African Journal of Biology and Medical Research
ISSN: 2689-534X
Volume 6, Issue 3, 2023 (pp. 63-71)
www.abjournals.org

INVENTORY AND SPATIAL DISTRIBUTION OF INVASIVE AQUATIC PLANTS IN THE LOWER PART OF THE NYONG RIVER AT LOKOUNDJE IN THE OCEAN DEPARTMENT (SOUTH-CAMEROON)

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Cite this article:

Nwamo R.D., Ndjouondo G.P., Essiane Obono A.E., Tchogom Manga J.J. (2023), Inventory and Spatial Distribution of Invasive Aquatic Plants in the Lower Part of the Nyong River at Lokoundje in the Ocean Department (South-Cameroon). African Journal of Biology and Medical Research 6(3), 63-71. DOI: 10.52589/AJBMR-OVZ74ZXX

Manuscript History

Received: 2 Feb 2023

Accepted: 12 March 2023

Published: 26 Sept 2023

ABSTRACT : *The study, conducted from February to June 2020, presents a specific inventory of aquatic invasive plants and a mapping of their distribution gained from field observations and data collection campaigns on the lower part of the Nyong River. Specifically, it was a question of inventorying plant species and geo-referencing their biotopes. Through the results obtained, 12 taxa of aquatic invasive species are present (10 species upstream, 08 in transition, and 02 downstream). Of the 12 species, 10 have an ornamental mode of introduction and 01 is endemic to the environment. In addition, it also emerges from this study that the spatial distribution of the species of aquatic plants designated in the study area presents clusters mainly around the islets represented and on certain parts of the banks of the river.*

KEYWORDS: Inventory, Invasive Aquatic Plants, Mapping, Nyong River.

Article DOI: 10.52589/xxxxxx
DOI URL: https://doi.org/10.52589/xxxxxxxxx

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INTRODUCTION

The development of human societies has contributed to the breakdown of natural barriers and the expansion of species outside their original range **(Danho et al., 2014)**. The ecological disturbances of natural environments associated with a growing increase in trade volumes have favored the introduction and dispersal of many plant species, some of which have now become harmful to the environment **(Lowe et al., 2000)**. This is the case of invasive aquatic plants which pose a particularly acute problem in tropical and intertropical zones **(N'dah & Arfi, 1996)**. Indeed, they represent a threat to rivers and freshwater basins both in areas close to the sea and inland **(Labrada & Fornasari, 2002)**. Due to their extremely high growth rate, they can quickly cover large areas and considerably modify the functioning of the ecosystems concerned **(N'dah & Arfi, 1996)**. These species have impacts on biodiversity, public health, and agricultural systems. Indeed, they contribute to the disappearance of local species by competing with them and sometimes jeopardizing the survival of some of them. Others, such as Elodées, can lead to the asphyxiation of water bodies used to supply drinking water **(CGF & CBNB, 2010)**. Many rivers in Cameroon like the Wouri, the Nkam, the Moungo, and the Nyong, and their tributaries are thus invaded by these plants. However, these rivers are vital compartments containing many natural resources (fauna, flora, micro-organisms, mineral elements) **(Karim et al., 2006; Tchiaze et al., 2016)**. This observation is made on the Nyong River, in particular, the lower part, which for several years has undergone continuous degradation under the combined effect of anthropogenic and climatic factors, with the consequences of the erosion of halieutic biodiversity, the uncontrolled and supernumerary development of certain invasive plants, scarcity of water resources, food insecurity, declining incomes and rural exodus **(Nouga et al., 2017)**. The Nyong River, which is full of great biodiversity, unfortunately, finds itself under pressure from human activities despite its importance for the survival of several millions of inhabitants. The Nyong River, still very little known, is therefore exposed to a certain disappearance in the coming years due to its invasion by many invasive species because, in Cameroon, to date, both for this river and for many others, there is still no comprehensive list of invasive species, even though piecemeal work has been carried out there. To this end, the work carried out in Mbalmayo, in particular, that of **Nouga et al. (2017)** focused on the one hand on the socio-economic aspects of the fight against invasive aquatic plants of the Nyong River in the commune, and the other hand on the development of a management plan for invasive aquatic plant species: the case of the Nyong River. **Tchiaze et al. (2016)** evaluated the distribution and valuation of invasive macrophytes in the coastal region (Cameroon): the case of *Eichhornia crassipes* (Mart.) Solms-Laubach. This study lists the invasive species of the Nyong River and their stage in the process of invasion of the environment and gives a map of the distribution of invasive plant species in the lower part of the Nyong River. In addition, the problem of invasive plants is now the subject of growing interest for conservation and the subject of international cooperation **(Danho et al., 2014)**. It is becoming essential to conduct a study that will make it possible to inventory the specific richness of invasive aquatic plants in the lower part of the Nyong River. Also, until now, different techniques have been developed to control invasive species and their effects on the environment. Until recently, the focus has been on developing tools to prevent biological invasions. In addition to prevention, research aims to identify future invaders and determine their biological and ecological characteristics **(Devin & Beisel, 2006)**. Initiatives such as the global invasive species program list inform international opinion on the danger of these taxa **(Lowe et al., 2000)**. The International Union for Conservation of Nature, for its part, through

