



RESEARCH PAPER

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Evaluation of the diversity and characterization of the distribution of the arborescent species of the town of Daloa (Cental-Western of Côte d'Ivoire)

Kouassi Kouadio Henri*, Kouassi Kanga Justin, Sidibe Ousmane

**Department of Agroforestry, Faculty of Plant Biology and Ecology, Jean Lorougnon Guédé University, Daloa, Côte d'Ivoire*

Department of Environment, Faculty of Biodiversity and Tropical Ecology, Jean Lorougnon Guédé University, Daloa, Côte d'Ivoire

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Abstract

In Côte d'Ivoire, no study on the urban flora took into account the types of urban forestry planning. However, certain reasoned types of planning constitute zones refuge for woody numerous species. The objective of this study is to evaluate diversity and to characterize distribution of the arborescent species in the types of town-planning of Daloa. With this intention, inventories of arborescent species of dbh ≥ 10 cm and at least 2m height in square small squares of 400m² (20m x 20m) coupled to itinerant inventories inside the various types of planning were carried out. Eight types of urban forestry planning were identified in the town of Daloa. The overall floristic richness of arborescent species is 101 species divided into 37 families and 81 genera. The diversity and the distribution of the arborescent woody species vary according to the types of planning. Indeed, the dwellings are the mediums the most diversified in genera and woody in cash arborescent. On the other hand, the sports equipment and public garden are the least diversified mediums. On the other hand, all the types of planning are floristically homogeneous. The type of planning is not a determining factor in the distribution of the arborescent woody species in the town of Daloa.

***Corresponding Author:** KOUASSI Kouadio Henri ✉ kouassikangajustin@gmail.com

Introduction

In Côte d'Ivoire like everywhere into the world, the problems involved in the irrational urbanization are becoming more and more of importance and width (Oura, 2013). Implying a loss and a fragmentation of the natural habitats, the fast and uncontrolled urbanisation of the localities is recognized today like one of the major causes of erosion of the biodiversity (Shochat and *et al.*, 2010).

Indeed, the current populations attach more significance with what has a monetary value while forgetting the invaluable advantage of having green spaces in a city. Sometimes even the Master line of urbanisation became null and void (Ogalama, 2013) and the implementation of the plans prepared for a long-term planning of green spaces downtown is often not effective.

This phenomenon has become increasingly apparent for a few years in the commune of Daloa and will be accentuated if nothing is undertaken. According to work of Tuo *et al.* 2016, its statute of city-crossroads caused an urban sprawl without precedent. This form of urbanisation in time and space to the detriment of the natural environment is particularly alarming from an environmental, economic and social point of view.

Despite the many global disasters associated with the phenomenon of increasing urbanization and international commitments to counteract this phenomenon, Radji *et al.*, Simza (2012), including in Côte d'Ivoire. In addition, the considerable evolution of habitat types and the diversity of species in the city are still insufficiently documented (Smith *et al.*, 2006); Aguejedad, 2011).

In addition, studies on the assessment of diversity and characterization of the distribution of woody species in different types of development are almost non-existent in Côte d'Ivoire in general and in the city of Daloa in particular. In the city of Daloa, only one survey of pathway-aligned trees was conducted (Kouassi *et al.*, 2018).

The urban ecological balance is still in existence, and this requires research, coupled with participation in communication with all political, economic and social actors. It is from this perspective that this work has been initiated with the general objective of assessing the diversity of wood types in Daloa.

Specifically, the study of characterizing the typology of urban forest development, assessing the diversity of woody species and describing woody plant groups of development types.

Materials and methods

Sites of the study

Capital of west-center of Côte d'Ivoire, Daloa is localised between 6°30' and 8° of northern latitude and between 5° and 8° of western longitude (Fig. 1). The commune of Daloa is characterized by a great space extension with 393 ha in 1962, 838 ha in 1975, 1 118.25 ha in 1980 and 9 650.75 ha in 2014 (Diarra *et al.*, 2016). This situation makes of it the third big city of the country after Abidjan and Bouaké.

The climate of the Department of Daloa is wet tropical type characterized by two rainy seasons of unequal importance, separated by two small dry seasons. The average height of precipitations is of 1,317mm a year with an average temperature of 25.6°C (Amian *et al.*, 2017).

The geological formations are those of the Precambrian means dominated primarily by the granites, to which some intrusions of schist and flysch are added (Yao *et al.*, 2012). The grounds which result from the degradation of these rocks ferralitic fairly in strongly are desaturated (Oswald, 1994).

