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Chapter

Phytoecological Study, Ethnobotanical and Dynamic of Dry Vegetation in the Ngazidja Island, Comoros Archipelago

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Abstract

The dry vegetation of Ngazidja, Comoros Islands, is very rich in biological diversity. However, it is the most threatened and least known in this island. The purpose of this study is to provide ecological information about dry vegetation and to elaborate proposals for conservation. Data collection is ecological surveys, and ethnobotanical and socioeconomic surveys. Several floristic, and structural and soil parameters were processed and analyzed to characterize the sites. Five types of dry vegetal formations are identified: the dry forests of Lac-salé, Ngouni-Hamboda and Infoundihé-Chambouani, and the dry thickets of Singani, Domoni-Amboini, Hahaya. Eighteen surveys of 10 transects were undertaken. The forests are well stratified and the trees do not exceed 15 m high, with deciduous leaves. The density varies from 500 to 800 individuals per hectare in forest against 310 to 165 in thicket. A total of 103 species, belonging to 46 families, were recorded in these formations, including 70 trees and shrubs. Natural regeneration is only good for thickets and the dry forests of Lac salé and Infoundihé-Chambouani. Sustainable alternative solutions are proposed in order to improve the socioeconomic living conditions of the population and the conservation of biodiversity.

Keywords: dry vegetation dynamic, socio-economic, conservation biodiversity of ecosystems, Ngazidja, Comoros

1. Introduction

The recent geological nature of the Archipelago of the Comoros, their geographical position, the smallness of the territory and their multi-insularity give them a great originality that reflects the diversity of the landscapes and the richness of the vegetation, the fauna and the flora [1–3]. The flora of the Comoros has a great similarity with that of Madagascar. The archipelago is under a small

influence of the African continent, while some elements of the flora could come from Asia [4]. The vegetation of the Comoros Islands is known for its richness in endemic plant species; however, it remains little studied. It is characterized by two types of vegetation: medium-high and high-altitude moist forests, and low-lying, deciduous, lowland forests [2, 5–7]. The proportion of land covered by forests would decrease from 6.6% in 1990 to 1.7% in 2012, with nearly 500 ha of forest being lost each year [8]. In Ngazidja, forest cover is estimated at 8658 ha of natural forest [9]. The dry forest and thicket are found along the South-East and North slopes as well as the West Coast. Remnants of poorly disturbed dry forests are reduced to small areas of a few hectares regularly grazed by livestock [7]. In addition to these threats, climate change does not spare them. Forest species in arid and semi-arid areas have reached their limit of adaptation to aridity and, therefore, are more vulnerable to increased drought than wetland forest species [10]. In 2006, Labat already said it is urgent to identify these remnants of dry forests and thickets, because these types of vegetation are the most threatened. To our

