Habitats characterization in the Taratibu, Quirimbas National Park-PNQ, Ancuabe District, Mozambique

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ABSTRACT: Taratibu was recently declared as a key biodiversity area (KBA) and knowledge on its habitats is very important for the conservation of this area. The present study aimed to identify and describe the main habitats from Taratibu, in PNQ, in order to improve knowledge on its characteristics. For this, techniques of transect, point-square and point-quadrant were used for the vegetation survey and the abiotic parameters of each habitat were determined. Five habitats were described: closed seasonal riparian habitat of *Siphonochilus* and *Rawsonia*, with dominance of *Rawsonia lucida*, whose IVI was 14%, humid soil, maximum temperatures of 26º C and with 89% canopy cover; semi-closed deciduous forest habitat of Bamboo and *Milletia*, with dominance of the *Milletia stuhlmannii* species, whose IVI was 42%, humid soil, maximum temperatures of 28º C and with 73% cover; open mountain habitat, vellozio-euphorbiaceae-Inselberg, with dominance of the *Xerophyta argentea* species, whose IVI was 38%, reasonable and dry soil, maximum temperatures of 30ºC and with 0% of tree canopy cover; semi-open Miombo deciduous forest habitat, with dominance of the *Julbernadia globiflora* species, whose IVI was 18%, dry soil, maximum temperatures of 28ºC and with 36% canopy cover; and closed *Pouteria* rain forest habitat, dominated by the *Pouteria pseudoracemosa* species, whose IVI was 30%, wet soil, maximum temperatures of 28ºC and with 88% canopy cover.
Keywords: vegetation; parameters; temperature; soil; luminosity.

Caracterização de habitats na concessão de Taratibu, Parque Nacional das Quirimbas-PNQ, Distrito de Ancuabe, Moçambique

RESUMO: Taratibu foi declarado recentemente com uma área chave de biodiversidade (KBA) e o conhecimento dos seus habitats é de extrema importância para a sua conservação. O presente estudo teve como objetivo descrever os principais habitats existente em Taratibu-PNQ, com vista a conhecer as suas caraterísticas. Para tal foram utilizadas, técnicas de transeto, ponto-quadrante e quadrados pontuais para o levantamento da vegetação e foram determinados os parâmetros abióticos de cada habitat. Foram descritos 5 habitats, designadamente: habitat fechado ribeirinho sazonal de *Siphonochilus* e *Rawsonia*, com dominância da espécie *Rawsonia lucida*, cujo IVI foi de 14%, solo húmido, temperaturas máximas de 26º C e com 89% de cobertura de dossel; habitat semi-fechado de floresta caduca de Bambu e *Milletia*, com dominância da espécie *Milletia stuhlmannii*, cujo IVI foi de 42%, solo húmido, temperaturas máximas de 28º C e com 73% de cobertura de dossel; habitat aberto de montanha, vellozio-euphorbiaceae- *Inselberg*, com dominância da espécie *Xerophyta argentea,* cujo IVI foi de 38%, solo razo e seco, temperaturas máximas de 30ºC e com 0% de cobertura de dossel arboreo; habitat de floresta caduca semi-aberta de Miombo, com dominância da espécie *Julbernadia globiflora,* cujo IVI foi de 18%, solos seco, temperaturas máximas de 28ºC e com 36% de cobertura de dossel e habitat fechado de floresta Pluvial de Pouteria, dominado pela espécie *Pouteria pseudoracemosa*, cujo IVI foi de 30%, solo húmido, temperaturas máximas de 28ºC e com 88% de cobertura de dossel.
Palavras-chave: vegetação; parâmetros; temperatura; solo; luminosidade.

1. INTRODUCTION

Mozambique is a country rich in biological diversity (OLSON et al., 2001), comprising a wide diversity of terrestrial, marine, coastal and aquatic ecosystems. These ecosystems contain habitats that support a great species diversity (MICOA, 2009). It is also one of the few countries in the Southern African region that has a considerable area of native forest, and it is estimated that approximately 40 million hectares (ha) or 51% of the land area of Mozambique is covered by native forests, mainly Miombo woodlands which are the most predominant in Cabo Delgado Province (MARZOLI, 2007).

According to AMABIS; MARTHOS (2004) define habitats as being the environment occupied by a given species or community (plants, animals, and other organisms), characterized by their physical and biotic properties.

These play a very important role for the conservation of biological and genetic diversity and for the preservation of evolutionary processes, as well as space and shelter for animal and plant species contributing to their maintenance (DE GROOT et al., 2002). Habitat loss and fragmentation due the human activities are the greatest threats to biological diversity (PINEDA; HALFFTER, 2004; FISCHER et al., 2005). These factors frequently interrupt dispersal between

favorable habitats, destabilizing the metapopulations (PRIMACK; RODRIGUES, 2001).

The region of Taratibu was recently declared as a key biodiversity area (WCS et al., 2021) and presents a variety of habitats. These face major problems due to the growing trend of alterations caused by recent human activities in the perimeter of the conservation area, originating in the buffer zone, such as fragmentation due to agriculture, the occupation of land for housing and exploitation of construction material and wood commercialization, which puts at risk the biodiversity of the same area.

A second motivation for this study pertains to the lack of information on habitats and vegetation available to researchers in the areas of herpetofauna, entomofauna and mastofauna in Cabo Delgado province, concerning the need to characterize the habitats where these groups of animals live.