The area contains the semi-décidues forests with *Celtis spp* and *Triplochiton scleroxylon* in the sector mesophilic of the Guinean field, with the central-western of Côte d'Ivoire (Guillaumet et Adjanohoun, 1971). All this natural vegetation is currently deeply degraded and parcelled out under the effect of the intensive farming and the increasing urbanisation.

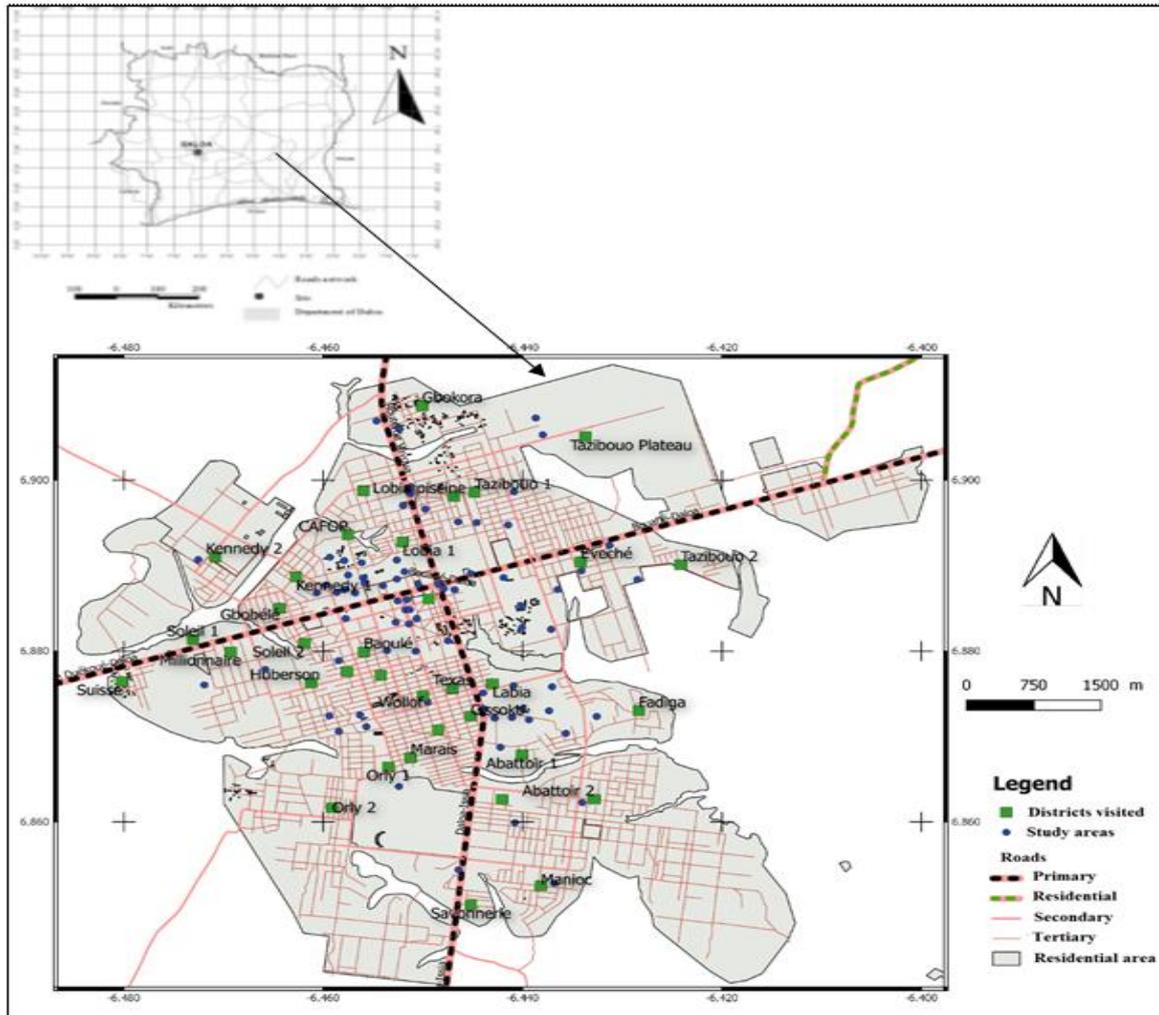


Fig. 1. Location of the sites of study in the town of Dalao.