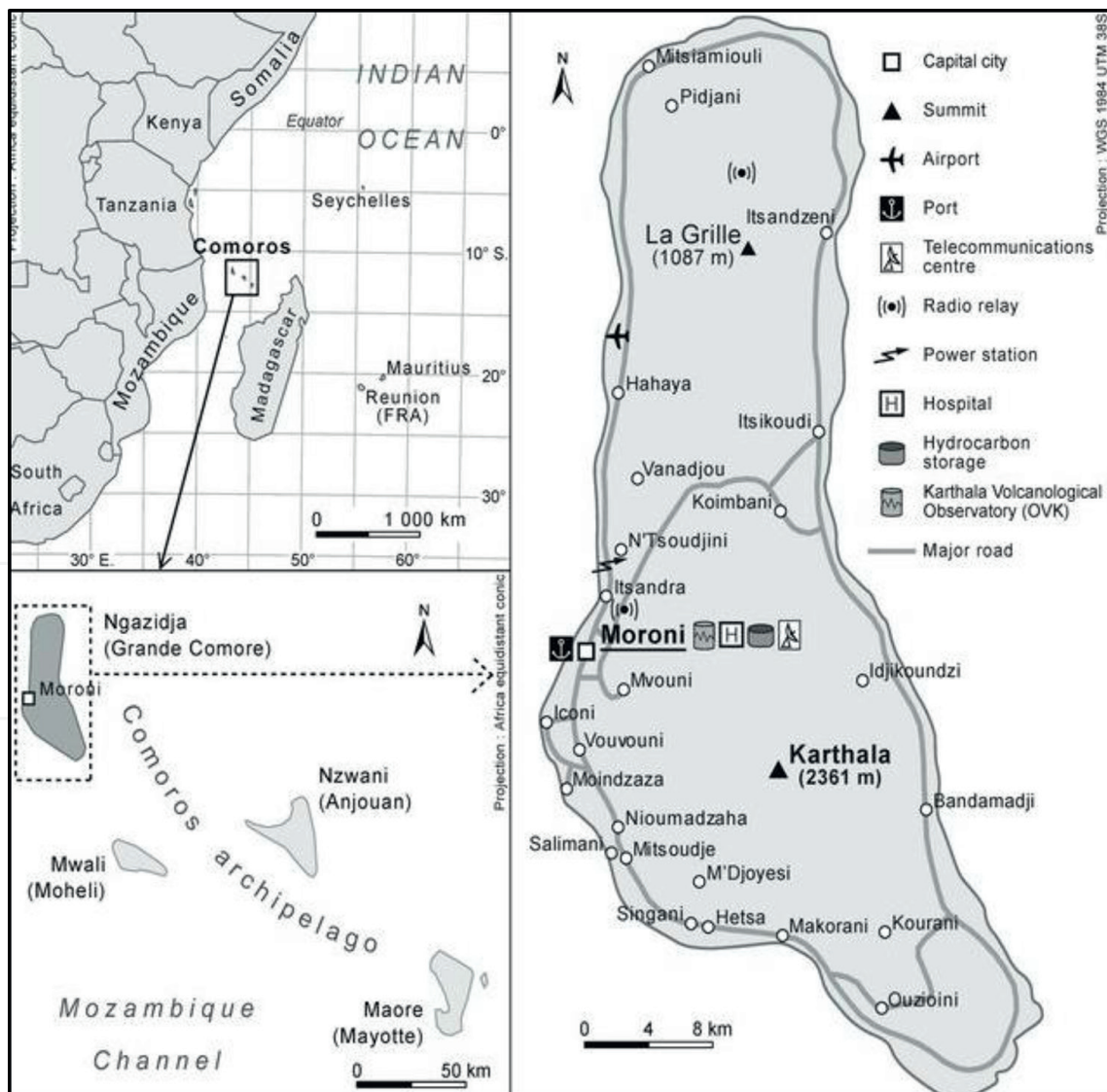


Figure 1.
Location of Ngazidja island, Comoros archipelago.

knowledge, no study has been undertaken on the ecological characteristics of the dry plant formations on Ngazidja, Comoros Archipelago (**Figure 1**). The present study aim at providing ecological information on the dry vegetation formations of Ngazidja Island and propose solutions for their conservation. The hypotheses are: (i) the dry plant formations are still very rich in endemic and indigenous species and are still threatened; (ii) These knowledge should facilitate the definition of ways of managing and conserving the natural and semi-natural habitats of dryland species, especially forests and thickets in a context of insularity but also to demographic and urban expansion socioeconomic dynamics. Our approach is based on the survey of the floristic and structural description, and the determination of threats and pressures.

2. Materials and methods

2.1 Identification of types of plant formations, choice and location of study sites

Identification of types of plant formations, choice and location of study sites. Surveys of the study areas were carried out between June and September 2019 and between January and May 2020. It consists of locating the main well preserved dry vegetation allowing to have the maximum number of endemic or native species. The choice of study sites was based on bibliographic information, stratification of various maps and direct field observations. Some criteria were taken into consideration (**Figure 2**):

- the type of formation present in the site and its state of degradation;
- the accessibility of the site and the representativeness of the site formation.
- Among the visited sites, five types of dry vegetal formations were selected:
 - dry forest of Lac-salé (“salt lake”) is limited in the north-east by the village of Ivoini and in the south-east by the town of Bangoua-kouni;
 - dry forest of Ngouni-Hamboda is limited in the north-east by the city of Moroni and in the south-east by the city of Ikoni;
 - dry forest of Infoundihé-Chambouani is located in the south-west. It is bounded in the north-west by Infoundihé-Chambouani village and in the southwest by Dzahadjou and by the National Road towards Sima-Ambouani village;
 - dry thicket of Singani is located in the south-west of this locality.
 - dry thicket Domoni-Amboini-Hahaya is limited in the north-east by the locality of Ntsaouéni and in the south-east by the town of Hahaya.

Other very degraded dry plant formations (forests and thickets) were also visited in order to maximize the number of plant species.