The characterisation of the structure of a habitat allows correct programming of silvicultural activities, better technical and economic management of habitats, thus facilitating rational and sustained use (HOSOKAWA, 1986). Also, habitat surveys, are important tools for the knowledge of biodiversity, as support to establish conservation priorities and the preservation of natural environments, through the evaluation of endemic, rare and endangered species, as well as species of ecological importance. In this context, the present study will allow future studies to be developed within the perimeter of the habitats studied here, and that is why the main aim of this study was to describe the main habitats existing in Taratibu-PNQ.

2. MATERIAL AND METHODS
2.1. Study area
The study was carried out in the Taratibu region located in the Quirimbas National Park, Ancuabe district, which is situated to the South of Cabo Delgado Province, Northern Mozambique, situated between the 12º50'S and 12º38'S South latitudes, and 39º32'E and 39º58'E East longitudes.

The region is characterized by a dry semi-arid and sub-humid climate, with an average annual rainfall between 800 and 1200mm, distributed from October to March. The average annual temperature ranges from 20 to 25º C (MAE, 2014).

2.2. Sampling Procedure
Five areas consisting of different vegetation formations were selected, according to the previous reconnaissance carried out in the study area, for the identification of plant species, characterization of vegetation and abiotic parameters (temperature, soil moisture and light), in order to ensure a representative sample for habitat classification.

2.3. Characterization of the vegetation occurring in each habitat
The characterization of the vegetation, it was based on the floristic and physiognomic survey in different vegetation formation type. Flora was characterized identifying plant species present in each vegetation type formation. The frequency and abundance were estimated (Table 1) as well as the physiognomic composition, based on the general external appearance (structure and dominance) of the vegetation and determined through the visual approach (RIZZINI, 1979) and was characterized by the observation of its vertical stratification (BARBOSA, 2006).

The characterization was based on transects established within each vegetation formation type (GOLDSMITH et al., 1986; RICHARDS, 1996).

Table 1. Phytosociological parameters used in the habitats of Taratibu, PNQ.
Tabela 1. Parâmetros fitossociológicos utilizados nos habitats de Taratibu, PNQ.

Parameter	Formule
Average area	$AM = |\sum d/N|^2$
Absolute density	$DA = \frac{A}{(d)^2}$
Relative density	$DR = \frac{ni}{N} \times 100(\%)$
Basal área	$ABi = D^2 \times \pi \div 4$
Dominance	$DoA = ABmi \times ni$
Relative dominance	$DoR = \frac{\sum ABi}{ABT} \times 100$
Absolute frequency	$FA = \frac{pi}{P} \times 100$
Relative frequency	$FR = \frac{FAi}{\sum FA} \times 100$
Importance value	$DRi + FRi + DoRi$

Notes: N- number of individuals of each species; AD- absolute density; RD- relative density; AoD- absolute dominance; RR- relative dominance; AF- absolute frequency; RF- relative frequency; IVI- importance value index; ABi- basal area of the species; D- diameter in meters; π-3. 1416; ABmi- average basal area per species; ni- number of trees per species; ABi- total basal area of a given species; ABT- total basal area of all individuals of all sampled species; pi- number of points that a given species i occurs; P- total number of samples (points); FAi- absolute frequency of a given species; ∑FA- absolute frequency of all species.

For the quantification of tree and shrub species, the techniques of Transect and Point-square (Figure 1) were used. Four transects of 50 meters (m) length each, separated from each other by 10 m distance, were sampled. In each transect, six quadrants of 4 m² were placed, 8 m apart from each other. In each quadrant four sections were determined, marking and identifying the individual (with diameter ≥ 5 cm) closest to the central point that met the inclusion criteria and then recording its distance to the central point of the quadrant, as well as its diameter. Thus, in each sampling unit, four trees or shrubs were sampled (MARTINS, 1993).
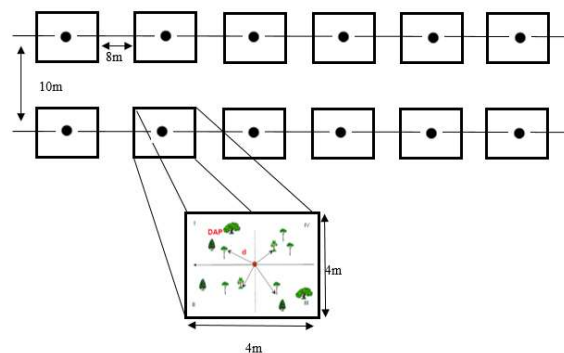

Figure 1. Technical sketch of the distribution of transects and quadrants for tree and shrub species (JOAQUIM, 2019).
Figura 1. Esboço técnico da distribuição dos transectos e quadrantes para as espécies arbóreas e arbustivas (JOAQUIM, 2019).

In the same transects, at 10 meters, the herbaceous vegetation was sampled using the technique of point squares (BARBOUR et al., 1987) (Figure 2). Every 20 cm along the transect, the presence of the species touched by a 1-meter stick placed vertically was recorded.
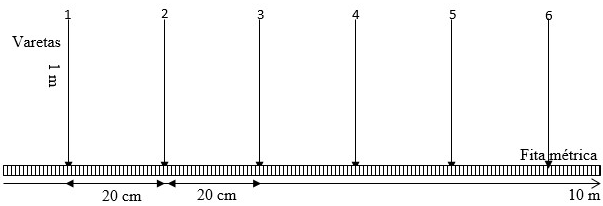
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Figure 2. Technical sketch for the herbaceous species. Source: (JOÃO, 2019).
Figura 2. Esboço técnico para as espécies herbáceas. Fonte: (JOÃO, 2019).

