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Characterization of the Ecological Niche and Determination of the Biomass of *Pandanus* spp. in the Dibombari Area, Douala-Cameroon

Hyacinthe Angoni[1*], Jean Ekindi[2], Jean Charbell Mbega[1], Jean Luc Ngimbis[3], Gordon Ajonina[2]

[1]Faculty of Sciences, University of Yaounde I, Yaounde, Cameroon
[2]University of Douala, CWCS Mouanko, Douala, Cameroon
[3]CRESA Wood, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Yaounde, Cameroon
Email: *hyacinthe.angoni@facsciences-uy1.cm, majechell25@yahoo.fr

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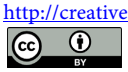

Abstract

A study was carried out in the mangroves of Dibombari in order to determine the density of *Pandanus* spp., its biomass and its dendrometric characteristics in the sites of Njouki, Biendende and Bonamassouka. At each site studied, stand density, biomass and dendrometric characteristics were determined. To achieve our results, an inventory and the dendrometry of *Pandanus* spp. were carried out in transects of 10 m × 10 m where even the roots and leaves were counted, then the destructive method made it possible to determine the biomass. The results of the inventory show that in the sites of Njouki, Biendende and Bonamassouka, the density is respectively: 6100 plants/hectare; 4800 plants/hectare; 2800 plants/hectare. The individual plant biomasses of *Pandanus* spp. in the sites of Njouki, Biendende and Bonamassouka have respectively an aerial and underground biomass of 45%; 35% and 20%. The results of the dendrometry show that the average diameters, the average heights, the number of roots and leaves are respectively the following: 11.81 cm; 5.39 m; 44 leaves and 20 roots at Njouki, 9.43 cm; 8.63 m; 18 leaves and 11 roots in Biendende; 9.39 cm; 4.32 m; 73 leaves and 31 roots in Bonamassouka.

Subject Areas

Environmental Sciences

Keywords

Ecological Niche, Biomass, *Pandanus* spp., Mangrove, Littoral

1. Introduction

Carbon dioxide (CO_2) is one of the main greenhouse gases responsible for the current increase in Earth's temperature [1]. This leads to climate change, the consequences of which are disastrous [2]. Three strategies make it possible to mitigate CO_2 emissions: the overall reduction in the use of fossil energy, the development of renewable energy sources and the sequestration of CO_2 in natural sinks [3]. It is therefore essential to limit the quantity of atmospheric CO_2 by conserving carbon (C) sinks existing in forest areas, among which mangroves hold a recognized place.

The mangrove is a forest ecosystem, made up of particular plant species called "mangroves", which develop in the intertidal zone of tropical and subtropical countries, almost entirely composed of sclerophyll and evergreen deciduous trees and shrubs, with roots stilts or pneumatophores which are fixed in generally hydromorphic soils, subject to periodic swings of the tides [4] [5]. The mangrove has the dual competence of being a sink for atmospheric CO_2 and a source of organic and inorganic carbon for coastal areas. It has the greatest carbon sequestration capacity (1023 Mg ha^{-1} on average) than forest areas [6].

Mangroves help protect infrastructure and livelihoods from coastal erosion. Its stilt roots absorb the energy of the powers, thus acting as a breakwater, preventing coastal erosion. Mangroves provide a source of wood energy for local communities and are used as building material for houses. They are also of vital importance to the local fishing sector, particularly because of their function as spawning grounds for a multitude of species of commercial fish and invertebrates, which are the basis of the culture and livelihoods of the communities. In tropical regions, it occupies nearly 75% of the length of coasts and deltas. According to estimates, it covers 14 to 23 million hectares worldwide [7].

The structure of mangrove vegetation is particular. Forest species reach more than 100 cm in diameter and 60 m in height, especially in the Wouri estuary [5]. Cameroonian mangrove forests cover approximately 200,000 hectares and occupy more than 30% of its coast; they represent 6% of the coverage of Africa which is the second longest in Central Africa behind that of Gabon and the fourth largest in Africa. Africa [8] [9]. Mangrove, associated coastal forests and associated non-vegetated lands according to [5], cover a total area of 395,185 ha distributed in three main areas (from north to south): Rio Del Rey Estuary (180,535 ha; 45.7%), Cameroon Estuary (203,567; 51.5%) and Ntem Estuary (11,083; 2.8%).

