"Science Stays True Here"
Advances in Ecological and Environmental Research (ISSN 2517-9454, USA), 1-20 | Science Signpost Publishing

Introduction, Distribution and Drivers of Non-native Mangrove Palm *Nypa fruticans* Van Wurmb (Arecaceae) in Cameroon, Gulf of Guinea

MOUDINGO, J-Hude[1,2*], AJONINA, Gordon[2,3], DIBONG, Didier[3,4], TOMEDI[3], Minette

1. Département de Biologie des Organismes Végétaux, Faculté des Sciences, Université de Douala, B.P. 24157 Douala, Cameroun.

2. Cameroon Wildlife Conservation Society P. O. Box. 54 Mouanko, Littoral Region-Cameroon.

3. Département d'Aquaculture, Institut des Sciences Halieutiques, University of Douala, B.P. 2701 Douala, Cameroun.

4. Department of Geosciences and Environment, Faculty of Sciences, University of Douala, P. O. Box. 24157 Douala, Cameroon.

Received: May 05, 2018 / Accepted: June 12, 2018 / Published: January 25, 2019

Abstract: In this paper, we investigate *Nypa fruticans* Van Wurmb (Arecaceae), a native plant from the indo-pacific, introduction, dispersal, drivers, invadability and distribution in Cameroon's mangrove and its shoreline, Atlantic Gulf of Guinea. The study used a combination of observation (qualitative) approach including naïve and scientific. Desk research and interpretative document analysis were the main research methods that guided the finding, selecting, and rigorous examination of Nypa palm invasion process.

Hence, we found that historically Nypa have been wildly distributed and with re-introduction in the Gulf of Guinea. Today, over 10 Guinea Current Large Marine Ecosystem countries harbours *Nypa* at varied scale, of which in Nigeria's all the coastal and marine line (nine states) served as the fundamental niche. We equally hypothesis that the species has been present in Cameroon's Marine and Coastal line alongside its mangrove ecosystem since First World War period. No single Cameroon mangrove block was Nypa palm free. Hence, the study provided evidences that *Nypa* dispersed was currently present in many localities and future spread because of climatic factors, paucity in policy and institutional framework, taxa and habitat characteristic, land use and socioeconomic practices. Dispersal mechanism was through barochory, hydrochory and anthropochory likely its invadability upper rate was 175 Nypa palm/ha/year. We suggest further research on biophysical impacts and possible management scenarios of Nypa palm.

Key words: Mangrove ecosystem, fundamental niche, *Nypa fruticans*, invasion, Gulf of Guinea

Corresponding author: MOUDINGO, J-Hude, Département de Biologie des Organismes Végétaux, Faculté des Sciences, Université de Douala, B.P. 24157 Douala, Cameroun. Email: M_ekindi@yahoo.fr

1. Introduction

Disturbed ecosystems are particularly vulnerable to invasion by plant species. Mangrove like the terrestrial ecosystem faced the challenge of intentional or unintentionally introduction of non-native or invasive species. This are usually studied under the themes “Invasion biology” (Davis 2011) or ‘biological invasion’ (Richardson 2011).

Current taxonomic status of mangrove, revealed that there are six indigenous woody species of which most were described (Letouzey 1968; Valet 1973) and one introduced species of mangroves in the Gulf of Guinea (Saenger and Bellan 1995; Sunderland and Morakinyo 2002; UNEP 2007; Spalding et al. 2010; Ajonina 2016). The species introduced, Nypa palm (*Nypa fruticans*), has been diversely reported and described (Hamilton and Dennis 1988; Balick and Beck 1990; Päiväke 1996; Teo et al. 2010). Actually, Nypa palm natural current range was only confined within the tropical Indo- West Pacific region (FAO 1994; Ellison et al. 2010; Lovly and Merlee-Teresa 2016). For Duke (2006), it may be due to the change in climatic conditions which might have cause triggers the loss of resourceful genotypes that can tolerate wider environmental conditions. Nypa palm are found in mangrove coastal environment, muddy estuaries or shallow lagoons and brackish freshwater swamps (Walsh 1974; Tomlinson 1986) compare to other palms (Lovly and Merlee-Teresa 2016). In Malaysia, for example Fong (1982) noticed that Nypa palm thrived in simple or complex channel tributaries. It has been reported to be naturalised recently in Panama and Trinidad (Bacon 2001; Dransfield et al. 2008; Ellison et al. 2010; Lovly and Merlee-Teresa 2016) and in the Central-West Africa marine and coastlines (Sunderland and Morakinyo 2002; Ukpong 2007; Ajonina 2016). Bacon (2001) suggested that each country near to Nigeria, which a fundamental niche, or sharing same biogeography with should check the routes and rates of dispersal. Even, though the IUCN Red List of Threatened Species present *Nypa fruticans* as least concerned, the largest natural stands is found in Indonesia (7000 km^2), (Flach and Rumawas 1996; WAC 2011) and in Nigeria its occupying over 820 km^2 (GISD 2015).

Information’s of introduction, spread and impacts by Nypa palm exists and are well documented for Nigeria mangrove (Bacon 2001; Isebor et al. 2003; Ukpong 2007; Akpan et al. 2016; Ibel 2016) compare to its situation in Cameroon. The period of Nypa palm entry into Cameroon’s mangrove is uncertain, drivers’ parenthetically and current distribution are unknown and more speculative. Moreover, little or no detail empirical research has been conducted on revealing Nypa palm status in Cameroon. Globally, reports by the Cameroon Government (MINEPDED 2014; MINFOF 2014; MINEPDED 2017) and some researchers (Ajonina 2008; Ajonina et al. 2010; Tening et al. 2013; Moudingo et al. 2017) have incidentally and inadequately talked on Nypa palm. Worst till, in the Cameroon’s National Biodiversity Strategies and Action

Plans (NBSAP II 2012) information on non-native or invasive species is dearth. Whereas, literature on managing plant invasions is very rich and contains a diversity of concepts including, Prevention, Eradication, Control and Early Detection as described by Davis (2011). Hence, to manage Nypa palm invasiveness and invadability, there are prerequisites knowledge in the Cameroon context (Moudingo et al. 2015) such as introduction, drivers and current/potential future distribution that are necessary before embarking in any approach to management. This paper is amongst the many series, which will be published on Nypa palm (*Nypa fruticans*-Wurmb) in Cameroon, of which it's in line with Cameroon's master research plan developed in 2014, the Guinea Current Large Marine Ecosystem (GCLME 2005) recommendations, CBD/ Aichi Biodiversity Targets (Target 9) *per se*.