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its program on invasive species, has put in place definitions and legal frameworks for their eradication in protected areas **(Dahno et al., 2014)**.

MATERIAL AND METHODS

Choice of Stations

The choice of the sampling point was made about the diversity and accessibility of plant species. After the prospecting phase and consultation with resource persons, three (03) stations were selected and geo-located using a Garmin GPS (Global Positioning System). This is the Donenda (DON) upstream station, located between 03°19'30" North latitude and 10°1'30" East longitude and 16 km from the mouth. Dikobé (DIK), the intermediate station, is a transitional zone between Donenda and Béhondo located between 3°18'0'' North latitude and 10°0'0'' East longitude and 14 km from the mouth. The downstream station, Béhondo (BEH), is dominated by islets and located 4 km from the mouth between 3°16'30" North latitude and 9°55'30" East longitude **(Fig. 1)**.

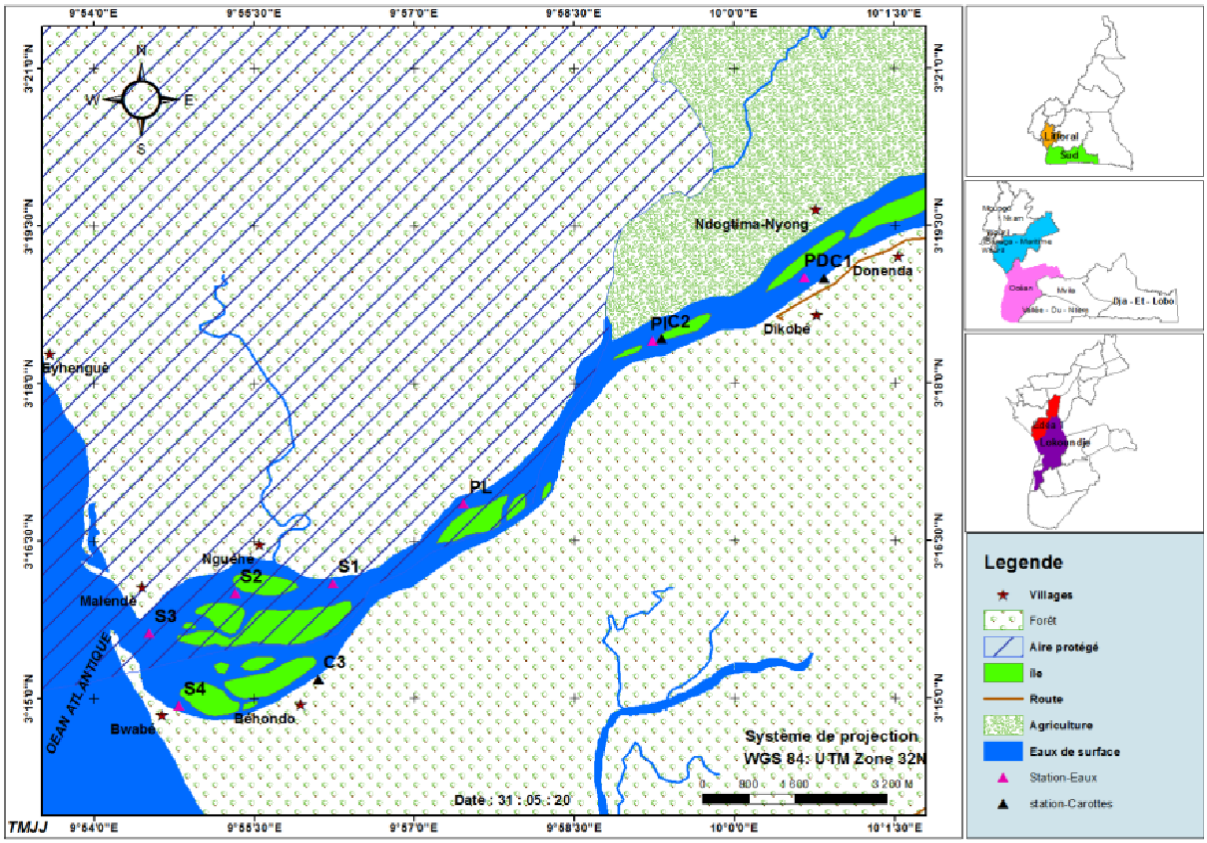

Figure 1: Invasive species sampling stations

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Determination of the Species Richness of Invasive Aquatic Plants in the Lower Part of the Nyong River

The richness of plant species present in the determined study section does not take into account the relative abundance of species but their spatial distribution. The census of the different foci (communities) of macrophytes was carried out for one week by patrolling the 500m long transects located at each station. To this end, invasive aquatic plant species were visually identified by following the watercourse and the islets using a motorized canoe. Then, each household was geo-referenced. The plants listed were then collected, codified, and kept in a herbarium for later identification. For each species, the preparation of the herbarium consisted of harvesting the entire plant including the root system, the basal and stem leaves as well as the reproductive parts (flowers and/or fruits, cones, or sporangia). The plants identified were classified according to their stage in the process of invasion by Richardson et al. (2000) for which there were 3 phases in the establishment process of an invasive alien plant: Introduction (newly introduced and possessing adult individuals), Colonization (the plant establishes a population reproducing and increasing to form colonies maintaining themselves by themselves), and Naturalization (the species establishes a self-maintaining population). It disperses and becomes incorporated into the resident flora.

Mapping the Distribution of Invasive Plant Species