2.4. Characterization of abiotic parameters, (luminosity, soil moisture and temperature).
Luminosity
Along the transects established within the habitats, every 5m, at breast height, the luminosity was estimated using A4 paper and considering four percentage intervals, as follows:

(i) 25% when one quarter of the area of the paper was illuminated, (ii) 50% if the illumination covered about one half of the area of the paper, (iii) 75% equivalent to three quarters of the illuminated area of the paper and, finally, (iv) if the paper was fully illuminated, luminosity was 100%. The arithmetic means of the percentages of the illuminated areas of all the papers sampled per habitat was then taken to obtain the mean of the overall luminosity for each habitat.

The sampling of the luminosity rates per habitat took place at 8 am, 12 am and 3 pm during the wet season in order to sample various angles of light radiation in each habitat. This way, inference was made from the luminosity data, the level of canopy cover using the following formula:

$$\% = At - Ami \tag{01}$$

where: %- percentage of cover; At- total area of the paper; Ami- average illuminated area.

And it was considered the criteria of the table below to determine more open or closed habitat.

Table 2. Canopy cover determination.
Tabela 2. Determinação da cobertura de dossel.

Percentage of coverage	Habitat canopy cover
0-25%	Open
26-50%	Semi-open
51-75%	Semi-closed
76-100%	Closed

Moisture
For the determination of the soil moisture gradient, a classification was made according to direct observation in the field on the presence or absence of water, along the soil surface throughout the sampling period, thus defining three types of gradients: dry, wet and waterlogged (STALMANS; BEILFUSS, 2008).

Temperature
The temperature of each habitat was also determined, during the morning, afternoon, and evening periods. Then, an arithmetic means of the temperatures obtained in all periods was made in order to obtain the average daily temperatures. For this, the following formula was used:

$$\bar{T} = \frac{\sum T}{n} \tag{02}$$

where: $\bar{T}$- average temperature; T- temperature (maximum/minimum of all periods); n- number of sampling periods. This was recorded using a Thermometer.

2.5. Mapping of the main habitats existing in the Taratibu Concession
The mapping of habitats was conducted through the capture of geographic points, using the Global Positioning System (GPS). Then the points were imported into Google Earth, where the polygons were delimeted according to the differences in habitat coverage and the polygons were downloaded in Kml format and imported into the geographic information system QGIS 2.18.12, thus creating a digital map (Figure 18).

2.6. Habitat classification of Taratibu.
Habitat classification was based on the abiotic characteristics, such as: luminosity, soil moisture and temperature, as well as biotic characteristics, floristic composition and the physiognomy of the vegetation itself based on the results obtained in points 2.3 and 2.4. After the word habitat, the habitat names were associated with the characteristics of the canopy, the configurative environment, the effect of the seasons on vegetation and the dominant tree and grass species.

2.7. Data Analysis
Data analysis was conducted using Microsoft Office Excel 2016, for producing graphs and the calculating the phytosociological parameters.

We estimated the absolute and relative values of density, frequency, and dominance as well as the value of importance (VI) of the species for the tree and shrub strata. Also, the absolute and relative frequencies for the herbaceous strata (MULLER-DOMBOIS; ELLEMBERG, 1974) were calculated in a particular way by the equations described in the methodology (Table 1).

3. RESULTS
A total of five (5) habitats were classified and described for the different vegetation formations type present in the Taratibu Concession, namely, Closed Seasonal Riverine Habitat *Siphonochilus* and *Rowsonia* (HFRSR), Semi-enclosed Bamboo and *Milletia* Deciduous Forest Habitat (HSFCBM), Open Mountain Habitat, Vellozio-euphorbiaceae - Inselberg (HAMVE), Semi-open Miombo deciduous forest habitat (HSAFCM) E and Closed Rain Forest *Pouteria* Habitat (HFFPP).

4.1. Closed Seasonal Riverine Habitat *Siphonochilus* and *Rowsonia* (HFRSR)
Location and characterization: located at coordinates S 12º 48'32", E 39º 41'42" with an elevation of 325 metres (m) with a predominance of loose rocks and temporary or periodic water courses during the wet season.

The habitat presents a forest physiognomy, with a dominance of the tree and shrub strata and an almost absent herbaceous stratum due to the greater coverage of the upper stratum. The trees have non-succulent, leathery and evergreen leaves (almost always green).

This habitat has a closed canopy with 89% coverage, average daily temperatures vary from 26.8º C maximum and 25.7º C minimum and periodically flooded soil. It remains with water throughout the rainy season and dries out completely in the dry season (Figure 3).

As for the floristic component, the tree stratum is dominated by the species *Rawsonia lucida, Ancylobotrys petersiana*

(Klotzsch) Pierre and *Pseudobersama mossambicensis* (Sim) Verdc. with the respective relative frequencies (Figure 4).

Figure 3. Seasonal closed stream habitat *Siphonochilus* and *Rowsonia*. Source (CARAVELA, 2018).
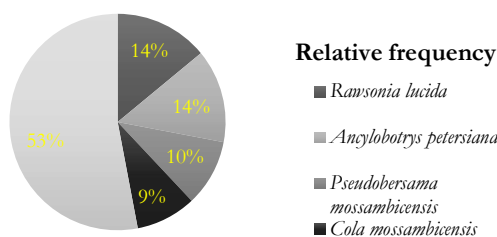Figura 3. Habitat fechado Ribeirinho sazonal *Siphonochilus* e *Rowsonia* (CARAVELA, 2018).