Target 9: By 2020, invasive alien species and pathways are identifed and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.

2. Materials and Methods

Location and general description of study site

Cameroon (475 000 km^2) is located at the extreme north-eastern end of the Gulf of Guinea and lies in the Bight of Biafra between Longitudes 8^0 and 17^0E and Latitudes 2^0 and 13^0 N. The Cameroon coastal area which span from the Equatorial Guinea border (Campo River, $2^0 20^{'}$N; $9^0$30'E) and Nigerian border in the north (Akwayafe River, $4^0 40^{'}$N; $8^0$15'E). Our study area straddled on regions namely Southwest, Littoral and South. Cameroon maritime and coastal zone (15,400 km^2) has been fully described in Ibe et al. (1999) and MINEPDED (2017). Henceforward, This area lies within the Atlantic Ocean with its continental shelf island, the exclusive economic zone and the Coastal fresh water and brackish wet lands ramified by an astonishing network of rivers and creeks, the beaches and dunes, mangroves, coastal plains, river deltas and estuaries, lagoons, swamps, coastal forests, watersheds. Special regards will be across five coastal divisions namely Ndian, Fako, Wouri, Sanaga Maritime and Ocean with marine and coastal area.

These low-lying coastal area water bodies are characterized by very dense rivers and periodic tidal variations and ranges along water channels. These differences depend on the hydrological properties and the slopes of the various channels. Most of the time, all these rivers and streams discharges in the Atlantic Ocean.

The climate of Cameroon is inter-tropical (hot, moist and dry conditions) and is usually dominated in the south region by the equatorial type. Climate difference at various locations is determined by the proximity to either the sea or the altitude like the Mount Cameroons hills in the South west region. The coastal areas of the

south receive most of the rainfall; with annual totals reaching 3850 mm or more (the World's most humid spot is located in the area of Mount Cameroon, with over 9400 mm annual mean rainfall). Temperature varies greatly along the marine and coastal line depending where are in the South, Littoral or south west region. The population concentration is highest in the Cameroon estuary (with town like Douala, Limbe, etc.) while other are have spare population.

Study species

Basic information about palms and its taxonomy has been catalogued and reported diversely by Tomlinson (1979); Balick and Beck (1990); Ellison et al. (2010). Palms family (Palmea or Areaceae) have over 180 genera and 2300 species (Tomlinson 1979; Dransfield et al. 2008). Palms are among the few monocots families with woody tissues (Riffle 2008). It has been hypothesized that some of these species amongst which Nypa palm to originally be distributed in four continent (tropical Africa, Asia, Europe and America) (Duke 2006; Dransfield et al. 2008) and the oldest of palms encountered (Päiväke 1996). Todaya, Nypa palm found on all continent (Ellison et al. 2010; GISD 2015).

Hereafter, Nypa (*Nypa fruticans*, Wurmb.) with stemless appearance (shrubby meaning fruticans) (Duke 2006) has horizontal creeping stems known as rhizomes, growing underground and is a monotypic and only species under subfamily Nypoideae (Tomlinson 1986; UNEP 2007; Dransfield et al. 2008; Spalding et al. 2010; Lovly and Merlee-Teresa 2016) and considered to be a mangrove species as well. In its natural range, the species occurs in tidal or semi tidal forest and rain forest margins especially Indo-pacific block (Ellison et al. 2010).

Mangrove Palm: *Nypa fruticans* or *Nypa fructicans* - known as the Attap Palm (Singapore), Nipa Palm (Philippines), and Mangrove Palm or Nipah palm (Malaysia) - grows in brackish water. Its fruit is in the form of an impressive spiky head, about the size of a "soccer ball", which breaks up after it ripens. Nipa (*Nypa fruticans*) is a monoecious palm with special characteristics. **Leaves:** A palm with large fronds can be up to 9 m long. **Flowers and Fruit:** Flowers are yellow and arranged in a clump on a stalk. The seeds which make up the buoyant fruit are dispersal by water. **Similar species:** None.

Research designed

Nypa was incidentally captured in Ajonina (2008, 2016) but somewhat buttress in Moudingo et al. (2017). The study used a combination of observation (qualitative) approach including naïve and scientific observation but active as defined by Amin (2005). A desktop review of article of Nypa per se. This was due to the fact that the researcher collected and examined numerous secondary data such as previously published articles, public

reports (Amin 2005; Creswell 2009; Narayanan 2015) related to mangrove. Multiple views from different scholarly materials to highlight mangrove ecology and its species like Nypa palm were highlighted by the researchers, hence the adoption of the qualitative research approach for this research. Also, the visual texts (Denzin and Lincoln 1994) and data were used analysed and comprehend Nypa palm stage of invasion and future distribution.

Travis (2016) opines that desk research seeks to thoroughly analyse secondary data and these are from the internet, online databases, published reports, information from Government agencies and magazines. This is exactly what the researchers did to gain a broader and deeper interpretation of Nypa introduction and spread under study. The interpretative document analysis process (Amin 2005; Hefferman 2013) that is guided by the essential factors, namely, authenticity, credibility, representativeness before the final stage of deducing the meanings illustrated in the examined documents. The researcher commenced the analytical process by scrutinising the documents severally to gain the overall representation of their contents (Creswell 1998) and summarization of the main ideas (Peshkin 1993). Finally, the facts were evaluated and presented in a persuasive write-up to accentuate comprehensive understanding (Denzin and Lincoln 1994) of Nypa palm ecology in Cameroon.

3. Results and Discussion

Introduction or spreading in West-Central Africa (the Gulf of Guinea): review

Many authors (Sunderland and Morakinyo 2002; Ukpong 2007; Dransfield et al. 2008; Ellison et al. 2010; Akpan et al. 2016; Ibel 2016) have revealed the status of Nypa palm following its successive introduction more than a century ago, from the first point, the Cross River Estuary, Nigeria. Nypa was transported and outplanted in different localities (planted along the ldua Oron beach in 1912) between 1906 and 1945 (Bacon 2001; Ukpong 2007; Isebor et al. 2003). Some area outplanted or transplanted even enjoyed protection from colonial administration while other did not. Nypa palm is present, widespread and abundant throughout most mangrove areas and its associated littoral forest in Nigeria (Saenger and Bellan 1995; Ukpong 2007; Akpan et al. 2016).