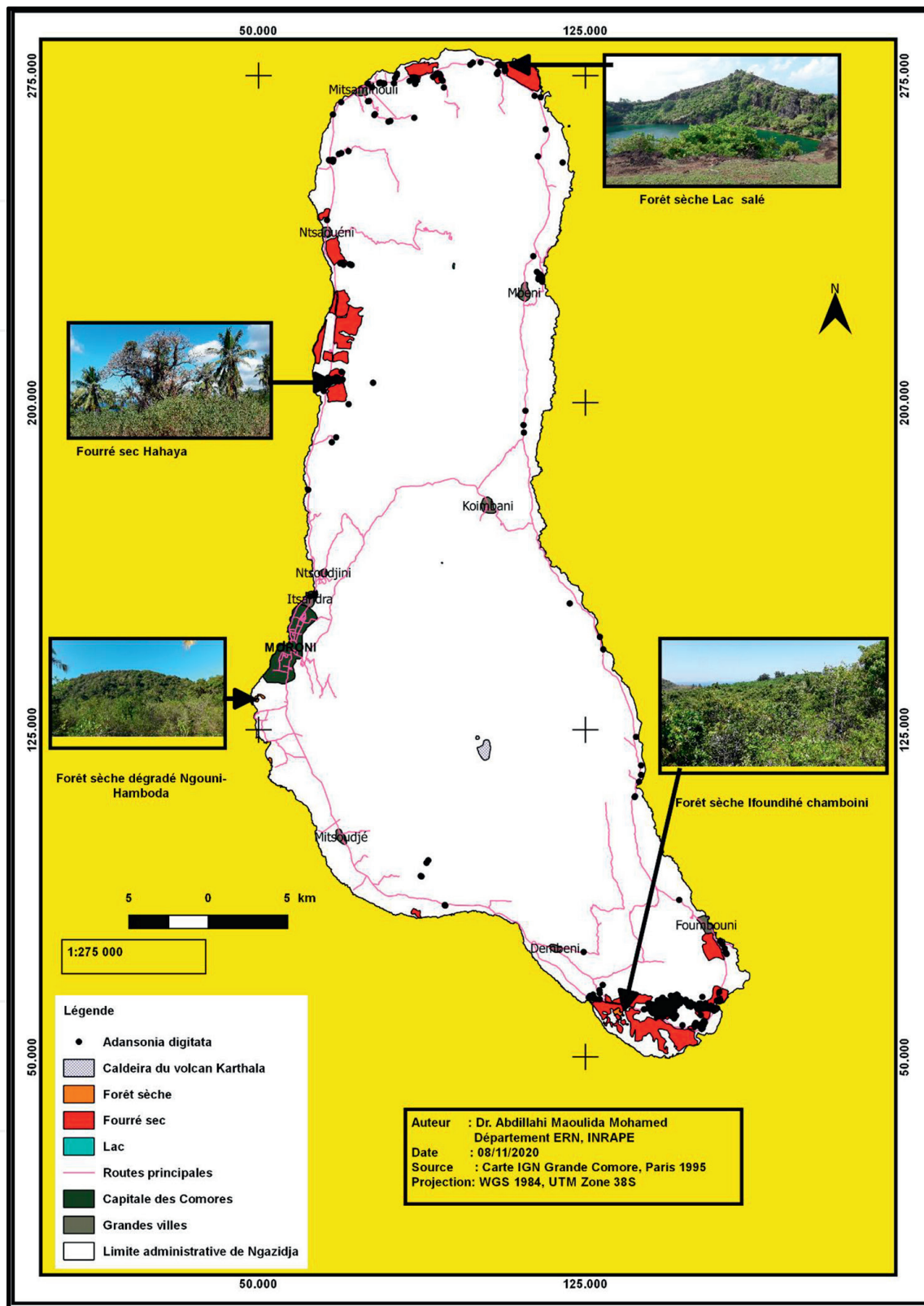


Figure 2. Location of study sites and dry plant formations and the dry vegetation formations in Ngazidja Island.

2.2 Collection of data

The Phytoecological study was used. Surveys were conducted between October 2019 and January 2020 and between April and July 2020 to maximize the chances of harvesting easily identifiable, fertile specimens. The sampling was based on:

- the plateau of the Braun-Blanquet method, used to highlight the floristic diversity and the biological spectrum, according to [11] and based on the homogeneity criteria of [12];
- Gautier's linear survey [13] was used to describe the vertical structure and natural regeneration. For the horizontal structure, density was analyzed using the Quadrat Center to one point or QCP method [14];

Eighteen (18) surveys and 10 transects following a North–South gradient, perpendicular to the sea, were delineated. Part of species was identified onsite, another part was identified at the INRAPE herbarium and the rest with the flora of Madagascar and Comoros [15] with the databases samples of the herbarium of the Museum of Natural History of Paris [16] and the Herbarium of Mayotte on the basis of the National Botanical Conservatory of Mascaraing.

Species density was assessed by counting trees with a diameter at breast height greater than 10 cm. This DBH is established from the measurement of the circumference using a tape measure. The size of the trees was evaluated by the total height (Ht), measured using a clisimeter.

Physionomic analysis, floristic diversity and similarity: Quantitative vegetation parameters (density, basal area, regeneration, species richness, biological spectra, maximum tree height) were used to characterize the types of vegetation.

For the study of natural regeneration, the Placeau method was used and consists in measuring the diameter of all the individuals of each species present in a 1 ha plot. Those individuals are classified into two categories: regenerated species (DHP < 10 cm or Nr) and seed species (DHP ≥ 10 cm or Ns). The regeneration potential is expressed by the number of regenerated individuals over the number of seed-bearing individuals, expressed by the regeneration rate (TR): $TR (\%) = (Nr/NS) \times 100$

- if the regeneration rate is less than 100%, the species is in difficulty of regeneration;
- if the regeneration rate is between 100% and 1000%, the regeneration is good;
- if this rate is greater than 1000%, the regeneration is very good.

Threat assessment on dry vegetation formations: Ethnobotanical surveys were conducted among local populations, 200 individuals, in 14 localities bordering the study sites: Singani, Dzhadjou, Sima-Ambouani, Ifoundihé-chambouani, Ikoni, Moroni, Hahaya, Domoni-Ambouani, Domoni-Adjou, Ntsaouéni, Bangoua-kouni, Ouella, Ivoini and Ouémani. They understand the interactions of local communities with plant resources (different uses) as well as the threats that weigh on the habitats. Observations were also made in the field. The formula of [17] was used to evaluate the species utilization index in order to know the species that were widely used. The people concerned above all are those who appear to have a direct or indirect impact on dry forest or thicket: lumberjacks, wood traders, collectors of medicinal plants, peasants, carpenters, farmers, head of non-governmental associations. These surveys were carried out collectively or individually, in the form of semi-direct interviews with semi-open, open or sometimes closed questions asked to men (65%) and women (35%) between 18 and 70 years old. The information is collected using a dictaphone.

3. Result

3.1 Types of dry vegetation formations identified

The types of dry vegetation formations, the natural and semi-natural identified during this study in Ngazidja island are forests, thickets and savannas (**Figure 2**):

- The dry forests were located in Ouemani-Mitsamihouli and on the ridges of the Lac-salé “salt lake” in Bangoi-kouni;
- In the region of Mbadjini (south-east) around Ikoni Hill (south-center);
- The thickets (shrubby or bushy) were located in the coastal part of the three islands, especially in the north-west part (Hahaya), in far north (Bangoi-kouni to Ivoini) and in north-east;
- Savannas are found on the eastern side of Karthala, in the Diboini Plateau and along all the coastal parts of this island (but at different stages of evolution according to their degradation). Our study concerned the ecological characterization of dry forests and thickets in Ngazidja: dry forest and thicket.

