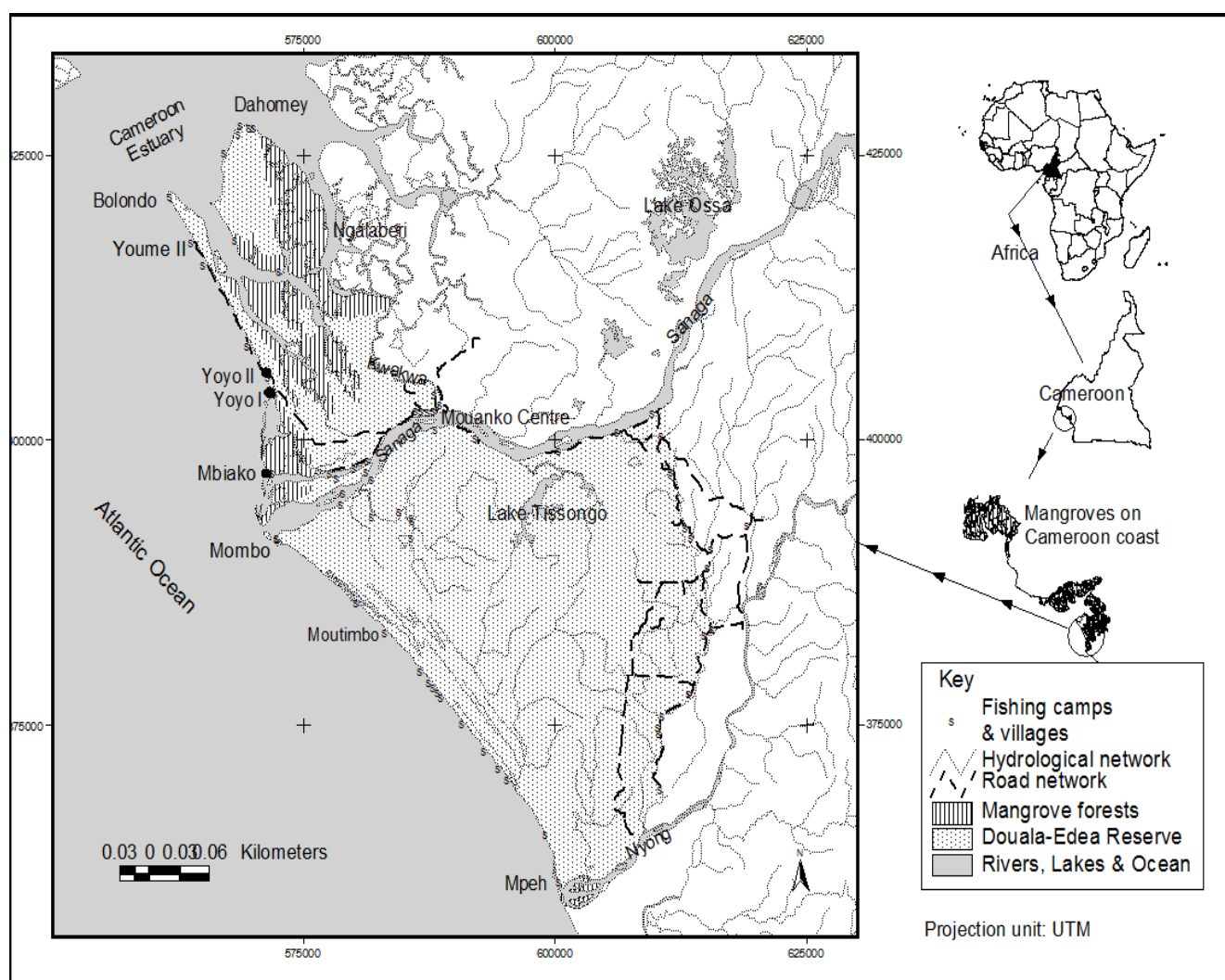


Figure 1. Location of the mangroves of the Douala-Edea national park Cameroon and study Areas [2].

2.2. Method

Purposive random and opportunistic sampling was used to identify and establish plots. A total of 15 plots of 20 X 20 m each were opened in the three study areas, that is 5 plots in

Yoyo I, 5 in Yoyo II, and 5 in Mbiako. Due to the diversity of this ecosystem, square nested plots were used [3]. Thus, square plots of 20 m X 20 m were established within *Nypa* palm vegetation.