The question by Sunderland and Morakinyo (2002) as to “Why was Nypa palm introduced to Africa?’ found its answer given by Bacon (2001) and Ukpong (2007). Presumably it was to either to check erosion in the coastal, for aesthetic beauty and or to provide income locals. Before and after the two world wars, over 6000 Nypa palm seeds (GISD 2015) were intentionally introduced and outplanted in many sites. As from 1950, it is believed that the species spread essentially by hydrochory (tides waves) exacerbated by ship navigation to other suitable pristine mangrove ecosystem site. Nypa palm has become invasive and is considered a pest and

weed (Sunderland and Morakinyo 2002; Ellison et al. 2010). Today, the impacts, possible economic value of Nypa in Nigeria are known (FAO 1994; Ukpong 2007; Ibel 2016).

In most state Nigeria, Nypa palm stand most have reached homeostasis. Nevertheless, it was intentionally introduced *de facto* with no risks analysis or assessment management. Intentional as proposed by Courtesy (2006), meaning that actions should been done for a purpose or with knowledge. No prior knowledge was available to understand its ecology. Nypa is significantly widespread in numerous locations across 09 states (according to the 1 October 1999 repartition). This situation of Nypa presence goes along the presence native mangrove species (*Rhizophora*, *Avicennia*, etc.) (Ibel 2016). Thus, *Nypa fruticans* has been looked as problem in Nigeria mangrove forest (Akpan et al. 2016). Before 2011, the original idea of Nypa clearance or eradication has been not possible so it was reformulated after the project hiatus to a "wise-use" alternative (Humphrey and Gordon 2012; Akpan et al. 2016; Ibel 2016).

Current distribution of Nypa palm in the Gulf of Guinea

Nypa palm do not occur in Eastern Africa Mangrove where *Rhizophora racemosa* don't occurs. Presently, Nypa palm occurrence is beyond first intentionally introduced country, Nigeria. After a century, Nypa is widespread and in certain countries floating fruits and seeds are visible along the shorelines. Some authors (CAB International 2004; Humphrey and Gordon 2012) reported that most mangrove ecosystem of these countries at the Gulf of Guinea are already infested and as species time stages ranging from pioneering (lag-introduction and spread) to expansion (scattered but numerous locations) as proposed by (Shigesada et al. 1995). Eleven (11) out of sixteen (16) countries of the Guinea Current Large Marine Ecosystem (GCLME) are already infested (Table 1) with probably few to numerous location or patches harbouring Nypa palm stands. Eradication might be possible when the species is spotted in little localities compare to when it has reached saturation (widespread) but homeostasis like in Nigeria's mangrove ecosystem (Akpan et al. 2016).

Table 1 Distribution of Nypa palm and seeds pressure status across the Guinea Current Large Marine Ecosystem (GCLME) countries

Country	Nypa palm state	Dispersal means	Authors
Sierra Leone	Present	?	CAB International (2004) & Humphrey and Gordon (2012).
Senegal	Present	?	
Nigeria	Widespread (saturation)	hydrochory & anthropochory	
Mauritania	widespread	hydrochory?	
Ghana	Present	hydrochory?	
Cameroon	widespread	hydrochory & anthropochory	
Equatorial Guinea (Island & mainland)	Present and Floating fruit (seed)	hydrochory	
Gabon	Floating fruit (seed)	hydrochory	
Congo Brazzaville	Floating fruit (seed)	hydrochory	
Congo	Floating fruit (seed)	hydrochory	
Angola	Floating fruit (seed)	hydrochory	

Period and Pathway of entry of Nypa palm into Cameroons mangrove

Nypa palm seeds escaped from the Cross Rivers state, Nigeria and entered fishing camps in and around the Rio del Rey mangrove, Cameroon. The first introduced and out planted points of Nypa palm is known and approximately less than 10 km (James town -Akwa Ibom State) and 300 km (Oloibiri Town -Bayelsa State) with respect to Cameroons bordering fishing camps like Jabena (Bakassi Peninsular), Uzama fishing camp (Akwabana Island), etc.. Proximate climatic similarity, mangrove habit and its margins-effect location favoured Nypa palm escape into Cameroon marine and mangrove ecosystem.

Usually, first flowers of Nypa palm occurs between three (03) and five (05) years after germination, and its fruit matured 5-9 months (Lovly and Merlee-Teresa 2016). Nypa palm completes growth, maturity and fruits production takes approximately five (05) years. It is possible, therefore, that Nypa palm following its life cycle, was already present in "*Kamerum*" (under Germany administration) and spread further (under British and French after 1915) in estuaries, island and peninsular (e.g. Jabane, Akwa yafe River, Rio del Rey, etc.) and mangrove between 1914-1918, period of the First World War (WWI) or early enough. After, the WWI, it was only then that Nypa palm effective presence was noticed. This explanation is line with unreliable source hypothesis that Nypa palm entered around the 1950s and that of Mbog (person com. 2016) which was to be in the early 1970s. Floating seed or fruit released and escape from the Nigeria stands between 1906 and 1912, first of all seeded from individual to many before became a stand noticeable. Probably limited knowledge on mangrove impeded the noticing and reporting of the presence of Nypa palm.

Afterwards, it spread south up to the Cameroon mangrove and associated forest estuary as noticed by (Din 1995; Saenger and Bellan 1995; Sunderland and Morakinyo 2002; Ajonina 2008; Ellison and Strickland 2010; Humphrey and Gordon 2012; Moudingo et al. 2015, 2017). Rio del Rey mangrove block was probably the first Nypa palm saturated zone, while other site became increasingly susceptible and saturated with seeded Nypa abundance according to Shigesada et al. (1995) classification. Most likely, Nypa palm seeds escaped by tidal current and found suitable sites to further spread between 1920 and 1925 in the Cameroon Estuary, Rio Ntem and other Mangrove site. Nypa palm spreading in the Cameroon (Wouri) estuary coincided with the first industrial exploitation of *Rhizophora racemosa* in one of its Island namely the Manoka Island as discussed by Mbog (pers. com. 2016).

Nypa palm uses and seed type's dispersal in Cameroon

The uses of Nypa palm are many and diverse (FAO 1994; David et al. 2008; Spalding et al. 2010; Akpan et al. 2016) across its introduced range. By 1930 onward, Nypa fronds are used for thatch and wall-partitioning (construction material in fishing camps) of dwellings, and as fuel wood for cooking and fish smoking, globally in the Rio del Rey (Nigeria and Cameroon). In some fishing camps fronds (dried petioles and stalks) were used to kick-start fire in fishing camps. Most of these fishing camps where local poor dwelled for livelihood are usually found around are where there are brackish and fresh water environments. The diverse uses might have served as a substantial trigger for further transportation of the seeds (fruit) by migrant fishing population (especially Nigerians, Ghanaians, etc.) further south to the equator in towns or fishing camps around Cameroon estuary (Limbe, Tiko, Douala, Moungo) where they were covertly planted.