Floristic inventories

The floristic data-gathering was done through statement of surface and the itinerant statement in each type of planning. The surface of the unit piece was estimated at 400m² (20m x 20m) inside which, all the woody species having at least a dbh of 10cm and a 2m height met were identified and their names noted on a card of statement. The operation was continued until we cover all the space occupied by installation. Itinerant statements were also realized between the small squares along the transects and in certain very difficult places of access and related to only the species omitted during statements of surface. Concerning the private residences, an itinerant inventory was also carried out inside each batch and all the plant species met inside these batches were noted. The surface of each visited batch varied between 450 of 600m².

Data analysis

Determination of the typology of urban green spaces

The classification of the types of planning was based on that of Jancel (1997) which proposes thirteen typologies namely: Parks, gardens and squares; Accompaniments of ways; Accompaniments of public buildings; Accompaniments of dwellings; Accompaniments of industrial and commercial establishments; Green spaces of social and educational establishments; Sports equipment; Cemeteries; Camp-sites; Family Gardens; Horticultural establishments; Arranged natural spaces and Trees of alignment.

Data analysis floristic

For each type of planning, the number of species, genereas and families was initially given, just as the morphological types and the chorological affinities.

Work of Aké-Assi (2001, 2002) and of Raunkier (1984) were used as a basis for the establishment of the floristic lists. These parameters made it possible to determine the floristic composition and to arise from woody associations in the types of planning. Diversity of the woody species was assessed by the indices of diversity usually used in the floristic studies throughout the world. It's Shannon-Weaver (1948), Simpson (1949) and Pielou's evenness (1966) indexes. These different indices were calculated using software R 2.8.0.

The comparison between the flora of different types of planning has been made through the coefficient of similarity Sørensen (1948). The mathematic expression of the coefficient is as follows :

$$Cs (s) = 100 \times 2c / (a+b)$$

In that formula, Cs is the coefficient of similarity of Sorensen where « a » represents the number of species registered in the site A, « b » represents the number of species registered in the site B and « c » represents the number of species common to the two sites (A and B) that we want to compare. That coefficient varies from 00% to 100% depending on the fact that the two sites have totally different (c=0) or identical (a=b=c) flora compositions. For a coefficient of similarity superior or equal to 50%, the two sites concerned are considered as homogenous.

Distribution of the arborescent species according to the types of planning

The determination of the ecological groupings and the distribution of the arborescent woody species required a Factorial Analysis of Correspondences (AFC). Software XLSTAT 2018.5.52459 was used to carry out various projections. The proximity between two statements means that their floristic composition is close, whereas the proximity between two species means that the stationnelles conditions their statements are close (Fenni, 1991). To facilitate the analysis, the name of the species was redefined according to the principle of coding of Bayer (1992). According to this method, the first three letters of the genera are associated with the first two letters of the specific epithet. For example, *Terminalia mentaly* gives Ter_me

Results and discussion

Types of urban forestry planning

During our investigations, 8 types of urban forestry planning were identified. They is the accompaniement of dwellings, of social and educational establishments, of industrial and commercial establishments, of public buildings, of sports equipments, public garden, trees of alignment and cemeteries.

Richness and floristic composition

The flora of the types of planning is rich approximately 101 arborescent species. These species are distributed into 37 families and 81 genera of which the most important are Ficus genera (7 species), Citrus genera and Terminalia genera (4 species). The dominant families are Moraceae (10 species), Caesalpiniaceae (8 species), Euphorbiaceae and Mimosaceae (7 species) and Annonaceae (5 species). The various types of planning differ largely in floristic term of wealth (Table 1).

The highest number of woody species, genera and families was recorded in the dwellings (78 species, 65 genera and 30 families) and in the social and educational establishments (73 species, 63 genera and 30 families). The least provided mediums woody in cash are the sports equipment with only 8 species and of the public garden with 4 species (Table 1).

Table 1. Arborescent species richness of the types of town-planning of Daloa.

Types of planning	Especies number	Genera number	Families number
PUB BUL	54	46	23
SOC & EDU	73	63	30
IND & COM	46	42	23
CEM	22	20	15
SPO EQU	8	8	8
PUB GAR	4	4	4
DWE	78	65	30
TRE ALI	19	15	14

PUB BUL: Public buildings accompaniment; SOC & EDU : green spaces of social and educational establishments; IND & COM: industrial and commercial establishments accompaniment; CEM: Cemeteries; SPO EQU: Sports equipment; PUB GAR: Public garden; DWE: Accompaniment for dwellings; TRE ALI: trees of alignment.