Figure 4. Tree stratum species with the highest relative frequency in the closed seasonal stream habitat *Siphonochilus* and *Rowsonia*.
Figura 4. Espécies do estrato arbóreo com maior frequência relativa do habitat fechado ribeirinho sazonal *Siphonochilus* e *Rowsonia*.

The herbaceous stratum is dominated by leafy coriaceous plants of the Zingiberaceae family, most notably the species *Siphonochilus* sp. with a relative frequency of (67%) followed by *Cissus* sp of the Vitaceae family with (22%).

The density of individuals of the HFRSR was 51.34 ind./m², being *Rawsonia lucida* Harv & Sond the species that presented the highest number of individuals and the highest value of importance with 14% (Figure 5).
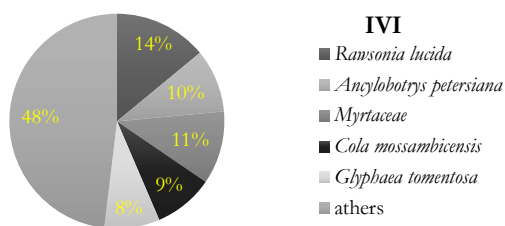

Figure 5. Tree stratum species with the highest Importance Index (IVI) in the closed seasonal riparian habitat *Siphonochilus* and *Rowsonia*.
Figura 5. Espécies do estrato arbóreo com maior índice de importância (IVI) do habitat fechado Ribeirinho sazonal *Siphonochilus* e *Rowsonia*.

4.2. Semi-enclosed Bamboo and *Milletia* Deciduous Forest Habitat (HSFFCBM)

Location and description: it is located adjacent to the Riverine habitat, at an elevation of 320 m at latitudes S 12º 48'29.6'' and longitude E 39º 41'40.4'' in Taratibu. It is a habitat with a semi-closed canopy, with approximately 73% coverage, with average daily temperatures of 28º C maximum and 27º C minimum, with a predominance of humid soil.

The habitat presents a physiognomy of deciduous forest in the dry season, whose herbaceous stratum presents a denser vegetation and with a considerable scarcity of trees. The lower stratum is also covered by plants of the Zingiberaceae and Dioscoreaceae family.

The Dioscoreaceae appear in the adult state in the form of scandering phanerophytes with support in the bamboo species (Figure 6).

Figure 6. Semi-enclosed deciduous forest habitat of Bamboo and *Milletia*. Source: (CARAVELA, 2018).
Figura 6. Habitat semi-fechado de floresta caduca de Bambu e *Milletia*. Fonte: (CARAVELA, 2018).

Floristically, the tree stratum is dominated by the species *Milletia stuhlmannii*, followed by *Xilotheca tettensis*, *Bridelia* spp. and *Combretum apiculatum* with the respective relative frequencies (Figure 7).
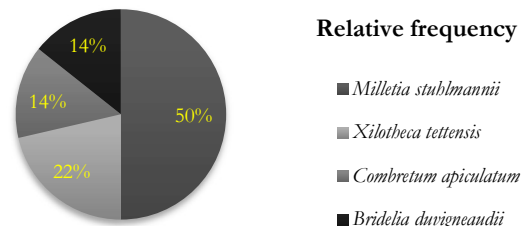

Figure 7. Tree stratum species of highest relative frequency in the semi-enclosed habitat of Bamboo and *Milletia* deciduous forest.
Figura 7. Espécies do estrato arbóreo de maior frequência relativa do habitat semi-fechado de floresta caduca de Bambu e *Milletia*.

In its herbaceous stratum there is a greater occurrence of the Poaceae family plants, especially *Oxytenanthera abyssinica* (A. Rich) Munro. with a relative frequency of 53%, followed by *Siphonochilus* spp of the Zingiberaceae family (35%), *Dioscorea dumetorum* of the Dioscoreaceae family (10%) and *Cyphostemma simulans* of the Vitaceae family with (2%).

The density of individuals of the HSFCBM was 0.192 ind./m², *Milletia stuhlmannii* being the species that presented the greatest number of individuals and the most important with 42% (Figure 8).
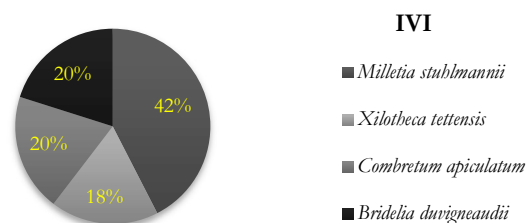

Figure 8. Tree stratum species with the highest Importance Index (IVI) in the semi-enclosed habitat of the Bamboo and *Milletia* deciduous forest.

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Figura 8. Espécies do estrato arbóreo com maior índice de importância (IVI) do habitat semi-fechado de floresta caduca de Bambu e *Milletia*.

4.3. Open Mountain Habitat, Vellozio-euphorbiaceae-Inselberg (HAMVE)

Location and description: this habitat is located at the geographical coordinates S12º49'10.5'', E 39º41'37.9'' with an elevation of 571 m.

It presents vegetation formed by xerophytic plants, whose most outstanding functional features are succulence, thorns and aromatic oils. It is grouped and thickened in the slopes rock with the reduced cover tree.