In the marine environment, the spread of non-native species is largely mediated by anthropogenic activities (Seebens et al. 2013). Locales transported the seeds of Nypa palm with them to their supposed destination across the coastline down south. So, as locales people (especially Nigerians, Ghanaians, etc.) moved further down south the equator, Nypa palm followed similar move to support precarious house construction. The reason was that woody or hard material will take more time to transport and was costly to acquire, hence, they resorted to use Nypa palm leaflets for thatch to roof and wall, so as to have shelter in mangrove area. Usually, the house looks fragile and suspended with no partition into room, all in trying to respect tides movement.

Beside these consideration, Nypa palm fruit/seed fall from parent plant by gravity (Barochory-primary dispersal) and carried by tides and escaped from the Nigeria and spread into Cameroons mangrove. The second important mechanism of dispersal is by water (tides) (hydrochoric-secondary dispersal) and third by human (anthropochory-tertiary dispersal). These further influenced the process of spread fruit (seeds) to suitable brackish and fresh water environment in Cameroon. Mangrove propagules or seeds are carried off shore by

water currents (Muller 1959). Sea water current dynamics played a significant role in this process of Nypa palm long distance dispersal mechanism in the Gulf of Guinea.

Nypa palm took advantage of dispersal agent and other vectors mindful of its flower phenophase and massive fruit production yearly to influence proportional and actual colonisation or establishment in many sites in the Gulf of Guinea Countries. It belief there are usually synchronous timing of seed release and sustained tides dynamics. Hence, ground branching of its rhizome led to other form dispersal, and favoured *in situ* site displacement, colonisation and naturalisation (saturation) on the other hand through seeds many self-made seeds nurseries pills up to generate gregarious population and or albeit small patches. Tides, creek and river margins had served as corridors for both short and long distance dispersal of Nypa palm and for migration of its fruits into new coastlines. Path analysis suggests that a high selfing ability directly increases the number of regions where a species is naturalized (Razanajatovo et al. 2016).

Major drivers of Nypa palm spread

Mangroves are plant communities of the intertidal coastal zone in the tropics and subtropics (Baba et al. 2013) and can be affected by an invader plant. Many threats that contribute to the decline and degradation of mangrove ecosystems worked in favour to Nypa palm succession and establishment. Nevertheless, major drivers of invasive (non-native) species are climatic, land use, habit characteristic and socioeconomic factors (Pitt 2008; Pysek et al. 2010; Bellard et al. 2016).

Climatic factors

Mangrove distribution is limited by temperature as revealed by Giri et al. (2011). Mangroves are plant communities of the intertidal coastal zone in the tropics and subtropics (Baba et al. 2013). Increase in atmospheric and water temperatures is expected to either increase or decrease mangrove productivity (increase growth or high litter production) for native species in most location but not simultaneously. Increased temperature could lead to an extension of warmer season with an irritating effect on mangrove species retarding flowering phenophase and natural regeneration. Native species like *Rhizophora* spp. accounting for over 90 % of mangrove forest might suffer more compared to Nypa palm. There are rising concerns about the continued disappearance of the species *Avicennia germinans* and possible extinction in the mangrove landscape (UNEP 2007). Though *A. germinans* presents favourable coppicing characteristics than *Rhizophora* that does not coppice (Ajonina 2008). Nypa palm possesses several positively selected genes related to "response to stress" such as salt tolerance and vivipary development and its adaptation (He et al. 2015). With

Nypa rhizome dichotomous branching system propagation could be advantage for continual dispersal. The growth of Nypa is favoured by high temperatures (Ukpong 2007 Zakaria et al. 2017).

Combined with climate effects, CO_2 directly affect plant growth and development. Mangrove plants operate the C_3 pathway of carbon fixation in the photosynthesis (Venkatesalu et al. 2008) thus metabolic responses with increased atmospheric CO_2 increases productivity and more efficient water use. Doubled levels of CO_2 have been demonstrated to significantly increase biomass *Rhizophora* seedlings compared to normal levels (Farnsworth et al. 1996) only under favourable salinity (Zakaria et al. 2017) and humidity (Ball et al. 1997). Some C_3 plants like palm trees can cope with this terrible phenomenon, most C_3 plants can lose efficiency in productivity of up to 40% in warm, sunny, and dry conditions (McFadden 2014).

Mangrove have survived numerous glacier and interglacial period following fossil radiocarbon dating and pollen analysis (Ellison and Strickland 2010). Nypa palm generally thrive in low salinity and where water at low tide is practicality fresh (Flach and Rumawas 1996; Zakaria et al. 2017). Major requirement is the physical aspect through the deposit sedimentation and favoured by especially hinterland erosion. The low-lying coast of Cameroon is associated to Atlantic Ocean and rainfall, important runoff, many rivers (Sanaga and its tributaries, Akwa Yafe, Ndiam, Meme, Moungo, Wouri, Dibamba, Nyong, etc.) that empties themselves in the sea (Ibe et al. 1999; Neba 1999) contributing to dilute seawater. No matter the shelter of the coastline both sedimentation and erosion will occur leading to change of water quality. The limit between fresh and saline water is not known in most Cameroon mangrove block, even so it belief, that synergy of these aspects alongside other abiotic factors could only enhance site suitability for Nypa palm establishment. In that way, Nypa palm might exist in a simple or complex tributaries, mud and tidal flat and creeks, if the tide and freshwater input are sustained (Sum et al. 2013).

Policy and institutional framework

There is currently no legal and policy framework that would facilitate the management of invasive or nonnative plant in Cameroon' marine and coastal Ecosystem. Present forestry and environment legislation and policy frameworks of Cameroon are well developed and provide for an overall framework for management of Cameroon's forestry and wildlife resources. Yet, special ecosystems challenge by plant invasion in mangrove are not taken into consideration, thus limiting the application of some national and international framework to the management of marine, mangroves ecosystem and the control of its resources. Three marine and coastal protected areas are under creation and the process is quite slow. Most local development reluctantly look at mangrove ecosystem talk less of invasive plant species. Law enforcement to regulate mangrove harvest is too

weak. Most certain is the way the legislative defines what is a 'mangrove'. There is no local nor national strategy specific to curtail marine and coastal invasive plant like the non-native (Nypa palm) species *per se*.