3.2 Physiognomic characteristics

Dry forests of Lac-salé and Ngouni-Hamboda (**Figure 3**) present 3 strata, with some emergents with *Adansonia digitata* and *Albizia* sp. at a height of up to 20 m:

- A continuous lower stratum, with a recovery rate of 50% and an average height between 1 and 3 m. This stratum consisted in numerous grasses and shrubs such as *Acalypha indica* (Euphorbiaceae), *Oeceoclades lonchophylla* (Orchidaceae) (species that is becoming increasingly rare in the north of the island), *Aloe alexandrei* and seedlings or young plants of the upper strata species *Erythroxylum platyclada*, *E. lanceum* (Erythroxylaceae), *Diospyros comorensis* (Ebenaceae), *Ochna ciliata* (Ochnaceae) and *Turraea wakefieldii* (Meliaceae).



Figure 3.
Dry forest of Hamboda with a mesophilic tendency.

- An average open shrub stratum with a recovery rate of 30 to 75% and a height of between 3 and 11 m. This stratum is composed of small trees such as *Terminalia ulexoides* (Combretaceae), *Alangium salviifolium* (Alangiaceae), *Sorindeia madagascariensis* (Anacardiaceae), *Pyrostria bibracteata* (Rubiaceae), *Diospyros comorensis*, *Commiphora arafy* (Burseraceae) and *Phyllarthron comorense* (Bignoniaceae). This stratum was completely invaded by lianas such as, *Vanilla humblotii* (Orchidaceae), *Rhoicissus revoilii* and *Cissus quadrangularis* (Vitaceae).
- An upper stratum, moderately dense, with a recovery rate of 60%, varying in height from 10 to 15 m. The most abundant and dominant species in this stratum were *Ficus sycomorus* (Moraceae), *Albizia lebbeck* and *Albizia glaberima* (Mimosaceae) and *Drypetes thouarsii* et *D. comorensis* (Euphorbiaceae) (**Figure 4**) and *Ochna ciliata* (Ochnaceae). Various creepers such as *Rhoicissus revoilii* and *Saba comorensis* (Apocynaceae) were present in this stratum. The minimum area value of 300 m² corresponds to a cumulative number of species equal to 60.

In the Ifoundihé-Chambouani dry forest, three strata were identified with some emergents with *A. lebbeck* and *A. glaberima* and at a height of up to 15 m:

- A very open lower stratum with a recovery rate of 45% and whose height is less than 1 m. The species of this stratum are: *Erythroxylum lanceum* (Erythroxylaceae), numerous seedlings of *Ochna ciliata* (Ochnaceae) and numerous grasses such as *Tacca leontopetaloides* (Taccaceae) and *A. indica* (Euphorbiaceae).
- An average stratum with a recovery rate of 35% and a variable height between 2 and 4 m.
- The dominant species are *Sorindeia madagascariensis* (Anacardiaceae), *Turraea sericea* (Meliaceae) (**Figure 5**), *Terminalia ulexoides* (Combretaceae), *Diospyros comorensis* and *Euclea racemosa* subsp. *schimperii* (Ebenaceae). This stratum is completely invaded by *Lantana camara*, *Saba comorensis*, *C. quadrangularis*, *Dioscorea comorensis* (Dioscoreaceae) and *Rhoicissus revoilii*.



Figure 4.
Drypetes comorensis (fruits).



Figure 5.
Turraea virens (flowers).

- An upper stratum of 6 to 12 m, discontinuous mainly composed of *Operculicarya gummifera* (Anacardiaceae), *F. sycomorus* (Moraceae) and *A. lebbeck* (Fabaceae). The minimum area value was 300 m². It corresponded to a number of 60 species.

Dry thickets of Singani (**Figure 6**) and Domoni-Ambouani-Hahaya have no stratification, with a very open canopy (10–20% recovery rate). It is a shrub vegetation 5 to 8 m high, which differed from other formations in the region only by reducing the size of the species and their foliage. Only baobabs and Albizia exceed 8 m and can reach 12 m. The minimum area of this thicket is 250m² and corresponds to 48 plant species. The dominant species are *Pyrostria bibracteata*, *Euclea racemosa* subsp. *schimperi*, *A. digitata*, *Vitex doniana*, *Albizia glaberrima*, *Phyllarthron comorense*, *F. sycomorus*, *Erythroxylum platycladum* (Erythroxylaceae), *Oeceoclades lonchophylla* and *Acampe pachyglossa* (Orchidaceae). The soil is covered by numerous seedlings of *Phyllarthron comorense*, *Euclea racemosa* subsp. *schimperi*.



Figure 6.
Acampe pachyglossa on tree of *Vitex doniana*, in dry Singani thicket.