Heinis (2012) affirms that the mapping of the main invasive alien plant species is essential to identify the different places where these species develop and thus put in place the measures necessary to limit them. It also makes it possible to assess, over the longer term, the speed of propagation of these species and/or to monitor and assess the effectiveness of the various measures that have been taken to combat certain species. In some cases, this makes it possible to avoid any problem of new colonization or invasion in the context of works and/or development by importing fill contaminated by the species. In addition, the precise location of invasive species and their mapping make it possible to establish the degree of invasion of a site and thus determine the strategy to be undertaken to fight against these species. **Heinis (2012)** at the end of these studies also concludes that the mapping aims to improve coordination between the different actors affected by this problem, and also to raise awareness among stakeholders and improve prevention against these species. In practical terms, to map the distribution of invasive aquatic plant species, a GPS has made it possible to geo-locate and geo-reference the areas occupied by them. Subsequently, a background map was chosen, the collected data was added to it and the style was changed. Subsequently, the pop-ups were configured and the map was saved for use.

Data Processing

The identification of the invasive aquatic plants collected was carried out at the National Herbarium of Cameroon. The data collected was processed using the Excel 2013 spreadsheet and Google Earth and Arcgis.10.3 software was used to produce the maps.

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RESULTS AND DISCUSSION

Species Richness

The general physiognomy of the invasive aquatic plants of the lower part of the Nyong shows that the upstream and the transition are more diversified than the downstream. The largest geographical distributions of plants are therefore observed upstream and in transition with a predominance of the Onagraceae family (03 species) followed by Poaceae (02 species). Twelve (12) species of invasive aquatic plants have been identified, all exotic distributed in nine (09) families, eight (08) genera including two (02) undetermined **(Table 1)**. The majority of families develop in the DIK station (07 families), followed by the DON station (05 families), and finally the BEH station where there are 02 families. Many families are represented by a single species including Cyperaceae, Araliaceae, Commelinaceae, Asteraceae, Euphorbiaceae, Amaryllidaceae, and Pandanaceae. Apart from the two indeterminate species, it appears on the whole of the site studied that all the species listed have an interest in the field of ornament with an invasive character because they would have been introduced largely intentionally by humans. Furthermore, it also emerges from the results obtained that one species is endemic to Cameroon, namely *Pandanus latiloculatus* **(Table 1)**. The results obtained also reflect the presence of *Hydrocotyle ranunculoides* L. f., a naturalized species, an emerging rank 2 invasive native to America, as well as that of species of the genus *Ludwigia* which are known as "emerging" invasive species according to **Heinis (2012)**, proven invasive in extension in natural environments and rank 4 on the **Lavergne (2010)** scale of invasibility.