Purely mangrove lands occupy 221,163 ha (56%), distributed respectively in the three zones: Rio Del Rey Estuary, 125,259 ha (56.6%); Cameroon Estuary, 93,550 ha (42.3%) and Ntem Estuary, 2,354 ha (1.1%). Other occupations include associated coastal forest land 13,130 ha (3.3%), plantation and habitation land (62,864 ha) (15.9%) and non-vegetated land (98,028 ha) (24.8%).

However, mangroves are threatened by deforestation linked to urban development and coastal infrastructure, unsustainable logging for fish smoking, and pollution from pesticides and fertilizers, as well as logging. hydrocarbons and gas. Clearing for the creation of palm oil plantations, rising sea levels, erosion and in-

creased sedimentation are also behind the decline of mangroves in Cameroon and Central Africa [10]. Invasion by certain undesirable accompanying species such as *Pandanus* spp. [5] is widespread in the Wouri estuary in Dibombari. Hence the need to know the reasons for its expansion by characterizing its ecological niche and determining its biomass.

In Cameroon, mangroves are protected by Law No. 2024/008 of July 24, 2024 on forest and wildlife and Law No. 96/12 of August 5, 1996 on the legal framework for Environment management; Article 94 of this law stipulates that "mangrove ecosystems require particular protection in relation to the importance they have for the conservation of aquatic biodiversity and the maintenance of ecological balances". The application of these laws and regulations is not sufficiently taken into consideration on the field, which consequently exposes natural resources and areas to degradation and over exploitation [11]. Field activities revealed a proliferation of *Pandanus* spp., accompanying species of mangrove species that bring out the importance of this study. The main objective of which is to characterize the ecological niche and determine the biomass of *Pandanus* spp. in the studied area of Dibombari with the aim of contributing to the sustainable management of the mangroves ecosystems. The specific objectives are:

- determine the geographical distribution of *Pandanus* spp.;
- inventory of *Pandanus* spp. plant formations in the said study area in Dibombari;
- collect the dendrometric parameters of *Pandanus* spp. in the said study area in Dibombari.

2. Material

2.1. Study Site

The municipality of DIBOMBARI, which was created in 1955 by law No. 1489 of November 11, 1955, is located 18 km from the city of Douala, capital of the Littoral Region of which it is part. It is located between the Littoral, South-West and West Regions. It is one of the 13 districts that make up the Moungo Department. Its area is 1500 km^2. It has 38 villages, 9 of which are located in urban areas. Its population is estimated according to the latest demographic surveys at 17,141 inhabitants. The 02 constituent chiefdoms of the municipality of DIBOMBARI (**Figure 1**) are that of the Pongo canton (1st degree) with 20 villages and that of the BAKOKO canton (2nd degree) with 18 villages.

It is located at the southern entrance to the Moungo Department of the Littoral Region and is limited:

- To the South by the Municipality of Douala IV (Department of Wouri) and the Bépélé River serving as a natural border;
- To the East by DJEBALE;
- To the North by the Municipality of Dibombari (Department of Moungo);
- To the West by the Municipality of Tiko.

Its geographical limits extend from 9˚ 39' North Latitude and 4˚ 1' East Longitude.