Within the woody flora of Daloa, we are noted 67,74% of Microphanerophytes, 24,73% of Mesophanerophytes, 7,53% of Megaphanerophytes. With regard to phytogeographical affinities, one observed an abundance of the introduced species (47%), then come the species from the zone of transition forest-savanna (GC-SZ) and the species Guineo-Congolian (GC) with each one 23% of the species woody. The species Sudano-Zambezian (SZ) are represented with only 7% of the species.

Diversity of arborescent species

The values of the indices of Shannon, Equitabilité and Simpson calculated for each type of town-planning of Daloa are consigned in table 2. As regards the index of Shannon, the computed values vary from 3,96 to 1,33 respectively for the dwellings and the public garden (Table 2). For the whole of the types of planning, the values of the index of equitability of Pielou and index of Simpson are very high. They evolve from 0,90 to 0,98.

Table 2. Values of diversity indexes in different types of planning.

Types of planning	Shannon index	Pielou index	Simpson index
PUB BUL	3,64	0,91	0,97
SOC & EDU	3,84	0,90	0,97
IND & COM	3,53	0,92	0,97
CEM	3,03	0,98	0,98
SPO EQU	2,15	0,98	0,94
PUB GAR	1,33	0,96	0,90
DWE	3,96	0,91	0,98
TRE ALI	2,74	0,95	0,95

PUB BUL: Public buildings accompaniment; SOC & EDU: green spaces of social and educational establishments; IND & COM: industrial and commercial establishments accompaniment; CEM: Cemeteries; SPO EQU: Sports equipment; PUB GAR: Public garden ; DWE: Accompaniment for dwellings; TRE ALI: trees of alignment.

Homogeneity of the flora enters the types of planning

The estimates of the scale factors between the various types of planning are consigned in table 3. The values of the estimated coefficients show that only 7 couples out of the 28 couples obtained a value of scale factor

higher than 50% (Table 3). The strongest values were obtained between the social and educational establishments and the dwellings with a coefficient of about 78,15%. The public garden and the sports equipment recorded the low values (8,33%).

Distribution of the arborescent woody species according to the types of town planning of Daloa

The AFC carried out (Fig. 2) watch the distribution of the arborescent woody species according to the types of planning. This analysis emphasizes four groups of arborescent woody species set out again in the factorial design formed by the first two components (axes 1 and 2). The office plurality of the percentages of inertia absorptive by the first two axes is of 65,60% of the variability observed of which 36,37 % are applied to the axis 1 and 29,23% with axis 2. Located negatively compared to axis 1 and positively compared to axis 2, group 1 is only made up of the park. No species is dependent on this medium. With a broad distribution, *Azadirachta indica*, *Delonix regia* and *Senna siamea* forming group 2, are dependent on no type of installation. The remaining woody species set out again at the same time in the dwellings, the social and educational establishments, the industrial and commercial establishment, the sports equipment, with the accesses of the ways, the public buildings and inside the cemeteries. This regrouping sets up group 3. In these biotopes, the woody species met will be *Mangifera indica*, *Azadirachta indica*, *Albizia lebbek*, *Ficus benjamina*, *Citrus sinensis*, *Morinda lucida*, *Terminalia mentaly*, *Calotropis procera*, *Duranta repens* etc...

Floristic diversity the low floristic wealth of the investigated types of planning confirms well the poverty of green spaces of our cities. Indeed, the urban cities and spaces are primarily characterized today by an absence of green spaces (Georgi and Dimitriou, 2010). Thus our cities suffer enormously from the ecological risks: upheavals of grounds, air pollution, anarchistic spreading out, increase in the effects of urban small island of heat, erosion of the biodiversity, etc... However, in the current trend of sustainable development, the safeguarding of the

urban biodiversity in particular raised and the reinforcement of the role of nature downtown from now on are essential like a major stake for the new strategies of urbanisation sustainable. The families of Moraceae, Caesalpiniaceae, Euphorbiaceae, Mimosaceae and Annonaceae inventoried that dominate the woody flora are not specific to this study. This same remark was passed at the national level by Vroh *et al.* (2014) and Kouadio *et al.* (2016), at the African level by Merimi et Boukroute (1996) and El-Lakany (2001), and on a world level by Fernandes and *et al.* (2004) and by Romero and *et al.* (2009). This predominance in the urban flora is due to the fact that most these species adapt well to the climatic conditions and edaphic of the city (Dardour *et al.*, 2014). The strongest values of the index of Shannon obtained within the social and educational establishments show that the flora of these mediums is diversified than those of the other zones. This strong floristic diversity can be due to the great floristic wealth coming from the introduction of new species at the time as of alteration work into these spaces. In the visited public garden, one finds

there that some species isolated such as *Azadirachta indica*, *Casuarina equisetifloia* and *Eucalyptus camaldulensis* in lower part of which some adventitious push. It is what results in the value of the index of Shannon which is weaker in these biotopes. This report is contrary with that done by Lamri in 2012 with Setif (Algeria). This situation of the town of Daloa is primarily due to the incapacity of the authorities to plan the urbanisation on the long run.