Geographic locations (Longitudes and Latitudes) and elevations of the selected sample sites were obtained in the field

with a portable Garmin GPS Maps 86, Global Positioning System (GPS). This data will be used as a reference material for the production of a geo-referenced sample location map from where the samples were collected. ESRI Arc GIS version 10.1 Software were used for this process.

Ropes were used to establish square plots of 20m X 20 m established on a selected stratum. Another subplot of 10 X 10m was established inside the 20 X 20 m plot. Within the subplot of 10 X 10 m, another subplot of 5 X 5 m was established. Four 1 X 1 m plots will then be established at the extremes of the 10 X 10 m plot. The number of *Nypa* palm present within the plots were counted and number of fronds per palm within the plots were also counted and recorded by the team for all 15 plots. Classification was done for each individual based on frond numbers and four developmental stages were investigated following [19]; Seedlings: from small individuals with one intact leaf to plants with three

leaves, Juveniles: a stage with four to seven larger leaves, Adults: individuals with eight to fourteen leaves, with or without reproductive organs, Mature: individuals with fifteen and more leaves, with or without reproductive organs. The average was obtained by summing the plot biomasses and divide by the number of plots. They were later converted to per hectare and reported [13, 14].

3. Results

3.1. *Nypa* Palm Distribution and Stand Structure

The map below (Figure 2), shows the spatial distribution pattern of *Nypa fruticans* in three communities and fifteen study plots.