Tableau 1: Matrix of Data Expressed As Presence/Absence of Aquatic Plants Recorded in the Three Stations

Familly	Species	DON	DIK	BEH	Eco	Type	I.M.
Amaryllidaceae	*Crinum natans* (Baker.)	1	0	1	A	InV.	Orn.
Araliaceae	*Hydrocotyle ranunculoides* f. minima (Kuntze.)	0	1	0	A	InV.	Orn.
Asteraceae	*Crassocephalum crepiduioides* (Benth.) S. Moore	0	1	0	A	InV.	Orn.
Commelinaceae	*Commelina benghalensis* L.	0	1	0	A	InV.	Orn.
Cyperaceae	*Cyperus papyrus* L.	1	1	0	A	InV.	Orn.
Euphorbiaceae	Indéterminée 1	0	1	0	A		
Onagraceae	*Ludwigia adscendens* (L.) H. Hara	1	1	0	A	InV.	Orn.
Onagraceae	*Ludwigia grandiflora* (Michx.)	1	1	0	A	InV.	Orn.

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Onagraceae	*Ludwigia peploides* (Kunth) P. H. Raven	1	1	0	A	InV.	Orn.
Pandanaceae	*Pandanus latiloculatus* (Huynh.)	1	0	1	A	InV.	Orn. /End.
Poaceae	*Echinochloa pyramidalis* (Lam.) Hitch. & Chase	1	1	0	A	InV.	Orn.
Poaceae	Indéterminée 2	1	1	0	A	InV.	

Eco. Ecology, **Orn.** Ornamental, **End.** Endemic, **InV.** Invasive, **MI.** Introduction Mode

The general physiognomy of the vegetation of the lower part of the Nyong shows that the upstream and the transition are less diversified than the downstream. **Priso et al. (2012)** formulated a similar conclusion which revealed from the work carried out on the Kondi that the diversity was high on the sites located upstream and decreased from upstream to downstream. On the other hand, **Nouga et al. (2017)**, in a study conducted on the development of the management plan for aquatic plant species, concluded that five species of invasive aquatic plants were encountered in the Nyong river basin at Mbalmayo in Cameroon, namely *Echinochloa pyramidalis*, *Ipomoea aquatica*, *Nymphaea lotus*, *Leersia hexandra*, and *Commelina benghalensis*. Moreover, the decrease in richness observed from upstream to downstream (mouth) observed at the end of the study would find an explanation for the increase in the flow of water about the balancing of the tides which is more noticeable at the mouth than on the mainland, the anthropic activities which fade as one approaches the sea and the clayey-sandy texture of the soil. Indeed, the clayey-loamy texture of the soil of DIK and Donenda would facilitate the inking of the roots due to the minor influence of the sea in this part of the river, unlike the soil of the downstream station which is closer to the mouth and subject to the permanent influence of seawater.

Spatial Distribution of Invasive Aquatic Plant Species Identified in the Study Area

The spatial distribution of the species of aquatic plants identified in the study area presents different plant foci found mainly on the banks of the river and around the islets sheltering villages. From this mapping of the spatial distribution of invasive aquatic plant species, ten (10) species are the most noticeable on the site and of these, *Ludwigia adscendens Cyperus papyrus* and *Pandanus latiloculatus* appear as those occupying most of the site of the study and are mainly found on the banks. The group of the seven least represented species is made up of *Hydrocotyle ranunculoides* L. f., *Crassocephalum* sp., *Commelina benghalensis*, Undetermined 1, *Crinum natans*, *Echinochloa pyramidalis* and Undetermined 2. From this map, we can also note a scarcity of aquatic plant foci as we go closer to the mouth with 2 species and 2 families encountered at Behondo **(Fig. 2)**.