The herbaceous and shrub stratum is predominant, with cormophytic and fissure plants. However, some trees of the *Ficus* and *Brachystegia* genus grow naturally along the mountain slopes.

It is an habitat without canopy, that is to say, with 0% cover due to the scarcity of trees along the mountain tops. Average daily temperatures vary between a maximum of 30º C and a minimum of 28º C and there is a predominance of dry soil with a substrate formed by granite bedrock, with cracks and depressions where there is a reduced amount of soil and water that serve as places where most of the vegetation grows. It is possible to identify small, isolated peat bogs, poor in specific plant richness. Exposed rocks covered by lichens and ferns are also found. However, the soils have low water retention capacity as they are shallow soils (Figure 9).

Figure 9. Mountain open habitat, Vellozio-euphorbiaceae-Inselberg. Source: (CARAVELA, 2018).
Figura 9. Habitat aberto de Montanha, Vellozio-euphorbiaceae-*Inselberg*. Fonte: (CARAVELA, 2018).

Floristically, the habitat is characterized by sheltering species of the Velloziaceae family with the species *Xerophyta argentea* standing out, followed by *Euphorbia unicornis, Euphorbia tirucalli, Myrothamnus flabellifolius* Welw. and *Strophanthus hypoleucos* in its shrub layer, with the respective relative frequencies (Figure 10).

Relative frequency

- ■ *Euphorbia tirucali*
- ■ *Xerophyta argentea*
- ■ *Euphorbia unicornis*
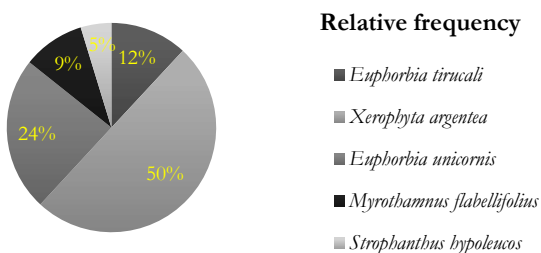- ■ *Myrothamnus flabellifolius*
- ■ *Strophanthus hypoleucos*

Figure 10. Tree stratum species of highest relative frequency in the open mountain habitat, vellozio-euphorbiaceae-Inselberg.
Figura 10. Espécies do estrato arbóreo de maior frequência relativa do habitat aberto de montanha, vellozio-euphorbiaceae-*Inselberg*.

In the herbaceous stratum, species of the Asphodelaceae family occur with greater dominance, especially the species *Aloe chabaudii* with a relative frequency of 40%, followed by *Selaginella caffrorum* of the Selaginellaceae family with 29%, *Cheilanthes inaequalis* (Kunze) of Sinopteridaceae family (19%), *Cyphostemma montanum* and *Cyphostemma simulans* both of Vitaceae family with (6%) and (4%) respectively and *Hibiscus surattensis* of Malvaceae family with (2%).

The density of individuals in the HAMVE was 0.317 ind./m², *Xerophyta argentea* being the species that showed the highest number of individuals and the most important with 38% (Figure 11).

IVI

- ■ *Euphorbia tirucali*
- ■ *Xerophyta argentea*
- ■ *Euphorbia unicornis*
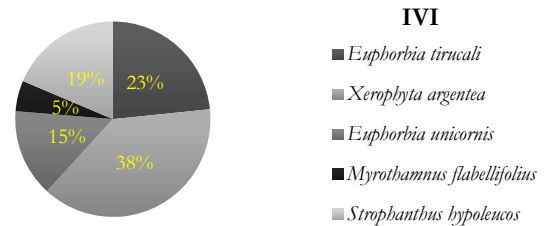- ■ *Myrothamnus flabellifolius*
- ■ *Strophanthus hypoleucos*

Figure 11. Tree stratum species with the highest importance index of the open mountain habitat, Vellozio-euphorbiaceae-*Inselberg*.
Figura 11. Espécies do estrato arbóreo de maior índice de importância do habitat aberto de montanha, Vellozio-euphorbiaceae-*Inselberg*.

4.4. Semi-open Miombo deciduous forest habitat (HSAFCM)

Location and description: this habitat is located at the geographical coordinates: S12°49'29'', E39°41'53'' Altitude: 320m.

The habitat has a forest physiognomy, with a dominance of the trees and herbaceous stratum. There are also few shrubs and there is an absence of lianas and epiphytes; however, there are some climbing plants of the Convolvulaceae and Asparagaceae family. The trees are somewhat close to one another and in the dry season have deciduous leaves. This habitat presents a semi-open canopy with 36% coverage. In addition, it has average daily temperatures ranging from a maximum of 29º C to a minimum of 27º C and dry soil (Figure 12).

Figure 12. Semi-open habitat of the Miombo deciduous forest. Source: (CARAVELA, 2018).
Figura 12. Habitat semi-aberto de floresta caduca de Miombo. Source: (CARAVELA, 2018).

Floristically, the tree stratum is characterized by plant species with greater dominance of the Fabaceae family, especially the *Julbernadia globiflora*, followed by the *Diplorhynchus condylocarpon, Brachystegia speciform,* and *Combretum apiculatum* species with the respective relative frequencies (Figure 13).