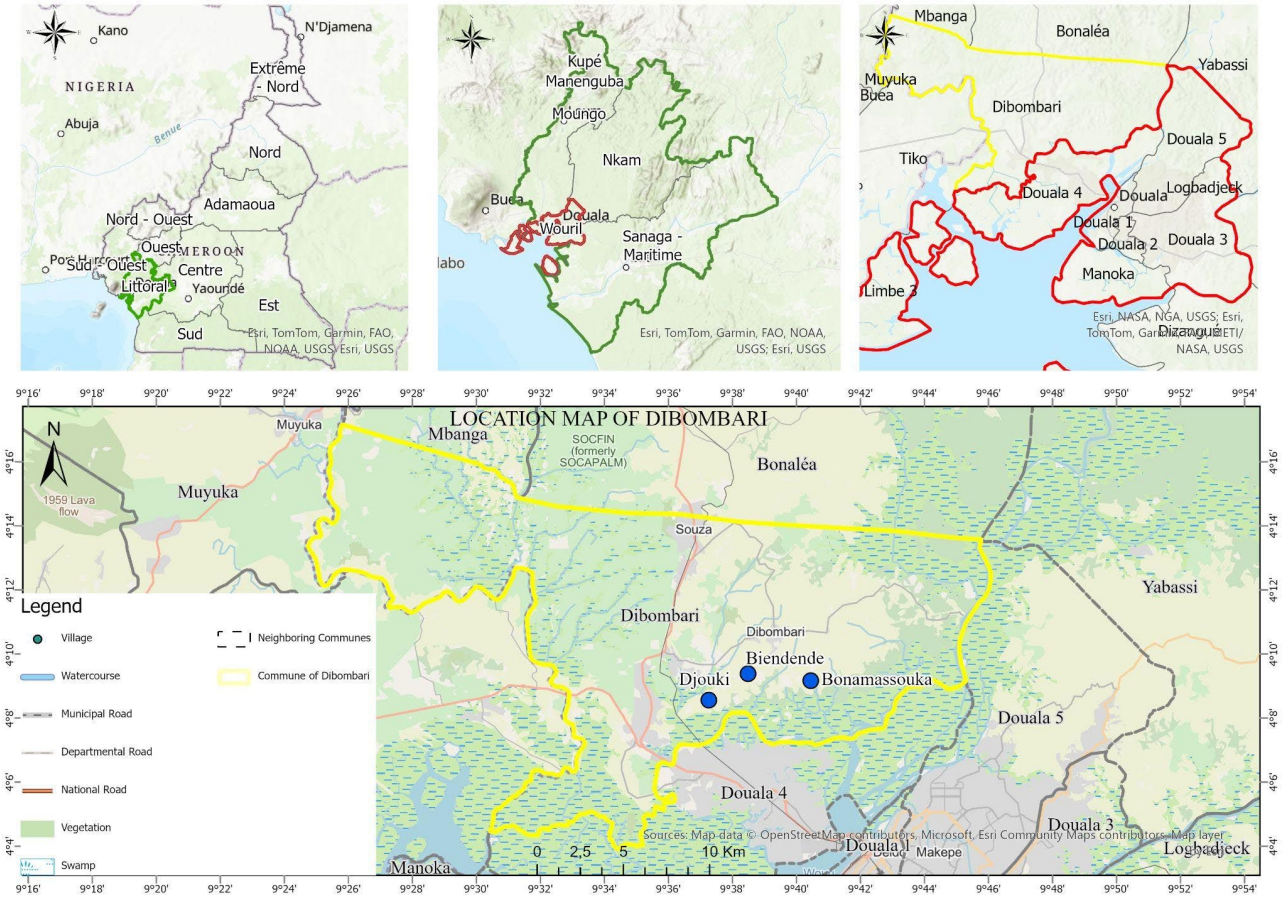

Figure 1. Location map of Dibombari in the Mungo Division.

2.2. Experimental Sample

The sampling technique used to collect the data is the standard quadrat [12]. This device allowed the collection of biometric data and inventories of *pandanus* spp. formations. The typical quadrat used is 10 m × 10 m in the mangrove. Thus, 03 quadrats of 10 m × 10 m were materialized in 03 sites namely: Djouki, Biendende and Bonamassouka. The choice of the study site for the transepts location was made according to the greater homogeneity of the populations of *Pandanus* spp. and accessibility of the environment.

3. Data Collection Methods

3.1. Method for Identifying Types of Plant Formations with *Pandanus* spp.

The studies took place between February and June 2023. A preliminary survey made it possible, by traveling along the Wouri the river in the Dibombari area, to identify the vegetation and characterize them. The characterization of the vegetation took into account the physiognomy of the vegetation, the size of the trees, the number of strata and the main species found. Following this survey, three sites were chosen for vegetation sampling with a view to assessing the relative threat

facing the mangrove. The site of Bonamassouka, Biendende and Djouki.

3.2. Floristic Inventory Methods of *Pandanus* spp.

The aim was to determine the number of individuals of *Pandanus* spp. in a given area. Thus the GPS coordinates of each transept of 100 m (one by site) were noted to establish a distribution map of *Pandanus* spp. (Figure 2). This inventory took place in the three identified sites of Bonamassouka; Biendende and Djouki.

Figure 2. GPS data collection on the study site.