3.3 Floristic characters

One hundred and three (103) species, belonging to 46 families, were recorded in the five formations, including 70 trees and shrubs (**Table 1**). The floristic composition of dry Forests shows sixty-five (65) species in 54 genera and 35 families. The most represented families are respectively Rubiaceae, Euphorbiaceae, Fabaceae, Apocynaceae and Erythroxylaceae. *Euclea racemosa subsp. schimperii*, *A. digitata*, *Alangium salviifolium*, *Phyllarthron comorense*, *Vitex doniana*, *Albizia glaberrima*, *Sorindeia madagascariensis*, *Pyrostria bibracteata* and *Tamarindus indica* are the most abundant species. The density varies from 500 to 800 plants per hectare. The different forms of biological adaptation observed in forest are foliar deciduousness in *A. lebeck*, *Turraea sericea*, *A. digitata*, *Commiphora arafy*, pachycaulia in *A. digitata*, epiphytism in *Aeranthus* sp. and *Acampe pachyglossa*, Geophytism in *Dioscorea comorensis* and *T. leontopetaloides* and crassulescence in *C. quadrangularis*. The biological spectrum is represented by Mesophanerophytes (55%), Microphanerophytes (25%) and Nanophanerophytes (15%).

N°	Scientific name	Family	English name	Status
1	<i>Sorindeia madagascariensis</i> (Spreng.) DC.	Anacardiaceae	Grape mango	Rare and native to Comoros, S. Somalia, Mozambique, Madagascar.
2	<i>Carissa spinarum</i> L.	Apocynaceae	Conkerberry/ bush plum/ Simple-spined num-num	Rare and native to Comoros, Africa to Indo-China, Australia to New Caledonia.
3	<i>Ophiocolea comorensis</i> H. Perrier	Bignoniaceae	—	Endemic to Comoros
4	<i>Phyllarthron comorense</i> D.C	Bignoniaceae	—	Endemic to Comoros
5	<i>Commiphora arafy</i> H.Perrier	Burseraceae	—	Rare and native to Comoros, Madagascar.
6	<i>Alangium salviifolium</i> (L.f.) Wangerin	Cornaceae	Sage-leaved <i>alangium</i>	Rare and native to Comoros, E. Tropical Africa, Comoros, Indian Subcontinent.
7	<i>Dioscorea comorensis</i> R. Knuth	Dioscoreaceae	—	Endemic to Comoros
8	<i>Diospyros comorensis</i> Hiern.	Ebenaceae	—	Rare and native to Comoros, Madagascar.
9	<i>Euclea racemosa subsp. schimperii</i> (A.DC.) F.White	Ebenaceae	“ the sea guarrie or dune guarrie ”	Native to to Comoros, Egypt to S. Africa, S. Arabian Peninsula
10	<i>Erythroxylum lanceum</i> Bojer	Erythroxylaceae	—	native to Comoros, N. Madagascar.
11	<i>Turraea sericea</i> S.m	Meliaceae	—	Rare and native to Comoros, Madagascar.
12	<i>Turraea virens</i> L.	Meliaceae	Mozambique honeyssuchle-tree	Rare and native to Comoros, Madagascar.

N°	Scientific name	Family	English name	Status
13	<i>Ochna ciliate</i> Lam.	Ochnaceae	—	Rare and native to Comoros, Aldabra, Madagascar.
14	<i>Gomphia dependens</i> DC.	Ochnaceae	—	Rare and native to Comoros, Madagascar.
15	<i>Comoranthus obconicus</i> Knobl.	Oleaceae	—	Rare and native to Comoros, Madagascar.
16	<i>Chionanthus insularis</i>	Oleaceae	—	Rare and endemic to Comoros
17	<i>Oeceoclades lonchophylla</i> (Rchb.f.) Garay & P.Taylor	Orchidaceae	—	Rare and native to Comoros, Tanzania, Mozambique, KwaZulu-Natal in South Africa
18	<i>Pandanus maximus</i> Martelli	Pandanaceae	—	Endemic to Comoros
19	<i>Phyllanthus comorensis</i> Leandri	Phyllanthaceae	—	Rare and Endemic to Comoros
20	<i>Drypetes comorensis</i> (Baill.) Pax & K.Hoffm.	Putranjivaceae	—	Very Rare and Endemic to Comoros
21	<i>Drypetes thouarsii</i> (Baill.) Leandri	Putranjivaceae	—	Rare and Native to Madagascar
22	<i>Pyrostria bibracteata</i> (Baker) Cavaco	Rubiaceae	—	Native to Comoros, Aldabra, Kenya, Madagascar, Mozambique, Seychelles, Tanzania, Zimbabwe
23	<i>Vepris boiviniana</i> (Baill.) Mzira	Rutaceae	—	Rare and native to Comoros, Madagascar.
24	<i>Sterculia madagascariensis</i> R. Br.	Sterculioideae	—	Very Rare and Endemic to Comoros
25	<i>Aloe alexandrei</i> Ellert	Xanthorrhoeaceae	—	Rare and Endemic to Ngazidja -Comoros

Table 1.
List of endemic and/or rare species observed in the dry vegetation of Ngazidja.

Natural regeneration is good for the dry forests of Lac salé and Infoundihe-Chambouani (986.64% to 995.64%) and it is bad for the Ngouni-Hamboda dry forest (50.96%).

In the thicket, fifty-three (50) species in 45 genera and 30 families. The most represented families are Fabaceae and Asteraceae. At the generic level, *Erythroxyllum* is the richest in species with three species. The density varies from 310 to 365 individuals per hectare. The different forms of biological adaptation observed in this dry thicket are pachycaulia in *A. digitata*, geophytism in *T. leontopetaloides*, epiphytism in *Angraecum eburneum*, *Acampe pachyglissa* and *Platyserium allicorne*, and crassulescence in *C. quadrangularis*. The predominant biological types are microphanerophytes (50%) and nanophanerophytes (35%). Natural regeneration is good for thickets (315.18% to 383.67%).