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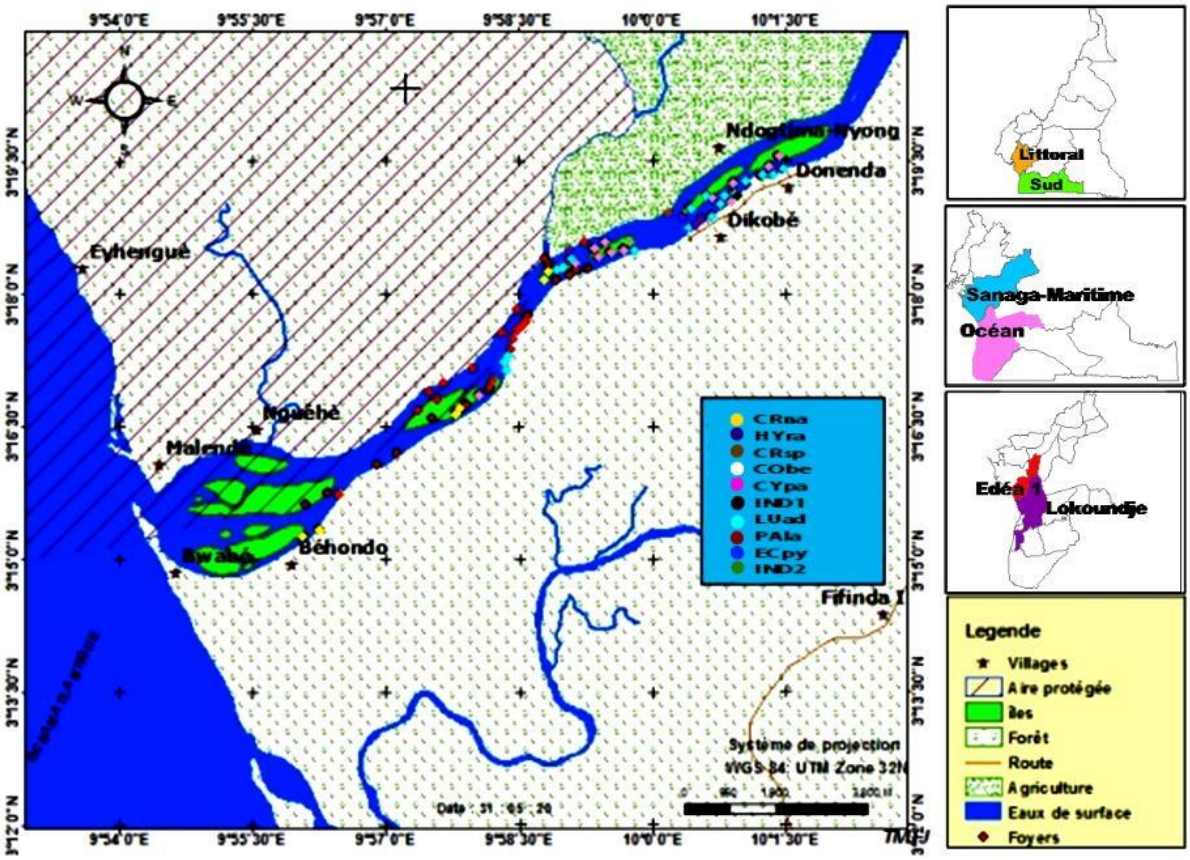

Figure 2: Mapping of the spatial distribution of invasive aquatic plant species recorded in the lower part of the Nyong River

Apart from the two indeterminate species, it appears on all the sites studied, that all the species listed have an interest in the field of the ornament with a character invasive because they would have been introduced largely intentionally by humans, which is similar to the results obtained by Ndano et al. (2014) where it appears that the different plants were introduced largely intentionally by humans through agriculture or as ornamental plants or even accidentally. To this end, Lavergne (2010) also specifies that *Hydrocotyle ranunculoides* is an exotic species (or group of related species) whose extent of spread is not known or is still limited in the Center region. Also, they are exotic plants (or groups of related species) whose proliferation, in undisturbed or little disturbed natural environments, cause significant damage (proven or supposed) to the abundance of populations and invaded plant communities.

Article DOI: 10.52589/xxxxxx
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CONCLUSION

The flora of the lower part of the Nyong River contains 09 families with those of Onagraceae (03 species) and Poaceae (02 species) as the most represented, with 12 species all invasive among which 10 would have been introduced as ornamental plants. Except for *Pandanus latiloculatus*, many species although present in the study area are not endemic. They form self-maintaining populations in competition with many other pioneer species. Furthermore, the genus *Ludwigia* is the most widespread. The study highlights the real absence of a global study on invasive plants in aquatic ecosystems in Cameroon, particularly on the lower part of the Nyong River. This problem has not been sufficiently documented to allow for permanent monitoring. The harvest data obtained so far are patchy and do not make it possible to effectively estimate the years of introduction of these species. The most precise documentation is that mentioned above. Similarly, the updating of works is almost non-existent. Also, studies on the socio-economic impact of those species on the activities of rural populations are not well documented.

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