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*RESEARCH ARTICLE*

# ASSESSMENT OF INFESTATION AND DISTRIBUTION OF LORANTHACEAE ON WOODY PLANTS OF THE MANDARA MOUNTAINS OF THE FAR NORTH REGION, CAMEROON

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## *Abstract*

Loranthaceae are a permanent danger to many woody plant species. The present study was carried out with the aim of evaluating the degree of parasitism of Loranthaceae on woody species of the Mandara Mountains in the Far North Region of Cameroon. A methodological approach based on surface surveys was adopted. On the hills, the species of Loranthaceae encountered and the host plants have been identified. The botanical inventory revealed a floristic composition of 73 species of phorophytes distributed in 43 genera and 24 families. These phorophytes are parasitized by 7 species of Loranthaceae (*Agelanthus dodoneifolius*, *Globimetula braunii*, *Phragmanthera capitata*, *Tapinanthus bangwensis*, *T. belvisii*, *T. globiferus* and *T. ophiodes*), distributed in 4 genera (*Agelanthus*, *Globimetula*, *Agmanthera* and *Tapinanthus*). *T. globiferus* and *A. dodoneifolius* are the most abundant ubiquitous Loranthaceae species of the 7 parasitic species inventoried and identified on the Mandara Mountains. The average parasite rate of the inventoried phorophytes is 27.35% andthe average infestation intensity is 4.07 tufts / plant. This rate and the intensity of infestation vary among plant families. The distribution of Loranthaceae tufts follows an ascending curve. Parasitism of woody plants by Loranthaceae species therefore represents a considerable threat to phorophytes. It would therefore be wise to explore the means of combating Loranthaceae, for the conservation of plant biodiversity which integrates sustainable development in the Far North Region, Cameroon.



## Introduction:-

Loranthaceae are chlorophyllian shrubs that develop as hemiparasites on other cultivated and spontaneous higher plants. The development of Loranthaceae species on host plants leads to their vulnerability and disappearance [1].

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The attachment of these hemiparasites to host plants causes the formation of a special organ called haustorium or sucker. The haustorium constitutes a structural and physiological bridge, which allows the transit of nutrients from the host plant to the parasitic plant [2-4]. Thanks to this organ, Loranthaceae collect water and mineral salts necessary for their development. The growth of the host plant is then slowed down and eventually fades away [5]. Loranthaceae therefore represent a real danger for many woody species in temperate and tropical zones [4, 6]. In Africa, in some countries such as Burkina Faso, Cameroon, Gabon, Ghana, Mali, Ivory-Coast and many other African countries, Loranthaceae cause significant damage to phorophytes [5,7]. These hemiparasitic plants belong to the order of Santalales and the family of Loranthaceae. The taxonomy of Loranthaceae reveals the existence of about 950 species, distributed in 77 genera around the world [1, 8]. In Africa, these same authors count around 500 species, distributed in 21 genera. In Cameroon, Loranthaceae are represented by more than 25 species, distributed in 6 genera, which are: *Agelanthus, Englerina, Globimetula, Helixanthera, Phragmanthera and Tapinanthus* [9]. They are present on most plant groups in Cameroon, including mangroves. They are noticeable on several species, with often very high rates and intensities of infestation [3, 10]. In the Mandara Mountains, to the best of our knowledge, no scientific study on Loranthaceae parasites of woody plants has been carried out. It is therefore important to conduct studies to assess the levels of infestation of these parasitic species in this area, in order to undertake phorophyte conservation actions. This study therefore aims to assess the degree of parasitism of Loranthaceae on woody species of the Mandara Mountains in the Far North Region of Cameroon.

## Materials and Methods:-

### Location of study area

The study was conducted on the hills of the Mandara Mountains located in the Sudano-Sahelian zone of Cameroon, with geographical coordinates 10 ° 00'00 " and 11 ° 00'00 " North latitude and 13 ° 30'00 ' 'and 14 ° 30'00' 'east longitude (Figure 1). Covering an area of 7,660 km², the Mandara Mountains cover the Divisions of Mayo-Sava and Mayo-Tsanaga, the Sub-division of Méri in Diamaré and the Sub-division of Mayo-Oulo in Mayo-Louti. They form a vast plain to the East and North and a set of mountain ranges called the Mandara Mountains in its western part along the Nigerian border.