Also the rate of sensitizing on the role of the urban forestry in the life of the populations is very weak. With that, it is necessary to add the ignorance of the role of the plant species in the life of the urban populations and the development to which they aspire. All these situations are confirmed by the values of the index of Simpson which follow the same trends as those of the index of Shannon. Let us tax met in all the mediums equitably are well distributed in the inventoried mediums, because all the calculated indices of Equitabilité tighten all worms the maximum value (1). That indicates homogeneity of urban forestry developments.

Table 3. Coefficients of similarity of Sorensen between the different types of town-planning of Daloa.

Types d'aménagement	PUB BUL	SOC & EDU	IND & COM	TRE ALI	CEM	SPO EQU	PUB GAR	DWE
PUB BUL	0	69,29	74	46,58	47,37	22,58	13,79	65,15
SOC & EDU		0	70,59	34,78	42,11	17,28	10,39	78,15
IND & COM			0	46,15	58,82	25,93	16	70,97
TRE ALI				0	43,9	29,63	26,09	37,11
CEM					0	26,67	23,08	44
SPO EQU						0	8,33	16,28
PUB GAR							0	9,76
DWE								0

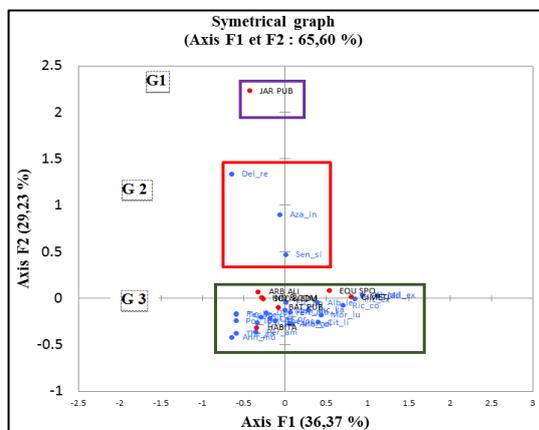


Fig. 2. Factorial Analysis of Correspondences relative to the distribution of arborecent species registered in the different types of planning.

The small degree of resemblance between the various types of town-planning of Daloa shows that in spite of the diversity of these spaces, each type of planning has a specific floristic wealth. Indeed, during forestry plannings, the choice of the plant species concerns in most case the appreciation the person in charge of the places. This situation leaves the possibility to each individual of arranging his space according to its taste. Urban environment strongly influences the choice of the plant species for the installation of spaces. During activities of installation, a particular choice is put on certain species having a strong gravitational power on the populations by their aesthetic aspects. So the amenagists use in most of

the time the same species for installation. And this situation confirms the regrouping of a high number of species and types of installation consisted group 3. Also, the afforestation it is always guided by the choice of the species to retimber and by the objective of the afforestation. This situation leaves the possibility to the amenagists of associating species with an aim of avoiding the plant health problems involved in the use of only one according to Bekkouch *et al.* (2011). It is clearly established that urban forestry planning is thus not a fact of the chance but raises of a very reasoned action.

The absence of species enfeoffing the public garden is related on the one hand on the low number of these spaces and the small proportion of woody species inventoried in these spaces. The arborescent woody species such as *Azadirachta indica*, *Delonix regia* and *Senna siamea* seem to be species which do not have affinity with a kind of planning. These species have a broader distribution since their frequencies and their abundances are constant whatever the types of planning considered.

Conclusion

At the conclusion of this study, it arises that the dwellings constitute the richest mediums floristically and most diversified while the medium poorest and less diversified are the public garden. As, the distribution of the woody species according to the types of planning it showed as the majority of the woody species are more prioritized at the same time within the cemeteries, of the public buildings, the educational social establishments, of the industrial and commercial establishments and the dwellings because of many services ecosystemic provided by those. This reason takes along the populations to integrate them in the types of planning. With the phenomenon of increasingly recurring small island of heat and atmospheric pollution with which our cities are confronted, it thus becomes indispensable to ensure the protection of the woody species and to better promote the massive introduction of the woody species into the types of planning into the town of Daloa.

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