3.4 Specific characteristics of the plant formations studied

After analyzing the relationships between the five types of vegetation formations and their floristic procession were established. A similarity between the vegetation formations, according to their dry forest and forested physiognomy and dissimilarity according to their floristic composition (**Table 1**) could be identified. Thus, the following vegetation formations were distinguished:

- The dry forest of Lac-salé with *Turraea virens*, *Comoranthus obconicus* (**Figure 7**), *A. digitata*, *A. alexandrei* (**Figure 8**) and *Drypetes comorensis*;
- The dry forest of Ifoundihé-Chambouani (**Figure 9**) with *Turraea sercicea*, *Commiphora araf* and *Chionanthus insularis*;
- The dry forest of Ngouni-Hamboda with a mesophilic tendency with *Diospyros comorensis*, *Carissa spinarum*, *Ophiocolea comorensis* and *Sterculia madagascariensis*;
- the dry thicket of Singani with *Vitex doniana*, *Pandanus maximus*, *Pyrostria bibracteata* and *Euclea racemosa* subsp. *Schimperi*;
- the dry thicket of Domoni-Ambouani-Hahaya with *Euclea racemosa* subsp. *schimperi*, *A. digitata*, *Erythroxylum lanceum* and *A. alexandrei*.

3.5 Pressures, threats and dynamic on dry vegetation

The threats affecting forests and dry thickets in the Comoros fall into two categories: anthropogenic threats and natural threats (**Figure 10**). Anthropogenic threats are mainly caused by the misuse of different resources from different vegetation formations:



Figure 7.
Comoranthus obconicus (fruits).



Figure 8.
Aloe alexandrei (flowers).



Figure 9.
Dry forest of Ifoundihé-Chambouani.

- Agriculture and urbanization: as the population increases, the need for arable land also increases. This case occurs in the study sites where several households complain of not having enough agricultural space, which leads them to clear the forest and thickets. Farmers continue to clear these areas, gradually practicing slash and burn cultivation (7%) and the search for space due to uncontrolled urbanization (32%).
- Overexploitation of forest wood for several uses: lumber, construction wood, fuel wood, animal fodder and medicinal plants. Moreover, although the thickets

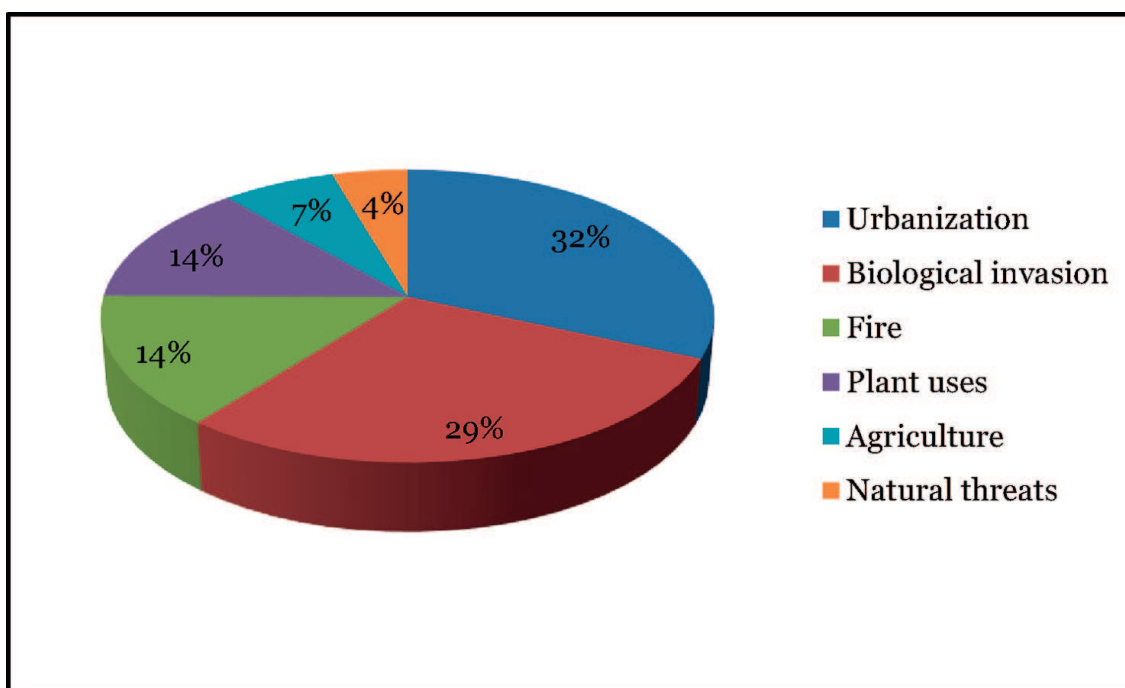


Figure 10.
 Types of threats and their impacts.

of the Comoros are practically poor in tree species, riparian populations still use the few trees present in these thickets (*Phyllarthron comorense*, *A. lebbeck*, *Albizia glaberima*, *Ochna ciliata*, *Phyllanthus comorensis*). These uses vary from one locality to another. Thus, the most popular species used by the local population from the dry forest are *Alangium salviifolium*, *Phyllarthron comorense*, *Terminalia ulexoides*, *Drypetes comorensis*, *Phyllanthus comoriensis*, *Phoenix reclinata*, *F. sycomorus* and *Ochna ciliata*. The observations and information gathered on the ground show that plants in urban areas are often subject to felling, either for competing of space, risk of uprooted trees falling, or for cultural reasons (related to popular beliefs that baobabs and tamarinds are hosts to evil spirits) in some places.