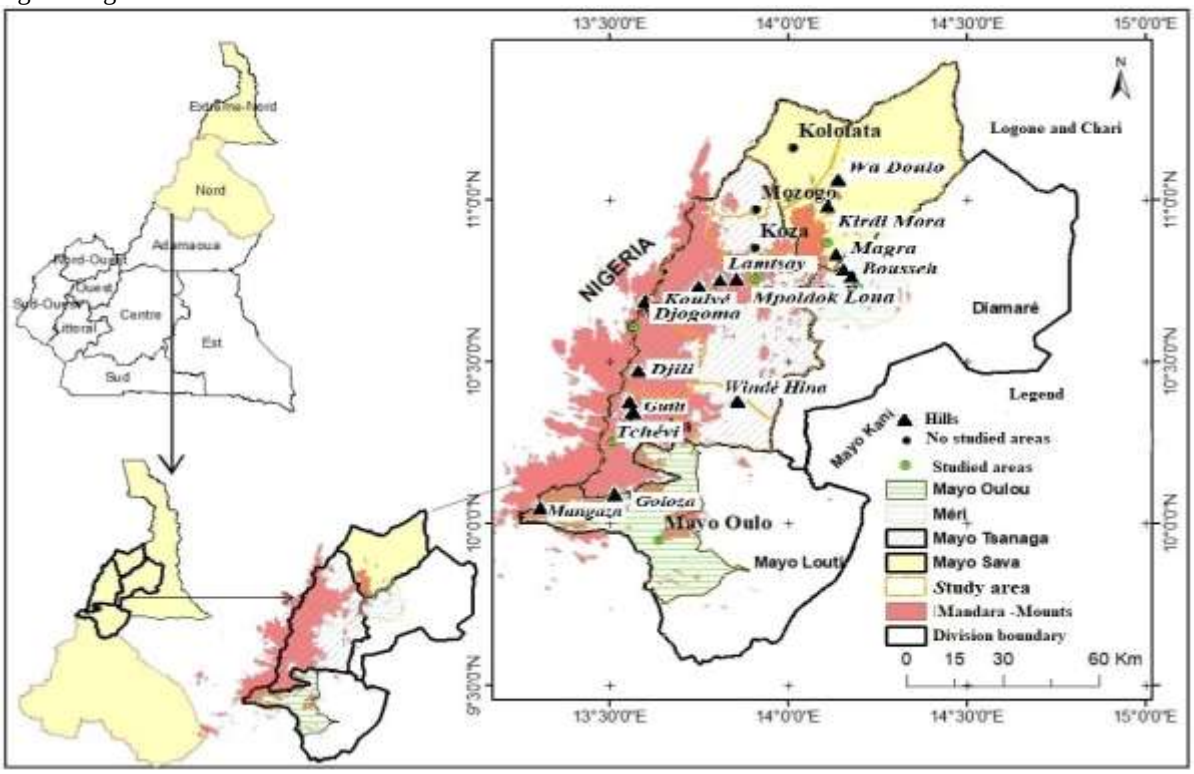


**Figure 1:**Location map of the study area.

### Characteristics of the Mandara Mountains

The Mandara Mountains are generally characterized by two main types of relief: the plain area representing about 80% of the total area and the mountainous area which represents 20%.The plain area entirely covers the eastern and

south-eastern parts of the Far North Region. Both the rainy season and off-season crops are generally cultivated there, and cotton is the main cash crop [11]. As for the mountainous area, it largely covers the west side and the south-west. It constitutes the continuity of the mountain ranges. This area is densely populated and is dominated from an agricultural point of view mainly by rainy season crops [12].

**Weather**

The Mandara Mountains are characterized by a tropical climate with Sudano-Sahelian variants in its southwestern part and Sudanese Sahelo in its northern part where we observe two seasons, a short rainy season of 3 to 4 months, ranging from June to September and a long dry season of 7 to 9 months, from October to May. The study area is characterized by a Sudano-Sahelian type climatic regime. The mean annual temperature of the Mandara Mountains is 28º C [13]. The rainfall is of the monomodal type and varies on average from 800 mm per year in the North to reach 1000 mm per year in the South [14, 15].

**Hydrography**

The hydrographic network of the Mandara Mountains, like that of the Far North Region in general, is made up of two different basins: Chad Basin and Niger Basin. The Mandara Mountains network is made up of numerous intermittent or seasonal watercourses (Mayo-Tsanaga, Mayo-Louti, etc.) which flow into one or the other of the two basins [11]. The Mandara Mountains are an area relatively rich in hydraulic resources because of the many rivers that originate there.

**Ecological units**

The Mandara Mountains are dotted with several ecological units which are among others savannahs, mountains, mayos, herds and forest reserves. The savannah of the Mandara Mountains area is wooded. The populations collect fuel and service wood there. This savannah is experiencing rapid degradation due to anthropogenic actions [16, 17]. The main problem there is deforestation and natural causes of biodiversity loss. Mountains make up almost a quarter of the territory of the Mandara Mountains area. They are used as places of dwelling for certain populations, in this case the Mafa. They also serve as grazing areas and agriculture is also practised using terrace cultivation techniques [12, 18]. The Mayos are mostly dry and constitute an important potential in natural resources such as sand. With the alluvium that settles on the banks during floods, the surroundings of Mayos are very popular for the development of market gardeners. The hardés are uncultivated areas abandoned by the populations [19].

**Vegetation**

The dominant plant formation of the Mandara Mountains is the wooded savannah. The flora is very diverse, especially on the mountains that make up the Mandara Mountains area. The majority of species found there are*Acacia albida, Ziziphus mauritiana, Tamarindus indica, Acacia seyal, Khaya senegalensis, Dalbergia sisso'o, Diospyros mespiliformis, Anogeissus leiocarpus, Daniellia oliveri, Tamarindus indica, Phyllanthus muellerianus* and various species. Some of these species are used mainly in traditional pharmacopoeia [20, 21]. Of all these species, *Z. mauritiana* is the most widespread and stands out as the most common plant formation in the study area. This vegetation of the Mandara Mountains is undergoing severe deterioration as a result of population growth and the excessive cutting of firewood and service wood [22, 23]. The vegetation is of the Sahelo-Sudanese type on the lower hills and border plains and Sudano-Sahelian type on the hill tops and plateaus [17, 23].