3.3. Dendrometric Data Collection Technique

The dendrometric collection parameters were done in the quadrat device described by [13]. Using a caliper and a tape measure (Figure 3), the circumferences of the trees were measured above the roots greater than 15 cm. Heights were measured at 1.30 cm from the ground. The total heights and those of the stems were measured using a stick graduated in cm. The number of roots and leaves was counted. The measured trees were marked using red paint.

Figure 3. Dendrometric data collection.

3.4. Biomass Data Collection Method

Data collection for biomass estimation was done using the destructive method. Fresh biomass was obtained by sampling all components of *Pandanus* spp. (leaves, stems and roots) which have been measured, weighed using a sensitive scale and labeled with tape and marker (Figure 4). Once the fresh masses of the biomass are obtained, they are compared to find out which part of the biomass is higher between the aboveground and underground biomass.

Figure 4. Biomass data collection.

3.5. Data Processing and Analysis

The data obtained were encoded and classified using Excel software which allowed us to have graphs that determine the densities, biomass, dendrometric parameters and nutrients of *Pandanus* spp. in the different sites studied and from of ArcGIS 10.5 mapping software, the map has been generated. The SPSS software made traits and analyzed the biomass, revealing their significance.

The parameters studied are:

Average diameters of *Pandanus* spp. The average diameter is calculated from the following formula:

Dmoy = ∑di/N. di represents the diameter of shaft i; N: total number of trees;

Average height of *Pandanus* spp.

Hmoy = ∑Hi/N. hi: height of the tree, N: total number of trees;

Leaf average:

Fmoy = ∑Fi/N. fi: number of leaves on the tree, N: total number of leaves;

Average of roots: Rmoy = ∑Ri/N. ri: number of leaves on the tree, N: total number of roots;

Density of *Pandanus* spp.: Np/S. Np: number of pandanus, S: surface;

4. Results

4.1. Inventories

A total of five species of mangroves divided into five families were identified along

the Wouri River from Douala to Dibombari. Table 1 presents the different species.

Table 1. The different coastal species.

Family	Species
Pandenaceae	*Pandanus* spp.
Avicenaceae	*Avicennia germinans*
Rhizophoraceae	*Rhizophora mangle*
Arecaceae	*Nypa.* spp.
Fabaceae	*Drepanocarpus lunatus.*

4.2. Geographic Distribution of *Pandanus* spp. in the Study Area

Pandanus spp. is widely distributed in the study area. Then: Bonamassouka with coordinates: 0576184 N and 0455927 in UTM 32 N (Universal Transverse Mercator) is located approximately 2 meters from the Wouri river, with black loamy-sandy soil on which the *Pandanus* spp. is less dense characterized by biometrics parameters which vary between 3 m and 6 m for heights, 5.2 cm and 13.6 cm for diameters. This site is also characterized by an abundance of Rhizophora mangle and other mangrove trees present in their natural environment.

In Biendende with geographical coordinates: 0573120 N and 0466001 in UTM 32 N (Universal Transverse Mercator) located approximately 2 meters from the Wouri river with black loamy-clayey soil on which the *Pandanus* spp. is denser than on the Bonamassouka site. The biometric parameters vary between 5 m and 14 m for heights, 6.3 cm and 19 cm for diameters. Companion species are *Nypa* spp., *Avicennia germinans*, and palm trees.

The locality of Njouki with coordinates: 0569249 N and 0456820 (Universal Transverse Mercator) is located approximately 2 meters from the Wouri river, with black loamy-sandy soil, there is a large density of *Pandanus* spp. than in the other sites with parameters varying between 3 m and 8 m for heights, 7.1 cm and 15.6 cm for diameters. Companion species are *Rhizophora mangle*, *Nypa*, *Avicennia germinans*.

4.3. Density of *Pandanus* spp.

The density of *Pandanus* spp. is distributed as follows: 6100 plants/hectare in Njouki; 4800 plants/hectare in Biendende and 2800 plants/hectare in Bonamassouka. Njouki is the densest site and Bonamassouka the least dense in populations of *Pandanus* spp.

The relative density of *Pandanus* spp. per hectare in all the sites results that: Njouki is the most degraded site with an occupancy rate of 45%, followed by Biendende with 35% and Bonamassouka with 20% (Figure 5). This percentage characterized the density of *Pandanus* spp. on sites studied.