Taxa adaptation and habitat characteristic

The richer the habitat the more difficult it could be to invaded (Jeschke and Strayer 2005). In term of flora, mangrove ecosystem in West –Central Africa are less rich compare to terrestrial forest. The *Rhizophora racemosa, Rhizophora harrisonii, Rhizophora mangle* (Rhizophoraceae), *Avicennia germinans* (Avicenniaceae), *Laguncularia racemosa, Conocarpus erectus* (Combretaceae) are considered mangrove indigenous plant species (Letouzey 1968) while *Nypa fruticans* an introduced species (Saenger and Bellan 1995; UNEP 2007; Spalding et al. 2010; Ajonina 2016). Nypa are present along most creeks and other rivers corridors in Cameroon e.g. rivers Dibamba (low-lying coast-Douala basin), lower Meme (low-lying coast -Ndiam basin), Mpolongwé (southern lowlands), etc. Coexistence was noticed at stand levels between *Nypa fruticans* with mostly Rhizophoraceae (*Rhizophora racemosa*) species in the Cameroon mangrove ecosystem (Ajonina 2008; Moudingo et al. 2017).

The introduced species uses it growth habit namely termed "Pleonanthic" to produce flower as it grows vegetatively simultaneously. In the field, the seed pressure and tides dynamics helps the species to rapidly dispersed (short and long distance), establish and even further spread especially by underground dichotomous branching before natural regeneration of native species like *Rhizophora* spp. or *Avicennia* sp. Such, underground growth is another form dispersal mechanism of Nypa palm. Hence, the performance of Nypa palm might impede the juvenile stage of native species (Rhizophoraceae). Nypa palm stand have a positive respond in Cameroon mangrove ecosystem as in its pristine native habitat. However, once they still roots or pneumatophores have established Nypa palm might not deterred the native species easily. In suitable condition, with its rhizome branching from below ground, we assumption that in soft muddy or mucking environment Nypa palm (non-native) might deterred native species like *Rhizophora* spp. or *Avicennia germinans* in most case.

Proximate habit and or landscape effect, species characteristic, primary and secondary dispersal mechanism and other environmental factors all might act in synergy to influence Nypa palm invasion processes. An early pioneering period enters into effect as new sub-populations are established, a middle period with rapid change as the population expands to new habitat, and a later period of condensing saturation or fill-in when new habitat and resources become scarce.

Land use and socioeconomic aspects

Human land-use patterns affect the spread of non-native species (Mooney and Hobbs 2000; Pitt 2008). Unsustainable anthropogenic and climate change are threatening the sustainability of coastal ecosystems in countries of West-Central Africa (Feka and Manzano 2008). Human activities such as tree felling, urbanization, oil and gas exploration and exploitation and other activities led to the interference in the normal mangrove by the Nypa palm (Isebor et al. 2003). Many specific human activities especially forest products for consumption at various levels (subsistence, artisanal, and industrial) reduce the area of native mangroves plant species (Ong 1982; Wolanski et al. 2000) practices, which hinders competition, coexistence and render mangrove ecosystem vulnerable to Nypa palm invasion. The most detrimental action recently observed are the excavation mangrove soil for dam, foot path and house constructions in the Cameroon Estuary, leaving behind only hard soil impossible for native species like the Rhizophoras to utilise but suitable for Nypa palm to be seeded. Mud flat or bare mangrove site with favourable tides are there suitable for Nypa naturalisation. Clearly, limited ecological knowledge, habitat destruction and fragmentation favoured plant introduction and invasion. According to Moudingo et al. (2017) Nypa palm invades any potential mangrove site under any exploitation regime even with little or no disturbance. According to him and his colleagues, the invadability rate (openness of the mangrove habitat) to Nypa palm in the Cameroon estuary range 12.5 – 175 Nypa palm/ha/year. Hence, during the establishment phase, landscape and habitat disturbance are they major factors that favours invasions, particularly invasions of alien plants (Pitt 2008).

Current distribution of Nypa palm across Cameroon mangrove block

With such an invadability rate know for the Nypa palm, the species has invaded Cameroon mangrove three blocks (Table 2). Today, the species are seeing everywhere at different growth stage and formed sporadic or dense stands and mono-stand in association especially with *Rhizophora* spp. Nypa palm in the Cameroon Estuary and Rio del Rey mangrove blocks are in well-established stands (under expansion) compare to the Nyong-Campo Landscape (Rio Ntem Estuary) which are patches or spotted (lag-pioneering phase) . From North to south Cameroon coastline, twenty three local government are affected and currently harbours Nypa palm (Table 2). Though, few, the number of affected villages or fishing camps might exponentially be. May be it is time for the valuation of mangrove Nypa palm in all it form.

Hence, we provide a comprehensive record of the distribution of *Nypa fruticans* in Cameroon, helpful most local government. The present landscape status of population of Nypa palm in Cameroons mangrove could not be ascertained because of the recent large scale reclamation works around it in Cameroon estuary and somewhat patchy nature of the stand in the Rio Ntem.

Table 2 Overview of *Nypa fruticans* distribution & stages- in Cameroon' marine and coastal environment

Fundamentals Niche –(Mangrove Block)	**Local government affected**	**Occupied Niche (Site/villages/ fishing camp affected)**	**Observed Nypa palm occurrence stages (Shigesada et al. 1995)**
South Region Nyong-Campo Landscape (Rio Ntem)	Kribi 1	Eboundja (Canton Batanga Sud),	Pioneering
	Kribi 2	Mpolongwé, Londji (Batanga North)	Pioneering
	Lokoundje	Lokoundje (Fifinda)	Pioneering
	Campo	Ebodja	Expansion
		Campo Beach	Pioneering
Littoral Region -Wouri (Cameroon Estuary)	Wouri (Douala 1)	Youpwé & Deido	Saturation
	Wouri (Douala 2)	Bonamouang	Expansion
	Wouri (Douala 3)	Ndopassi/Japoma (Dibamba pont)	Expansion
	Wouri (Douala 4)	Bonabéri	Expansion
	Wouri (Douala 5)	Akwa Nord	Expansion
	Wouri (Douala 6)	Manoka (Community Forest)	Saturation
Littoral Region -Sanaga Maritime (Cameroon Estuary)	Dibamba	Ndonga	-Pioneering
	Dizangué	Ndonga Yakalak	- free
	Edéa 1ere	Aide	- free
	Edéa 2e	Malimba	free
	Mouanko**	Yakalack, Malimba (yoyo, Mbiako, Youme…)	Saturation
Littoral Region -Nkam (Cameroon Estuary)	Yabassi	Wouri Bwellé	- free
		Bdjob Ndogpenda	- free
		Dibeng-Ndogbele	- free
		Bodiman	- free
Littoral Region -Moungo (Cameroon Estuary)	Dibombari	Dibombari (North Boder with bonaberi)	free
South west Region -Fako (Cameroon Estuary)	Limbe 1	Down Beach/Bota	Expansion
	Limbe 3	Bimbia/Mbeta	Pioneering
	Tiko		Pioneering
South west Region - West coast –(Rio Del Rey)	Limbe 2	Batoke	Pioneering
	(Fako)	West coast (Idenau)	Expansion
South west Region - Ndian** (Rio del Rey)	Bamuso	Pêcheries, Ekombe, Bakole, Balondo	Saturation
	Idabato	Kombo Amunja	Saturation
	Ekondo Titi	Ekondo-Titi Rural	Saturation
	Kombo Abedimo	Akwa	Saturation
	Kombo Etindi	Kombo Itindi Rural	Saturation
	Isangele	Isangele Rural	Saturation