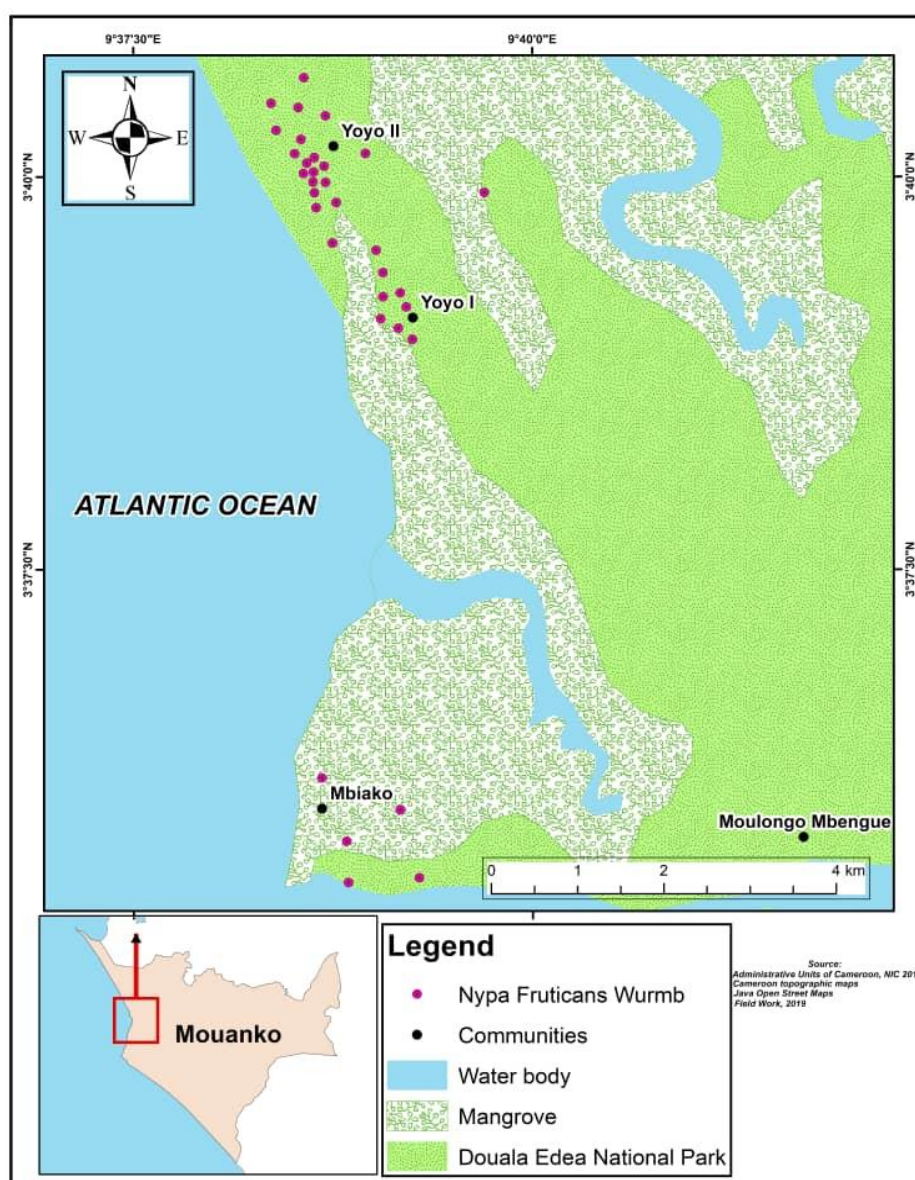


Figure 2. Map showing distribution of *Nypa* palm in Yoyo I, Yoyo II and Mbiako.

The distribution patterns in all stages was random, regular or clumped, though clumped distribution seems to be the main pattern for this species. In Yoyo I community, *Nypa fruticans* distribution was regularly. The distribution was clumped in Yoyo II Community whereas in Mbiako, the palm was randomly distributed. *Nypa* palm populations were found in the more brackish mangrove forest strips, situated further inland and away from the direct exposure to pure seawater. The results show that *Nypa* palm clusters vary across communities. The distribution of the palm in the study area was greater in some areas than others with *Nypa* palm count in Yoyo I (311)

41.75 % of the total count in all 15 plots followed by Yoyo II community (238) 31.95% mean while the lowest number of counts were recorded in Mbiako community with (count of 196) 26.31%.

3.2. *Nypa* Palm Stand Density

Based on processing of field data collection, Information on *Nypa* palm stands within the sampled areas on number of palms and frond numbers is presented below;

Table 1. Information on *Nypa* palm stands within the sampled areas.

PLOT NUMBER	Number Of Palms (20 X 20 m)	Number Of Fronds (20 X 20 M)	Number Of Fronds (Per Ha)	Number Of Palms (Per Ha)
plot 1	68	353	8825	1700
plot 2	57	332	8300	1425
plot 3	77	415	10375	1925
plot 4	57	354	8850	1425
plot 5	52	351	8775	1300
plot 6	68	338	8450	1700
plot 7	49	306	7650	1225
plot 8	41	258	6450	1025
plot 9	49	216	5400	1225
plot 10	31	228	5700	775
plot 11	50	389	9725	1250
plot 12	32	262	6550	800
plot 13	21	103	2575	525
plot 14	36	259	6475	900
plot 15	57	302	7550	1425
SUM	745	4466	111650	18625
AVERAGE	49.666667	297.7333333	7443.333333	1241.66667

The average number of *Nypa* individuals is estimated at about 1242 palms per hectare. With the highest value per hectare derived from Plot 3 and Plot 13 has the lowest average number of *Nypa. fruticans*. On the other hand, the average number of *Nypa* palm fronds is estimated at about 7443 fronds per hectare.

Plot 3 has the highest number of palms 77, followed by plot 1 and 6 and Plot 13 has the lowest average number of *Nypa. Fruticans*. Based on processing of field data collected, the average number of *Nypa* individuals is 50 palms within 20 x 20 m plots.

The amount of fronds was directly proportional (relatively) to the number of individuals of *Nypa* with plot 3 recording the highest number of 415 fronds while plot 13 had just 103 fronds (except at Plot 11 where frond numbers were high and plot 9 were fronds were low in relation to number of *Nypa* stands. With an average number of fronds within 20 x 20 m area given as 298 fronds. The number of fronds was directly proportional (relatively) to the number of individuals of *Nypa* (except at Plot 11 where number of fronds were high and plot 9 were fronds were low) (Table 1).