The presence of some other species is characterized by *Avicennia germinans* (Aviceniaceae), *Rhizophora racemosa* (Rhizophoraceae), *Drepanocarpus lunatus*, *Raphia palmapinus* (Palmaceae). We can conclude that the Njouki site is the most degraded. The most invasive species is *Pandanus* in the different sites.

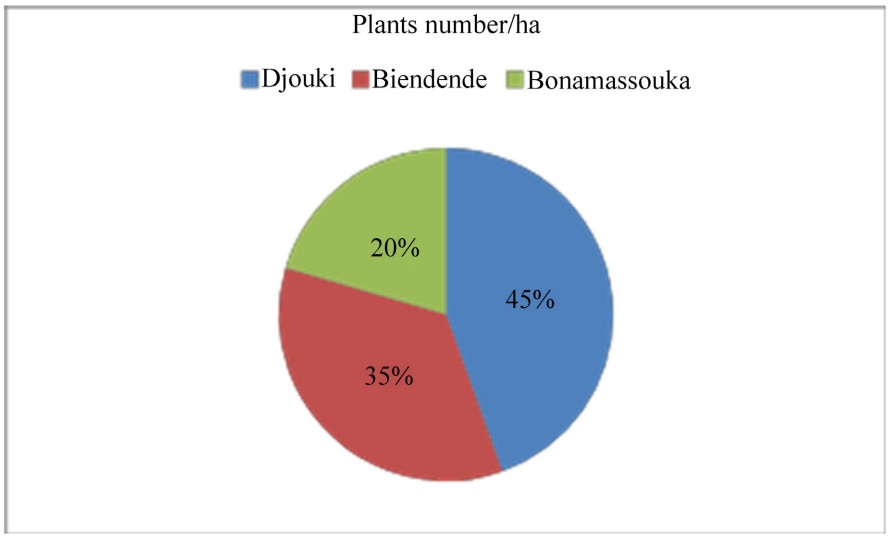

Figure 5. Pandanus counted per hectare in the three sites.

4.4. Biomass of Different Parts of *Pandanus* spp.

The biomass of all individuals of *Pandanus* spp. plants weighed in the three sites shows that: the aboveground biomass at Njouki has a value of 0.7771 t/ha, represents 36.98% while the underground biomass has a value of 0.13245 t/ha, represents 63.02%. The aboveground biomass in Biendende has a value of 0.938 t/ha, equivalent to 36.05% and that of the underground biomass is 0.16638 t/ha, equivalent to 63.95%. The value of the biomass in Bonamassouka is 0.10282 t/ha, representing 32.79% and that of the underground biomass is 0.21076 t/ha corresponds to 67.21%. The analysis shows the average rate of biomass (aboveground and underground) in sites studied (**Figure 6**).

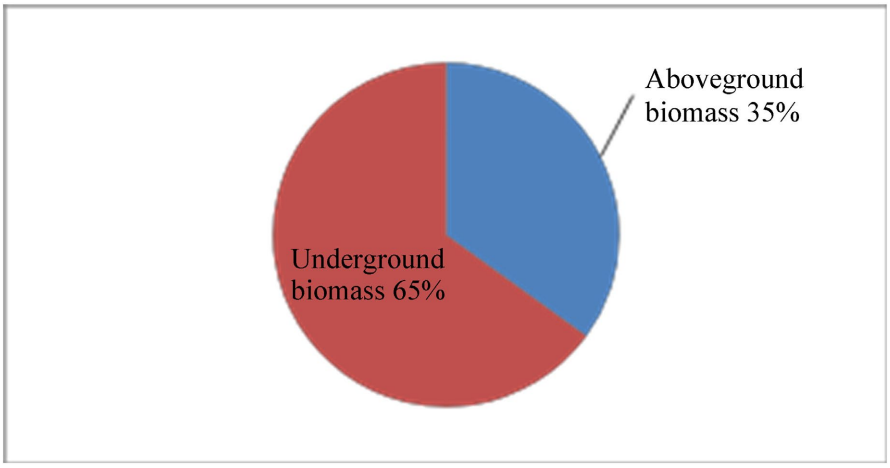

Figure 6. Biomass distribution according to plant parts.