*The future National Park of Douala-Edea is now gazetted as the Douala Edea Marine and Terrestrial National Park. The Douala-Edéa National Park, formerly known as the Douala-Edéa Wildlife Reserve, is a national park in the Littoral Region of Cameroon, **Proposed national park of Ndongoré and Rio del Rey Ramsar site, - potential site to be affected.

4. Conclusions and Recommendations for Future Perspectives

Historically, Nypa palm was wildly distributed and limited to specific islands, landscape and continent. Mindful, of its variety uses, this mangrove palm was re-introduced other especially in West Africa were it has colonised and become naturalised in many states in Nigeria. Nypa palm rapidly reached homeostasis and spread out of its first reintroduced site. No risks analysis or assessment was conducted prior to that intentional introduction, more than a century after over 10 countries of the GCLME are affected by Nypa palm.

In Cameroon shoreline Nypa palm was already present during and immediately after the First World War and thus further spread to the Cameroon estuary mangrove block contrary a certain school of though. Dispersal mechanism are natural and anthropogenic favoured by drivers like habitat destruction and fragmentation from anthropogenic disturbances. Nypa palm stand in the mangrove ecosystem of the Rio del Rey and Cameroon estuaries has reached saturation (homeostasis) stage while that of the Kribi-Campo landscape (Rio Ntem) is at the pioneering stage with many floating seeds/fruits. The estimated invadability rate upper limit was 175 Nypa palm/ha/year.

Nypa fruticans (Nypa palm) has spread across Cameroon mangrove blocks from north (border to Nigeria) to south (border to Equatorial Guinea), there is need for further research to understand why Nypa palm is look as an invasive species today, know its biophysical impacts and possible management scenarios that would maximise and minimise impacts. In this light administrative unit (local government) authorities with mangrove ecosystem and wetland when developing their development plans should include strategies and action to manage Nypa palm.

Acknowledgements

The authors thank the University of Douala for the time and resources it permitted them to use. We thank the FAO Cameroon Representation through its GEF support Community management Mangrove project and Cameroon Wildlife Conservation Society for providing an enabling environment for the field work and support from staff. The authors are also grateful for importance guidance and input from Prof. Brian W. van Wilgen and Dr David Le Maitre, both from Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University for spelling the need to embark such topic, to Prof. Ndongo DIN of the Department of Botany (Former Head), Faculty of Science, University of Douala. Thierry Dikoume (PhD-Student, University

of Douala), Diyouke Eugene (Geomatics Expert, CWCS), Etame Prince (Restorationist-CWCS), Agbor Claudia (Intern MINEPDED, South West, Region) and four anonymous reviewers provided useful comments on an earlier version of the manuscript.

Compliance with ethical standards

Funding: This study was funded by many quarters amongst which the supported by IDEAWILD (is a registered 501c(3))through the donation of a compass, computer and GPS t 650 use for field data collection and write up. The Cameroon Wildlife Conservation Society covered most of the field transport cost to the respective mangrove blocks.

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1]. Ajonina G (2016) Mangroves and wetlands of Sub-saharan Africa: potential for sustainable livelihoods and development. In: Ogunsanwo OY and Akinwole AO (eds) A keynote address presented at the 38th annual conference of forestry association of Nigeria (FAN). Port Harcourt, Nigeria, pp 22–49

[2]. Ajonina G, Kemajou J, Bitchick CA, Wambe NE (2010) Rapport technique sur l'évaluation chiffrée de la dégradation d'une partie de la mangrove du littoral. Consultancy Report. MINEPDED, Yaoundé, Cameroon

[3]. Ajonina NG (2008) Inventory and modelling mangrove forest stand dynamics following different levels of wood exploitation pressure in the douala-edea Atlantic Coast of Cameroon, Central Africa. Dissertation, Albert Ludwigs University of Freiburg

[4]. Akpan UF, Akpan FS, Oladele ON, Malizu LC, Odey BO (2016) Economic importance of Nypa fruticans in the Niger Delta Regions of Nigeria. In: Ogunsanwo OY and Akinwole AO (eds) Mangroves and wetlands of sub-saharan Africa: potential for sustainable livelihoods and development. 38th annual conference of forestry association of Nigeria. Port Harcourt River state, Nigeria, pp 738–744

[5]. Amin EM (2005) Social science research: conception, methodology and analysis. Makerere University, Kampala

[6]. Baba S, Chan HT, Aksornkoae S (2013) Useful products from mangrove and other coastal plants. International Society for Mangrove Ecosystems, Yokohama, Japan

[7]. Bacon P (2001) Germination of Nypa fruticans in Trinidad. Palms 45:57–61

[8]. Balick MJ, Beck HT (1990) Useful palms of the world: a synoptic bibliography. Columbia University Press, New York, NY

[9]. Ball M, Cochrane M, Rawson H (1997) Growth and water use of the mangroves *Rhizophora apiculata* and *R. stylosa* in response to salinity and humidity under ambient and elevated concentrations of atmospheric CO_2. Plant Cell Environ 20:1158–1166

[10]. Bellard C, Leroy B, Thuiller W, Rysman JF, Courchamp F (2016) Major drivers of invasion risks throughout the world. Ecosphere 7:e01241

[11]. CAB International (2004) Prévention et Gestion des espèces étrangères envahissantes: La mise en œuvre de la coopération en Afrique de l'Ouest. Compte rendu d'un atelier tenu à Accra, Ghana, de 9 au 11 mars. CAB International, Nairobi, Kenya

[12]. Courtesy A (2006) Legal strategies for combating invasive alien species. In: Koike F, Clout MN and Kawamichi M (eds) Assessment and control of biological invasion risks. SHOUKADOH Book Sellers, Gland, Switzerland, pp 27–34