Relative frequency

- ■ *Julbernadia globiflora*
- ■ *Diplorhynchus condylocarpon*
- ■ *Brachystegia speciform*
- ■ *Combretum apiculatum*
- ■ *Combretum zeyheri*
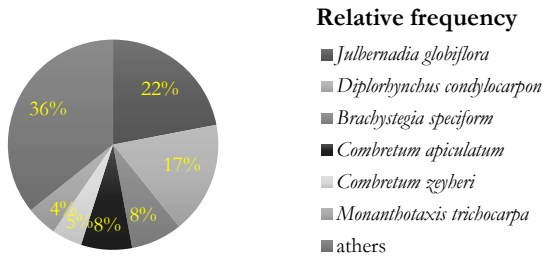- ■ *Monanthotaxis trichocarpa*
- ■ athers

Figure 13. Species of highest relative frequency in the semi-open deciduous forest habitat of Miombo.
Figura 15. Espécies de maior frequência relativa no habitat semi-aberto de floresta caduca de Miombo.

In the herbaceous stratum, the Poaceae family was more dominant, especially the species *Digitaria* sp. with a relative frequency of 85%, followed by *Cyphostemma simulans* (6%), *Asparagus africanus* (2%) and *Scadoxus multiflorus* (Martyn) Raf.com (1%).

The density of individuals of the HSAFCM was 0.122 ind./m², with *Julbernadia globiflora* being the species that presented the greatest number of individuals and the most important with 18% (Figure 14).

IVI

- ■ *Julbernadia globiflora*
- ■ *Diplorhynchus condylocarpon*
- ■ *Brachystegia speciform*
- ■ *Combretum apiculatum*
- ■ *Combretum zeyheri*
- ■ *Sterculia quinqueloba*
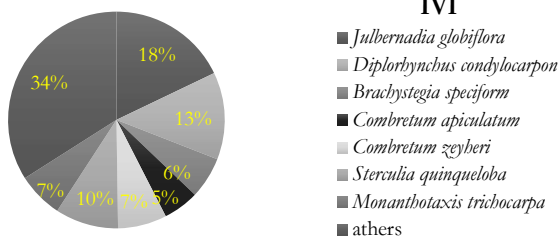- ■ *Monanthotaxis trichocarpa*
- ■ athers

Figure 14. Species with the highest importance value index in the semi-open deciduous forest habitat of Miombo.
Figura 14. Espécies de maior índice de valor de importância no habitat semi-aberto de floresta caduca de Miombo.

4.5. Closed Rain Forest *Pouteria* Habitat (HFFPP)

Location and description: located at the geographical coordinates S 12º 49'20", E 39º, 41'90", at an altitude of 401m.

Habitat characterized by a closed canopy with approximately 88% coverage, average daily temperatures ranging from a maximum of 28° C to a minimum of 26° C, with humid soil and no dry season.

It presents a forest physiognomy, with a dominance of the tree stratum and almost absent the herbaceous stratum, due to the densification of tall trees, with a greater reduction in the amount of light in the lower stratum, which makes the environment darker. There are lianas, perennial vegetation, coriaceous plants, and no succulent plants (Figure 15).

Floristically, the tree stratum is dominated by the species *Pouteria pseudoracemosa, Rawsonia lucida* Harv & Sond*, Englerophytum natalense* and *Rinorea arbórea* (Thouars) Baill with the respective relative frequencies (Figure 16).

In the herbaceous stratum, the species *Anchomanes abbreviatus* of the Araceae family was sparsely recorded with (100%) relative frequency.

The density of individuals of the HFFPP was 0.312 ind./m², with the *Pouteria pseudoracemosa* species showing the highest number of individuals and the most important at this site with 32% of IVI (Figure 17).

Figure 15. Closed Rain Forest habitat *Pouteria.* Source: (CARAVELA, 2018).
Figura 17: Habitat fechado de Floresta Pluvial *Pouteria.* Source: (CARAVELA, 2018).

Relative frequency

- ■ *Pouteria pseudoracemosa*
- ■ *Rawsonia lucida*
- ■ *Englerophytum natalense*
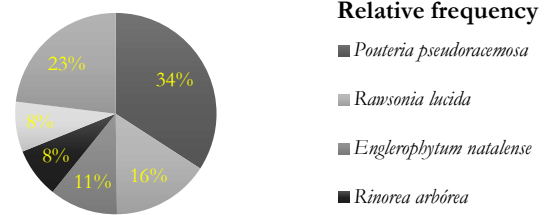- ■ *Rinorea arbórea*

Figure 16. Tree stratum species of highest relative frequency in the closed habitat of *Pouteria* rain forest.
Figura 16. Espécies do estrato arbóreo de maior frequência relativa no habitat fechado de floresta Pluvial *Pouteria.*

IVI

- ■ *Pouteria pseudoracemosa*
- ■ *Rawsonia lucida*
- ■ *Englerophytum natalense*
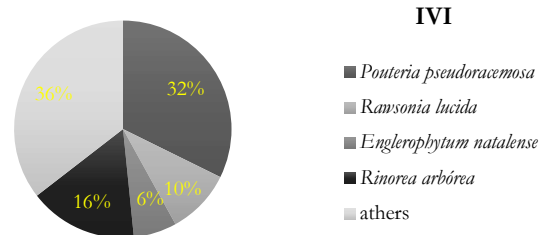- ■ *Rinorea arbórea*
- ■ athers

Figure 17. Tree stratum species of highest importance value index in the closed *Pouteria* Rainforest habitat.
Figura 17. Espécies do estrato arbóreo de maior índice de valor de importância no habitat fechado de Floresta Pluvial *Pouteria.*