- Breeding and stray animals: The threat to the dry thickets of Ngazidja is cattle. On a ground completely devoid of grass, especially in the dry season, cattle and goats roam in groups of 5 or 10 individuals in these formations, constantly grazing on grasses, seedlings of trees and shrubs, and lianas, thus preventing them from doing so. to regenerate properly.
- Invasive species: vegetation formations are also threatened by invasive species such as *A. lebbeck*, *Annona squamosa*, *Imperata cylindrica*, *Jatropha curcas*, *L. camara* and some lianas of small diameter (*Saba comorensis*, *C. quadrangularis* and *Rhoicissus revouilii*). However, *L. camara* is the most invasive because it forms clumps that block the regeneration of other species.

Threats of natural origin are volcanoes and cyclones. Only the habitats of Ngazidja are threatened by the Karthala volcano which is active. Many eruptions occurred and are noticed by long lava flows some of which are still very visible today. The last most devastating eruption was that of April 5, 1977 in Singani (Hambou), which destroyed many habitats. The Comoros Islands have experienced several cyclonic disturbances. The most

recent cyclones affected in Ngazidja in 1984, 1985 and 2018–2019. They devastated homes, plantations and various dry ecosystems. These cyclones can cause windfall in vegetation formations, creating canopy openings [9]. All these actions have led to the reduction of almost 80% of the cover of dry plant formations in Ngazidja, in the last 40 years.

4. Discussion

The analysis results showed that the dry plant formations studied were different from each other, in terms of physiognomy, with species that characterized each formation. In fact, it consists of the dry forests of Lac-salé, Ngouni-Hamboda and Ifoundihé-Chambouani, stratified forests and the two dry thickets of Singani and Domoni-Ambouani-Hahaya.

In terms of climate, the dry forest of Ifoundihé-Chambouani has several deciduous species while the dry forests of Ngouni-Hamboda and Lac-salé have few species that lose their foliage. Most species in these two last forests are usually evergreen for part of the year. Deciduous leaves condition the biological rhythm of a plant during the dry season to a slower state of life and it is one of the distinguishing criteria of tree formations of these dry forests. It is present in most trees of the upper and middle strata. Only trees from the mid and upper slopes lose their leaves during the dry season while those from the bottom do not lose their leaves during this season. For the Lac-salé, the lowland trees are found around Lake and thus directly receive moisture from this lake. This result is similar to what happens around Lake “Dziani Boundouni”, on the island of Mwali [18].

At the national level, the dry forest facie of Ngazidja is characteristic of the dry ecosystem facies of Comoros archipelago similar at the dry forests found in Africa, Madagascar and the islands of the Indian Ocean, with true stratification and deciduous or semi-deciduous leaves. Because these dry forests have a canopy that can reach 15 m high with 20 m for the emergents like at Madagascar [19]. The abundance of small-diameter creepers and large-diameter thickets in dry forests is typical of dry vegetation communities in the Comoros [6].

The floristic composition of the dry forests is similar and as it is also the case for the floristic composition of the two thickets. Due to their proximity, species exchanges can occur between the Comoros Islands at the flora level [20]. Of the five vegetation formations studied, 106 species were identified including 70 trees and shrubs, which is very close to the score of 70 species of trees and shrubs found in the dry vegetation formations of Mayotte by [21, 22]. The dry forest Ngazidja has many floristic affinities with the “sub-humid” zone, semi-xerophile megatherm of Islands of Maoré (Mayotte) [23] and Mwali (Mohéli) [24] and particularly its particularly dry coastal fringe. Several species were found in the Maoré dry vegetation formations [25, 26] with over 90% of native species, some of which are endemic to the Comoros or Maoré (such as *Aloe mayottensis*).

Ethnobotanical surveys showed that trees and shrubs are also exploited for firewood. Generally, in the Comoros, wood remains the most used fuel as it is free: on Ngazidja, all ligneous plants are used as firewood although there are preferences for some tree species such as *Nuxia pseudodentata*. Currently, this case has gotten worse because of the high demography that this Island is experiencing. Thus, since forest species have become very difficult to find, it is the species of thicket (*A. lebbeck*, *Ochna ciliata*, *Pyrostria bibracteata*, *Euclea racemosa* subsp. *schimperii*) that are targeted.

Invasive species are also numerous in these formation: *A. lebbeck* (Fabaceae) lebbeck or lebbek tree or flea tree or frywood and *L. camara* (Verbenaceae) “common lantana”

are considered among the highly invasives woody species of the Comoros Archipelago in dry vegetation [27, 28]. *L. camara* is very abundant and forms clumps in thickets. In Mayotte, this species is among the most threatening plant pests that invade any dry zone and forms dense bushes preventing any other species from establishing themselves [22, 23, 25].

In addition, most species are also completely invaded by lianas such as *Leptadenia madagascariensis* and *C. quadrangularis* (Vitaceae) veldt grape or adamant creeper or devil's backbone.