4.5. Dendrometric Characteristics of *Pandanus* spp.

The highest average diameter (11.81 cm) is observed in the Njouki site. It is higher than those of the sites of Mbiendende (9.43 cm) and Bonamassouka (9.39 cm).

However, the average height of the trees at the Biendende site (8.63 m) is higher than those of Njouki (5.39 m) and Bonamassouka (4.32 m). The average total number of leaves is 44 in Njouki, 60 in Biendende and 73 in Bonamasouka (Table 2).

Table 2. Dendrometric characteristics.

Site	Observations	Statistics	Diameter (cm)	Hight (m)	Number leaf	Number of roots
Njouki	62	minimum	7.1	3	14	7
		maximum	15.6	8	138	47
		mean	11.81	5.39	44	20
Biendende	48	minimum	6.3	5	21	10
		maximum	19	14	132	38
		mean	9.43	8.63	60	18
Bonamassouka	28	minimum	5.2	3	18	11
		maximum	13.6	6	308	128
		mean	9.39	4.32	73	31

The average number of roots is 20 in Njouki, 18 in Biendende and 31 in Bonamassouka.

The regression between the number of leaves and roots of *Pandanus* spp. in Bonamassouka shows a coefficient of determination $R^2 = 0.9843$, the shape of the slope is positive and therefore increasing. An $R^2 = 0.9843$ translates that the number of roots and leaves evolve in the same direction, therefore the number of roots accounts for 98% of the variation in the number of leaves.

5. Discussion

According to [5], *Pandanus* spp. is among the "accompanying" or accidental species of *Rhizophora* mangroves in Cameroonian mangroves. So it can only spread quickly in degraded areas. The consequence of its high density is that those sites are more degraded.

The ecological niche of the study area is characterized by a relief with a gentle slope located approximately 2 m from the Wouri River. Other floristic species such as *Avicennia germinans*, *Drepanocarpus lunatus* and *Raphia* spp. are also observed. Its fauna is characterized by the strong presence of antelopes, crabs and monitor lizards. Its soil is loamy-sandic, therefore full of organic matter. These observations were also made by [14] in his study in the coastal zone of Ntem River.

The underground biomass on all three sites is significantly higher than the aboveground biomass. [9] corroborates these observations. According to this author, most mangrove species have an average total biomass of more than 50% underground. Their root system helps reduce current velocity and increase sediment retention.

Additionally, by increasing sediment retention and accumulating organic matter, mangrove root systems stabilize soils and reduce the risk of erosion. Which

was also supported by the authors [15] [16].

Carbon stock depends mainly on depth and to a lesser extent on geomorphology and species dominance. By multiple component analyses, the most important carbon stocks are located at more than 50 cm depth, in mangroves with open canopy cover. Thus, the carbon stored in the standing biomass is estimated at 7,990 g C/m^2 and the overall carbon stock of mangroves is estimated at 1.2 Pg C/m^2. These data from IUCN (2009) are in agreement with the results obtained on the site.

6. Conclusions

This study aimed to characterize the ecological niche and determine the biomass of *Pandanus* spp. in the area studied in Dibombari for contribution to the sustainable management of mangroves. It was necessary to determine the geographical distribution and density of *Pandanus* spp., determine its biomass and determine its dendrometric parameters.

By the use of the different methods of collection and data analysis related to the theme, our study shows that the density of *Pandanus* spp. varies depending on the sites, therefore 45% in Njouki, 35% in Biendende and 20% in Bonamassouka. The biomass varies depending on the plants parts, therefore 63.95% for the aboveground biomass and 36.05% for the underground biomass. The dendrometric characteristics also vary depending on the site and the number of roots accounts for 98% of the variation in the number of leaves.

It should also be noted that *Pandanus* spp., due to its stilt roots, spreads over large areas and therefore represents a threat to the biodiversity of mangroves. There is a need for good management of this species.

However, to reduce the above-mentioned threats, measures have been proposed as a result. An in-depth study to determine the true role of this species in order to develop a management and monitoring plan.

Contribution of Authors

The authors of this article are divided into two groups:

The authors who participated in all project activities (data collection, sample collection, data analysis, review, correction) are Hyacinthe ANGONI, Gordon AJONINA. B., Jean EKINDI, Jean Luc NGIMBIS, Jean Charbell MBEGA.

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Conflicts of Interest

There is no conflict of interest.

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