[13]. Creswell JW (1998) Qualitative inquiry and research design: choosing among five traditions. Sage Publications, Thousand Oaks, CA

[14]. Creswell JW (2009) Research design. Sage Publications, Thousand Oaks, CA

[15]. David N, Ukoima H, Oddo E, Ekeke B, Emerhi E (2008) Local utilization of nypa palm (*Nypa fruticans*, Wurmb) in parts of rivers state, Nigeria. Acta Agron Niger 8:43–48

[16]. Davis MA (2011) Invasion biology. In: Simberloff D and Rejmanek M (eds) Encyclopedia of biological invasions. University of California Press, Berkeley, CA, pp 64–369

[17]. Denzin NK, Lincoln YS (1994) Introduction: entering the field of qualitative research. In: Denzin NK and Lincoln YS (eds) Handbook of qualitative research. Sage Publications, Thousand Oaks, CA, pp 1–17

[18]. Dransfield J, Uhl NW, Asmussen CB, Baker WJ, Harley MM, Lewis CE (2008) Genera palmarum: the evolution and classification of palms. Kew Publishing, Royal Botanic Gardens, Kew

[19]. Duke NC (2006) Australia's mangroves: the authoritative guide to australia's mangrove plants. University of Queensland, Queensland

[20]. Ellison J, Strickland P (2010) Stratigraphy and pollen analysis of recent sediments in the Douala Estuary, Cameroon. Report to WWF Central Africa Regional Programme Office, Yaounde, Cameroon. Aceessd 19 august 2010

[21]. Ellison J, Koedam NE, Wang Y, Primavera J, Eong OJ, Yong JW-H, Nam VN (2010) Nypa fruticans. The IUCN Red List of Threatened Species. ISSN 2307-8235 (online). http://dx.doi.org/10.2305/IUCN.UK.2010-2.RLTS.T178800A7610085.en or http://www.iucnredlist.org/details/178800/0. Accessed 2 october 2016

[22]. FAO (1994) Mangrove forest management guidelines. FAO Forestry Paper 117. FAO, Rome

[23]. Farnsworth EJ, Ellison AM, Gong WK (1996) Elevated CO_2 alters anatomy, physiology, growth, and reproduction of red mangrove (*Rhizophora mangle* L.). Oecologia 108:599–609

[24]. Feka NZ, Manzano MG (2008) The implications of wood exploitation for fish smoking on mangrove ecosystem conservation in the South West Province, Cameroon. Trop Conserv Sci 1:222–241

[25]. Flach M, Rumawas F (1996) Plants yielding non-seed carbohydrates. Backhuys Publishers, Leiden, NL

[26]. Fong FW (1982) Nypa swamps in Peninsular Malaysia. Proceedings of the 1st international wetlands conference. Ecological Management, Wetlands, pp 31–38

[27]. GCLME (Guinea Current Large Marine Ecosystem) (2005) Report of the regional training workshop on integrated coastal area management. UNIDO/UNDP/UNEP/GEF/ NOAA/NAPAD, Kribi, Cameroon

[28]. Giri C, Ochieng E, Tieszen LL, Zhu Z, Singh A, Loveland T, Masek J, Duke N (2011) Status and distribution of mangrove forests of the world using earth observation satellite data. Glob Ecol Biogeogr 20:154–159

[29]. GISD (Global Invasive Species Database) (2015) Species profile *Nypa fruticans*. http://www.iucngisd.org/gisd/species.php?sc=1838. Accessed 27 January 2018

[30]. Hamilton LS, Dennis HM (1988) Use and management of nipa palm (*Nypa fruticans*, Arecaceae): a review. Econ Bot 42:206–213

[31]. He Z, Zhang Z, Guo W, Zhang Y, Zhou R, Shi S (2015) *De novo* assembly of coding sequences of the mangrove palm (*Nypa fruticans*) using RNA-seq and discovery of whole-genome duplications in the ancestor of palms. PLoS One 10:e0145385

[32]. Hefferman C (2013) Qualitative research approach. http://www.explorable.com. Accessed 2 August 2016

[33]. Humphrey S, Gordon C (2012) Combating Living Resources Depletion and Coastal Area Degradation in the Guinea Current LME through Ecosystem-based Regional Actions (GCLME). UNEP Evaluation office, Nairobi, Kenya

[34]. Ibel A (2016) Harnessing ethno-botanical and non-timber forest products of the mangrove and wetlands. In: Ogunsanwo OY and Akinwole AO (eds) Mangroves and wetlands of sub-saharan Africa: potential for sustainable livelihoods and development 38th annual conference of forestry association of Nigeria (FAN). Port Harcourt, Nigeria, pp 231–258

[35]. Isebor CE, Ajayi TO, Anyanwu A (2003) The incidence of *Nypa fruticans* (Wurmb) and its impact on fisheries production in the Niger Delta mangrove ecosystem. In: 16th annual conference of the fisheries society of nigeria (FISON). Maiduguri, Nigeria, pp 13–16

[36]. Jeschke JM, Strayer DL (2005) Invasion success of vertebrates in Europe and North America. Proc Natl Acad Sci U S A 102:7198–7202

[37]. Letouzey R (1968) Etude phytogeographique du Cameroun. Paul Chevalier, Paris

[38]. Lovly M, Merlee-Teresa M (2016) Nypa palm (*Nypa fruticans* Wurmb.) a new record from Kerala. Int J Adv Res 4:1051–1055

[39]. McFadden K (2014) The rise of c4 plants. Ecology by proxy. umainepaleo. https://paleoecology.wordpress.com/2014/03/24/the-rise-of-c4-plants/. Accessed 9 September 2017

[40]. Ibe AC, Folack J, Mbome LI, Bokwe A, and Tangang A (1999) Cameroon coastal profile. MINEF-C/UNIDO/UNDP-GEF ISBN 2-910526-29-1. pp102

[41]. MINEPDED (2014) Stratégie nationale de gestion durable des mangroves et des écosystèmes côtiers au Cameroun et son plan de mise en œuvre. Ministère De L'environnement, De La Protection De La Nature et du Développement Durable (MINEPDED)/ FAO-GEF-Cameroon Project PCG/CMR/30/GEF. Yaounde, Cameoun. pp111

[42]. MINEPDED (2017) Les mangroves du Cameroun: etat de lieux et Gestion. Ministère De L'environnement, De La Protection De La Nature Et Du Développement Durable (MINEPDED)/ FAO-GEF-Cameroon Project PCG/CMR/30/GEF. Yaounde, Cameoun..pp 191