In Madagascar, nearly 23% of the 1003,000 ha of dry dense forests and 32% of the 1,444,000 ha of southern thorny scrub are considered degraded or secondary [29].

5. Conclusion

The study included Five types of dry vegetation formations in Ngazidja island, Comoros Archipelago: dry forests of Lac-salé, Ngouni-Hamboda and Infoundihé-Chambouani, and dry thickets of Singani and Domoni-Ambouani-Hahaya.

The physiognomy of the tree forests shows that they are well organized with deciduous leaves. These vegetation formations are different from each other with their own species:

- The dry forest of Lac-salé with *virens*, *Comoranthus obconicus*, *A. digitata*, *A. alexandrei* and *Drypetes comorensis*;
- The dry forest of Infoundihé-Chambouani with *Turraea sericea*, *Commiphora arafy*, and;
- The dry forest of Ngouni-Hamboda with a mesophilic tendency with *Diospyros comorensis*, *Carissa spinarum*, *Ophiocolea comorensis* and *Sterculia madagascariensis*;
- the dry thicket of Singani with *Vitex doniana*, *Pandanus maximus*, *Pyrostria bibracteata* and *Euclea racemosa* subsp. *Schimperi*;
- the dry thicket of Domoni-ambouani-Hahaya with *Euclea racemosa* subsp. *schimperi*, *A. digitata*, *Erythroxylum lanceum* and *A. alexandrei*.

In all the studied formations, the overall natural regeneration is good. Mesophanophytes, nanophanerophytes and lianas of small diameter are the predominant biological types. The most common biological traits are foliar deciduousness, pachycaulia and aphyllia.

In these plant formations, one hundred and three (103) species are distributed in forty-six (46) families, the most abundant of which are Fabaceae, Rubiaceae and Euphorbiaceae. The most dominant species are *Phyllarthron comorense*, *Diospyros comorensis*, *A. digitata*, *Euclea racemosa* subsp. *Schimperi*. Several endemic species were identified during this study, in these vegetation formations such as *Dioscorea comorensis*, *Diospyros comorensis*, *Phyllarthron comorense*, *Euclea racemosa* subsp. *Schimperi*, *Pyrostria bibracteata* and *Phyllanthus comoriensis*.

Some have just been observed for the first time in Ngazidja and are very rare and therefore threatened with extinction on the island such as *Turraea virens*, *Turraea*

N°	Scientific name	Family	English name	Status
1	<i>Sorindeia madagascariensis</i> (Spreng.) DC.	Anacardiaceae	Grape mango	Rare and native to Comoros, S. Somalia, Mozambique, Madagascar.
2	<i>Carissa spinarum</i> L.	Apocynaceae	Conkerberry/ bush plum/ Simple-spined num-num	Rare and native to Comoros, Africa to Indo-China, Australia to New Caledonia.
3	<i>Commiphora arafy</i> H. Perrier	Burseraceae	—	Rare and native to Comoros, Madagascar.
4	<i>Alangium salviifolium</i> (L.f.) Wangerin	Cornaceae	Sage-leaved <i>alangium</i>	Rare and native to Comoros, E. Tropical Africa, Comoros, Indian Subcontinent.
5	<i>Turraea sericea</i> S.m	Meliaceae	—	Rare and native to Comoros, Madagascar.
6	<i>Turraea virens</i> L.	Meliaceae	Mozambique honeyssuchle-tree	Rare and native to Comoros, Madagascar.
7	<i>Ochna ciliate</i> Lam.	Ochnaceae	—	Rare and native to Comoros, Aldabra, Madagascar.
8	<i>Gomphia dependens</i> DC.	Ochnaceae	—	Rare and native to Comoros, Madagascar.
9	<i>Comoranthus obconicus</i> Knobl.	Oleaceae	—	Rare and native to Comoros, Madagascar.
10	<i>Chionanthus insularis</i>	Oleaceae	—	Rare and endemic to Comoros
11	<i>Oeceoclades lonchophylla</i> (Rchb.f.) Garay & P.Taylor	Orchidaceae	—	Rare and native to Comoros, Tanzania, Mozambique, KwaZulu-Natal in South Africa
12	<i>Drypetes comorensis</i> (Baill.) Pax & K.Hoffm.	Putranjivaceae	—	Very Rare and Endemic to Comoros
13	<i>Drypetes thouarsii</i> (Baill.) Leandri	Putranjivaceae	—	Rare and Native to Madagascar
14	<i>Sterculia madagascariensis</i> R.Br.	Sterculioideae	—	Very Rare and Endemic to Comoros

Table 2.
List of species observed for the first time on the island of Ngazidja.

sericea, *Comoranthus obconicus*, *Sterculia madagascariensis*, *Alangium salviifolium*, *Commiphora arafy*, *Ouratea humblotii* and *Ochna ciliata* (**Table 2**).

Many of these species are widely used by the local population in various fields. The formations are subject to various pressures and threats of two types: anthropic and natural. The anthropogenic threat is the most important.

This article therefore aims at providing objective elements that can support conservation actions that could include:

- the delimitation or introduction of dry forests and thickets, in the strategy for the development of protected areas;

- the sensitization of national and local authorities and populations on the biological and ecological importance of dry forests and thickets;
- the ecological restoration of these ecosystems in areas degraded by local species;
- the evaluation of this ecosystem and development of management and conservation plans and steps to register in the International Union For The Conservation Of Nature Red List of Threatened ecosystem in Ngazidja island.

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