3.3. Individual Distribution of the Palm

The results show that *Nypa* palm individuals vary across communities. The distribution of categories of the palm in the study area was greater in some areas than others with *Nypa* palm seedling in Yoyo I recording 133 out of the total count of 307 seedlings in all 15 plots while Yoyo II had 108 seedlings and Mbiako only had 66 seedlings. Yoyo I community also recorded highest number of juvenile counts with 92 out of 226 juveniles whereas Yoyo II had 70 counts and Mbiako 64 juveniles. Yoyo I community also recorded highest number of individuals in the adult stage with a count of 67 whereas Yoyo II had 43 counts and Mbiako 37 adults. Meanwhile, the highest count of mature individuals were recorded Mbiako community with 29 out of 65 mature individual counts whereas, Yoyo I had a total of 19 mature stands while Yoyo II recorded lowest mature counts of 17.

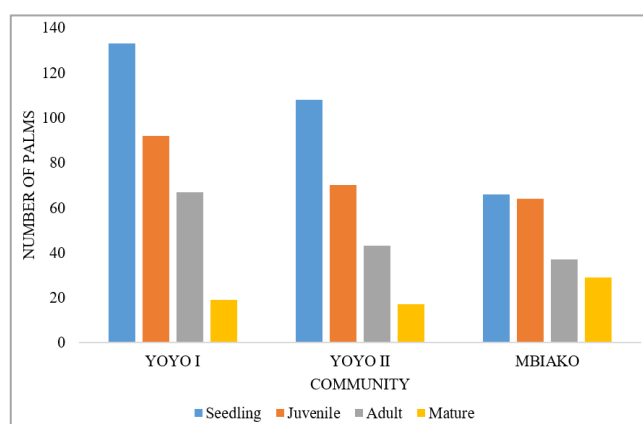


Figure 3. Distribution of the palm across sample communities.

A total of 311 counts were recorded in Yoyo I, 238 in Yoyo II and 196 in Mbiako as seen above (Figure 3). As indicated above *Nypa* palm categories (seedling, juvenile, adult) were higher in the two communities of Yoyo I and Yoyo II whereas the amount of mature *Nypa* palm in Mbiako was higher than in Yoyo I and II.

Table 2. Individual distribution of the palm across sample plots.

S/N	Seedling	Juvenile	Adult	Mature
plot 1	23	30	15	0
plot 2	25	21	8	3
plot 3	40	16	17	4
plot 4	24	9	18	6
plot 5	21	16	9	6
plot 6	41	17	3	7

S/N	Seedling	Juvenile	Adult	Mature
plot 7	23	14	8	4
plot 8	16	13	9	3
plot 9	26	9	14	0
plot 10	2	17	9	3
plot 11	0	24	15	11
plot 12	14	8	3	7
plot 13	13	6	2	0
plot 14	17	7	3	9
plot 15	22	19	14	2
Sum (20 x 20 m)	307	226	147	65
Sum per hectare	7675	5650	3675	1625
Average per hectare	511.6667	376.6667	245	108.3333

Plot 6 has the highest number of seedling, while Plot 11 has the lowest number of *Nypa fruticans* seedlings. The average number of *Nypa* seedling in the sampled area is estimated at about 512 palms per hectares (Table 2).

For the juvenile category, Plot 1 had the highest number while Plot 13 had the lowest number of *Nypa fruticans* juveniles. The average number of *Nypa* juveniles in the sampled area is estimated at about 377 juveniles per hectares (Table 2).

While for the adult category, plot 4 recorded the highest number while Plot 13 had the lowest number. The average number of *Nypa Fruticans* adults in the sampled area is 245 palms per hectares (Table 2).

Plot 11 had the highest number of matured palms and plot 13 had the lowest number of *Nypa Fruticans* matured palms. The average number of matured palm in the sampled area is 108 palms per hectares (Table 2).

4. Discussions

The distribution patterns in all stages was random, regular or clumped, though clumped distribution seems to be the main pattern for this species. In Yoyo I community, *Nypa* appears regularly and too clumped as it's the case with Yoyo II Community whereas in Mbiako, the palm is randomly distributed. This distribution is similar to that of Roazainah & Aslezaeim, [19], who concluded that, all stages except seedling stage showed a combination of random, clumped and regular distribution patterns during her study on the "demographic study of a mangrove palm, *Nypa fruticans*, Carey Island in Malaysia".