[43]. MINFOF (2014) Schéma directeur d'Aménagement des mangroves du Cameoun. MINFOF, Yaounde, Cameroun. pp 107 + annexes

[44]. Mooney HA, Hobbs RJ (2000) Invasive species in a changing world. Island Press, Washington, DC

[45]. Moudingo J-H, Ajonina G, Tomedi M, Dibong D (2017) Invadability/invasiveness of non-native mangrove palm (*Nypa fruticans* wurmb.) from long-term monitoring of permanent sample plots in Cameroon. European Conference on Tropical Ecology & Annual meeting of the society for tropical ecology (GTÖ). Brussels, Belgium, pp 263

[46]. Moudingo JH, Fon JN, Mokake SE, Ndembe ME (2015) Non-native mangrove Nypa fruticans invasion in the Gulf of Guinea. In: Ens E, Fisher J and Costello O (eds) Indigenous people and invasive species: perceptions, management, challenges and uses. IUCN Commission on Ecosystem Management Community Booklet, Sydney, Australia, pp 7–9

[47]. Muller J (1959) Palynology of the recent Orinoco delta and shelf sediments. Micropaleontology 5:1–32

[48]. Narayanan V (2015) Document analysis. International Institute of Business Analysis, Canada. http://www.fhyzics.com. Accessed 12 March 2017

[49]. NBSAP II (2012) Republic of cameroon 2012, national biodiversity strategy and action plan–version II–MINEPDED, Yaounde, Cameroon

[50]. Neba A (1999) Modern geography of the republic of Cameroon. NEBA, Camden, NJ

[51]. Ong JE (1982) Mangroves and aquaculture in Malaysia. Ambio 11:252–257

[52]. Päiväke AEA (1996) *Nypa fruticans* Wurmb. In: Flach M and Rumawas F (eds) Plant Resources of South-East Asia (PROSEA), Volume 9 Plants yielding non-seed carbohydrates. Wageningen, Prosea/Pudoc, Bogor, pp 133–137

[53]. Peshkin A (1993) The goodness of qualitative research. Educ Res 22:23–29

[54]. Pitt M (2008) The pitt review: learning lessons from the root of floods. COL, London, UK

[55]. Pysek P, Jarosik V, Hulme PE et al. (2010) Disentangling the role of environmental and human pressures on biological invasions across Europe. Proc Natl Acad Sci U S A 107:12157–12162

[56]. Razanajatovo M, Maurel N, Dawson W, Essl F, Kreft H, Pergl J, Pysek P, Weigelt P, Winter M, van Kleunen M (2016) Plants capable of selfing are more likely to become naturalized. Nat Commun 7:13313

[57]. Richardson DM (2011) Fifty years of invasion ecology: the legacy of charles elton. Blackwell Publishing Ltd., Oxford, UK

[58]. Riffle RL (2008) Timber press pocket guide to palms. Timber Press, Portland

[59]. Saenger P, Bellan MF (1995) The mangrove vegetation of the Atlantic Coast of Africa: a review. Université de Toulouse, Toulouse, France

[60]. Seebens H, Gastner MT, Blasius B (2013) The risk of marine bioinvasion caused by global shipping. Ecol Lett 16:782–790

[61]. Shigesada N, Kawasaki K, Takeda Y (1995) Modeling stratified diffusion in biological invasions. Am Nat 146:229–251

[62]. Spalding M, Kainuma M, Collins L (2010) World atlas of mangroves. Earthscan, Washington, DC

[63]. Sum PC, Khoo HE, Azlan A (2013) Comparison of nutrient composition of ripe and unripe fruits of Nypa fruticans. Fruits 68:491–498

[64]. Sunderland TC, Morakinyo T (2002) Nypa fruticans, a weed in West Africa. Palms 46:154–155

[65]. Tening AS, Chuyong GB, Asongwe GA, Fonge BA, Lifongo LL, Mvondo-Ze AD, Che VB, Suh CE (2013) Contribution of some water bodies and the role of soils in the physicochemical enrichment of the Douala-Edea mangrove ecosystem. Afr J Environ Sci Tech 7:336–349

[66]. Teo S, Ang W, Lok A, Kurukulasuriya B, Tan H (2010) The status and distribution of the nipah palm, *Nypa fruticans* Wurmb (Arecaceae), in Singapore. Nat Singapore 3:45–52

[67]. Tomlinson PB (1979) Systematics and ecology of the palmae. Annu Rev Ecol Syst 10:85–107

[68]. Tomlinson PS (1986) The botany of mangroves. Cambridge University Press, New York, NY

[69]. Travis (2016) Desk research: the what, why and how. http://www.helpdesk@userfocus.co.uk. Accessed 9 February 2017

[70]. Ukpong IE (2007) *Nypa fruticans* invasion and the integrity of mangrove ecosystem functioning in the marginal estuaries of south eastern nigeria. Department of Geography & Natural Resources Management University of Uyo, Uyo Akwa Ibom State, Nigeria, p 13 (https://www.academia.edu/7708886/NYPA_FRUTICANS_INVASION_AND_THE_INTEGRITY_OF_MANGROVE retrived october 2017)

[71]. UNEP (2007) Mangroves of Western and Central Africa. UNEP–WCMC, Cambridge, MA

[72]. Valet G (1973) Aperçu sur la végétation marine du Cameroun. Ann Fac Sci Univ Yaoundé n 15:17–24

[73]. Venkatesalu V, Senthilkumar A, Chandrasekaran M, Kannathasan K (2008) Screening of certain mangroves for photosynthetic carbon metabolic pathway. Photosynthetica 46:622–626

[74]. WAC (World Agroforestry Centre) (2011) Agroforestry tree database: Nypa fruticans. In Tamunaidu and Shiro (eds) Chemical characterization of various parts of nipa palm (Nypa fruticans). Industrial Crops and Products 34(3): 1423-1428

[75]. Walsh EG (1974) Mangroves: a review. In: Reimold RJ and Queen WH (eds) Ecology of halophytes. Academic Press, New York, NY, pp 51–174

[76]. Wolanski E, Spagnol S, Thomas S, Moore K, Alongi DM, Trott L, Davidson A (2000) Modelling and visualizing the fate of shrimp pond effluent in a mangrove-fringed tidal creek. Estuar Coast Shelf Sci 50:85–97

[77]. Zakaria RM, Aslezaeim N, Sofawi AB (2017) Effects of water properties and soil texture on the growth of a mangrove palm; *Nypa fruticans* on carey Island, Malaysia. Pak J Bot 49:33–39