4.6. Mapping of the main habitats within the Taratibu Concession

The five characterized habitats were mapped, closed seasonal riparian habitat-*Siphonochilus* and *Rowsonia,* semi-closed Bamboo and *Milletia* deciduous forest habitat, open mountain habitat Vellozio-euphorbiaceae-Inselberg, semi-open Miombo deciduous forest habitat and closed rain forest habitat *Pouteria (*Figure 18).
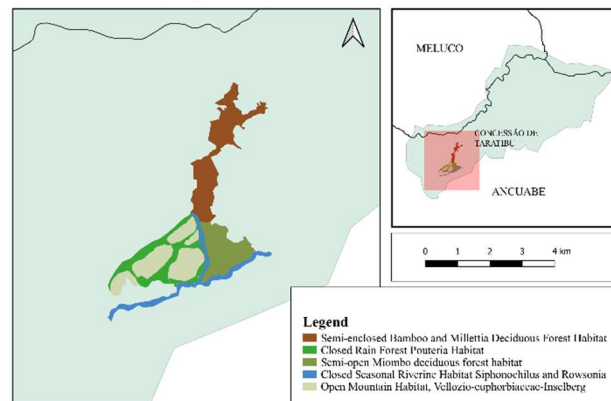

Figure 18. The main habitats mapped in the Taratibu Concession.

Besides illustrating the habitats, mapping it allowed to show the distribution and occurrence of vegetation of the same habitats. These show a variation of vegetation and environmental factors such as temperature, light, and soil moisture.

4. DISCUSSION

5.1. Seasonal closed Habitat *Siphonochilus* and *Rowsonia*

The species that presented the highest dominance and importance value at this site was *Rawsonia lucida*. Species of the Achariaceae family, present a pantropical distribution (MARQUETE et al., 2015). This result differs from what was observed in the study by (BANDEIRA et al., 2008) in the gallery forests in Quirimbas National Park, that revealed the species *Albizia gumifera* and *Adansonia digita*. It also differed from the study done by the Ministry for the Coordination of Environmental Action (MICOA, 2003), in a riverine forest in Quiterajo Administrative Post-PNQ, where the species of the genus *Albizia* sp. and *Adansonia digitata* were also recorded with greater dominance.

The observation of these species is likely a result of its large size and aspect, rather than a phytosociological dominance properly. This difference may also be related to the aerial method utilized by (MICOA, 2003), which visualized only the physiognomic aspect of the landscape. According to SANQUETTA et al., (2014), this method, despite covering a larger sampling area, not always all of it is evaluated in the inventories. And the detection of trees is limited due to the presence of suppressed trees, which cannot be observed because they are not visible on the surface (DURRIEU, 2015).

In the herbaceous stratum of this habitat dominates the species *Siphonochilus* spp. This result differs from the study of BANDEIRA et al. (2008), where it was recorded with greater dominance the species *Achyranthes aspera, Panicum maximum, Cucumis rehmannii,* it is also observed differences with the riparian forest habitat of the Marromeu National Reserve. (RNM, 2016), in which the species *Setaria* sp. dominates.

Siphonochilus spp. belong to the Zingiberaceae family, and species of this family can grow in shaded or semi-shaded and humid habitats, as well as on riverbanks (WOOD, 1995). These environmental characteristics are also recorded in the habitat under study, which may be associated with its predominance in this location. The difference of this result in relation to those of other studies, may be justified due to riparian forests being composed of species from adjacent formations, Rodrigues (2000), besides species characteristic of this type of forest formation, favored by the presence of adaptations to environments susceptible to flooding (KOSLOWSKI, 2002). It may also be associated due to the practice of itinerant agriculture in these habitats, which can lead to the modification and loss of flora in those places (RNM, 2016; PNQ, 2012), since PNQ is strongly occupied by human communities, while Taratibu is a concessionary portion of PNQ that benefits from a more rigorous protection which leaves its habitats more conserved and consequently less modified.

5.2. Semi-enclosed habitat of bamboo and *Milletia* deciduous forest

In this habitat, the species *Oxytenanthera abyssinica* (A. Rich) Munro of the subfamily Bambusoideae occurs in the herbaceous stratum with greater dominance. This result is similar to the study by (BANDEIRA et al., 2008) in the bamboo forest of the Quirimbas National Park and differs from the open bamboo forest of the southwestern Amazon region that presents the species *Guadua weberbaueri* with greater dominance, also belonging to the same subfamily (NELSON, 1994). However, species of the subfamily Bambusoideae often occur in humid locations (JUDZIEWICZ et al., 1999). This difference may be related to the aerial method used (NELSON, 1994), as it allows to sample more comprehensively the areas of interest (HELMER et al., 2015).

According to BANDEIRA et al. (2008), it was also recorded in its tree stratum the species of the genus *Milletia* with greater dominance, because it is associated with bamboos. According to PALGRAVE (2002) the *Milletia stuhlmannii* is a species that naturally occurs in areas of high humidity and in riparian zones, a result also recorded in this work. It differs from the open bamboo forest of the southwestern Amazon region in which *Acacia polyphylla* and *Zanthoxylum rhoifolium* dominates. This difference may be associated due to the plot sampling method used (SILVEIRA, 2001), as it allows quantifying all individuals within the plot, which reach the inclusion criteria (MORO; MARTINS 2011).

5.3. Open Mountain Habitat, Vellozio-euphorbiaceae-Inselberg

In the mountain habitat, the species *Xerophyta argentea* was recorded with the highest dominance. According to POREMBSKI (2007), this species presents adaptations to survive environmental stress in these areas, such as desiccation and low nutrient availability in the soil.