The findings of this research tie with that of several authors such as Theerawitaya *et al.*, [21]. Giesen *et al.*, [41], Jian *et al.*, [42], who studied *Nypa* palm populations around the world in

areas such as China, Thailand, Japan and Vietnam and noted that *Nypa palm* populations were found in the more brackish mangrove forest strips, situated further inland and away from the direct exposure to pure seawater and in mangrove areas with calm conditions and a high freshwater input.

The average number of *Nypa* individuals is estimated at about 1242 clusters per hectare. With the highest value per hectare derived from Plot III (1925) and Plot XIII has the lowest (525) number of *Nypa. fruticans*. Which is in line Matsui *et al.*, [15, 16] were the lowest clusters ($n=29$; 725 clusters/ha) in Kovit's farm, whereas Sompong's farm had 42 (1,050 clusters/ha) and Yong Yot's farm had 40 (1,000 clusters/ha) making Cluster density in this study range between 725 and 1,050. And Roazainah and Aslezaeim, [19] who stated that natural *Nypa* stands have a density range between 1,025 and 6,400 clusters per hectare.

On the other hand, the average number of *Nypa palm* fronds within a plot of 20 m x 20 m is estimated 278 fronds that is 7443 fronds per hectare. Which is lower than 542, that is, 13,550 fronds per hectare [16]. The amount of fronds was directly proportional (relatively) to the number of individuals of *Nypa*. More individuals of *Nypa palm*, then the more fronds can be found in the field at each plot. Which corresponds to results from Matsui *et al.*, [16] on "*Nypa (Nypa fruticans Wurmb)* Sap Collection in Southern Thailand".

The results revealed higher amounts of seedlings and amounts dropped as the specie matures in the areas complying with the primary rule of seed dispersal and acts as key factors that impact on the distribution of any population. Many studies showed a 'reverse J' structure or pyramid shaped distribution i.e. higher proportion of younger or early life stages than in older or later life stages [11, 43]. But contrary to Roazainah & Aslezaeim, [19] were *N. fruticans* were subject to being washed away by the daily high water. Therefore, the results indicated a 'J' structure, that is, seedlings were almost completely absent from the population of this species but the adult and mature stages showed the highest proportion. As the plants grow older, competition for resources like sunlight and space might contribute to the decreasing number of mature stage compared to adult stage.

5. Conclusion

This study investigates the distribution patterns of *Nypa palm (Nypa fruticans)* within brackish mangrove forest strips, which are situated further inland from areas directly exposed to pure seawater. The findings reveal a significant correlation between proximity to saline environments and the reproductive success of *Nypa palm*, as indicated by the higher densities of seedlings observed in these regions. This emphasizes the importance of salinity in the growth and propagation of *Nypa palm*. As *Nypa palm* matures, its biomass increases, potentially leading to the competitive exclusion of native mangrove species. This phenomenon poses a considerable threat to the biodiversity and ecological integrity of the mangrove eco-

system, highlighting the need for proactive management strategies to address the implications of *Nypa palm* proliferation.

To mitigate the potential adverse impacts, several management strategies are recommended. First, establishing a comprehensive monitoring program will allow for the assessment of *Nypa palm*'s distribution relative to indigenous mangrove species. This data is crucial for understanding the dynamics between *Nypa palm* and native flora. Management efforts should focus on controlling the spread of *Nypa palm* through selective removal and restoration initiatives aimed at re-establishing native mangrove species. These actions will help maintain the ecological balance within the mangrove ecosystem. Finally, engaging local communities in these management efforts is essential for promoting awareness and fostering sustainable practices. Additionally, encouraging further research on ecological interactions will provide valuable insights that can inform and enhance management strategies. By addressing these areas, we can work towards sustainable management practices that protect the health of mangrove ecosystems and ensure their long-term viability.

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Author Contributions

Guilen-Noel Nghokapin Tataw, Athanasius Fuashi Nkwatoh and Kamah Pascal were responsible for conceptual contributions and research design. Guilen-Noel Nghokapin Tataw, Pascal Bumtu, Dongang, Ceraphine Mangwa and Londe Roland Lemlack were responsible for data collection and analysis. Guilen-Noel Nghokapin Tataw is the principal researcher and wrote the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

Authors have declared that no competing interests exist.

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