And studies done by BANDEIRA et al., (2008) in Inselbergs of Quirimbas National Park show the species *Xerophyta* spp. belonging to the same genus with greater predominance. This result differs from the ones from MACHADO-FILHO (2012) conducted on rocky outcrops in Northeast Brazil, which recorded the Fabaceae family with greater dominance in this type of habitat. This difference may be associated with the fact that inselbergs are floristically characterized by vegetation adapted to xerophytic environments through morphological and physiological changes (POREMBSKI; BARTHOTT, 2000). Because the Fabaceae family presents survival strategies in this type of environment and is a numerous family (PEREIRA et al., 2011; BARBOSA et al., 2007).

For the herbaceous stratum there is occurrence with greater dominance the species *Aloe chabaudii* and is justified by the fact that this is also quite common in rocky environments (POREMBSKI, 2007). A study carried out by BANDEIRA et al., (2008) in Quirimbas National Park also revealed the same result, the same can be affirmed in the results found by POREMBSKI (2007) in rocky environments of Madagascar in Malagasy.

5.4. Semi-open Miombo deciduous forest habitat

In the miombo woodland habitat, *Julbernardia globiflora* was the most dominant and most important species in ecological terms at this site, as is one of the most predominant species in Miombo woodland and has the capacity to withstand adverse habitat conditions (CAMPBELL, 1996), this result is similar with UETELA, (2014) in a Miombo woodland of Pindanyanga in Manica and

MACUEIA (2018) unpublished data, in Taratibu Concession.

In the herbaceous stratum, it was recorded with greater dominance of *Digitaria* sp. This result was also verified in Quirimbas National Park, as being one of the species that occurs with greater dominance in that location (GNRB, 2009), as it belongs to the Poaceae family of great ecological importance due to the presence of its species in various ecosystems (WELKER; LONGHI-WAGNER, 2007).

5.5. Closed Rain Forest habitat *Pouteria*

In this habitat the species *Pouteria pseudoracemosa* of the Sapotaceae family showed the highest number of individuals and the highest value of importance. Its dominance may be associated with the fact that this family has a wide distribution in tropical regions. (CARNEIRO et al., 2013), and for being part of rainforests. It may also be associated with the greatest diversity of the *Pouteria* genus within the Sapotaceae family (PENNINGTON, 1990). Most of its species occur in humid forest regions (PENNINGTON, 1990; CASTRO et al., 2006), characteristics found in this habitat under study.

According to PENNINGTON (1990), the Sapotaceae family is very important in the African region as it contributes fundamentally to the abundance of individuals and ecological importance.

However, this result is like that found by KURTZ; ARAÚJO, (2000) in the Ombrophylous dense forest, where the Sapotaceae family was one of those that presented the greatest number of species and highest value of importance.

Its herbaceous stratum is almost absent. This may be related to the greater dominance of the tree stratum that does not allow the incidence of light on the lower stratum. This characteristic resembles those of the Atlantic Rainforest (MELO; MANTOVANI, 1994). However, only the species *Anchomanes abbreviates,* belonging to the Araceae family was recorded. This result was also verified in an Ombrophylous dense forest north of the São Francisco River, which showed a strong potential of the Araceae family from a large part of the Amazonian Domain (CABRERA; WILLINK, 1980). Its dominance is probably that this family is naturally cosmopolitan (JUDD et al., 1999), presenting a variety of life forms which confers great potential for colonizing different habitats (CROAT, 1990), occurring in areas varying from semi-desert to rainforest or mountainous regions (MAYO et al., 1997).

5. CONCLUSIONS

The characterization of the different habitats in the Taratibu Concession, allowed a better understanding of the environmental variations and the associated specific richness. Having classified and described closed seasonal Riverine-*Siphonochilus* and *Rowsonia* habitat, semi-closed Bamboo and *Milletia* deciduous forest habitat, open Vellozio-euphorbiaceae-Inselberg Mountain habitat, semi-open miombo forest habitat and Closed Rain Forest habitat *Pouteria.*

Of the five habitats identified and characterised, 90 species were found and 75 were identified.

The semi-open Miombo deciduous forest habitat and Seasonal stream *Siphonochilus* and *Rowsonia* revealed highest number of species. And the open forest habitat of Mountain, Vellozio-euphorbiaceae-*Inselberg* as well as Bamboo, were the ones that revealed lower number of species compared to the others, due to greater homogeneity of these.

The density and dominance differed between habitats, where the Riverine Forest habitat showed higher density value and higher dominance value in relation to the others. Of the habitats characterized, there were no great differences in temperature due to the closer proximity of the habitats.

Regarding luminosity, the open Mountain Forest habitat Vellozio-euphorbiaceae-Inselberg was the only one that presented a totally open canopy tree and the closed Rainforest habitat *Pouteria* and Riverine showed higher canopy cover than the others.

Soil moisture varies between habitats, with the semi-open Miombo deciduous forest habitat and open Mountain Forest, Vellozio-euphorbiaceae-Inselberg the ones that showed a dry soil gradient and the semi-closed Bamboo and Closed Rain Forest habitat *Pouteria* showed a wet soil gradient. And in the closed seasonal riparian habitat *Siphonochilus* and *Rowsonia* a periodically waterlogged soil gradient was recorded.

6. ACKNOWLEDGEMENTS

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