**Main economic activities**

**Agriculture**

Agriculture is the primary economic activity practised in the Mandara Mountains area. The main crops are diverse and varied [12, 24]. For food crops, we can cite rainy season sorghum, dry season sorghum, maize, peanuts, cowpeas, soybeans, sweet potatoes, potatoes and cassava. For vegetable crops, we find tomato, black nightshade, cabbage, salad, cucumber, leek, carrot, chili and okra. Fruit crops consist of mango, guajava and lemon trees [11].

**Breeding**

Animal husbandry is only a secondary activity for the inhabitants of the Mandara Mountains, who primarily practise agriculture. Nevertheless, two quite distinct types of breeding coexist, that of mountain farmers and that of Fulani herders. The latter represent only a tiny fraction of the population, but which weighs here with all its weight. In addition, the Mandara Mountains area also hosts herds of cattle which come on transhumance every year [16]. For livestock feed, there is the conservation of hay for the dry period and the exploitation of fodder species such as *Brachiaria* sp., *Acacia albida* makes it possible to alleviate the problem of fodder during the dry season [11, 16].

## Methods:-

For Loranthaceae inventory, surface survey method of identifying the Loranthaceae species found in 50 m x 10 m sub-plots in each of the 18 (50 m x 30 m) plots was adopted. These plots are arranged from the bottom to the top of the hills and spaced 100 m horizontally and 160 m vertically on each of the 2 slopes (East and West). In total, 540 plots (15 hills x 2 slopes x 18 plots) were surveyed. The experimental set-up is a randomized block. The hills are the main treatments and the plots are the replicates. The experimental unit consists of 18 plots.

For elevation influence on Loranthaceae, each of the 15 selected hills is divided into 3 elevation levels which are A1: <350 m, A2: 350 - 700 m and A3:> 700 m. The parasites and their host were inventoried in each of the 24 plots of 50 m x 10 m on each of the 3 altitude levels. These plots are laid out in the same way as before and spaced 100 m horizontally and 130 m vertically on each of the 3 altitude levels. This gives a total of 810 plots (15 Hills x 3 altitudes x 9 plots). The experimental set-up is a single randomized block. The elevations are the main treatments and the plots are the replicates. The experimental unit consists of 9 plots.

On each host plant, all tufts of the parasites were located, counted and identified with the naked eye or using binoculars for the parasites located at the level of the tops of large trees or by using the botanical guide [25], as did [5]. The Loranthaceae species determination key used by [26] was used to identify Loranthaceae species. For species (pests and hosts) not identified in the field, images are taken using a digital camera or a sample of plant organ (stems, leaves, flowers or fruit) is taken for identification with the herbarium or by experts.

By counting parasites and host plants, the impact of Loranthaceae on host plants was determined. The parameters used are infestation rate and intensity of parasitism of trees and shrubs by Loranthaceae species.

The parasite rate or infestation rate (T) is the percentage of infested plants relative to the total number of plants observed:

$$T = (n / N) \times 100;$$

where **N** is the total number of individuals observed and **n** is the number of infested individuals.

The intensity of parasitization or intensity of infestation (I), expresses the extent of the infestation on the parasitized individuals. It is expressed by the average number of Loranthaceae tufts observed per individual:

$$I = Ni/Nii ;$$

where **Ni** is the total number of parasite tufts and **Nii** is the total number of parasitized individuals.

**Statistical analysis**

Analysis of variance (ANOVA) was used to compare study sites, followed by Duncan's test at the 5% cut-off for separation of means. The distribution of the number of tufts of parasitic species on the hills was carried out using the EXCEL 2016 spreadsheet and Statgraphic version 7.1 software.

## Results and Discussion:-

**Taxonomic composition of phorophytes and Loranthaceae**

The results of inventory on the Mandara Mountains give a floristic composition of 73 species of phorophytes distributed in 43 genera and 24 families. These results are different from those of [27] who inventoried 86 woody species distributed in 71 genera and 36 families in his study entitled impact of human activities on the woody cover in the forest reserve of Kalfou, Cameroon. These observed differences would be due to the fact that this author conducted his studies in a forest reserve which is a protected area while our studies were conducted on the hills which are an area open to populations and to particular ecological and environmental conditions. In fact, in these areas, the excessive exploitation of natural resources (timber and NTFPs) associated with terraced agriculture which indirectly destroys the vegetation [28], thus leading to deforestation, is widely practised on these hills. These practices inevitably lead to the disappearance of plant species. This is why the low taxonomic composition is recorded on these hills. Our study revealed that the Mimosaceae and Combretaceae families are the most represented, each with 13 species, or 12.74%. The family of Caesalpiniaceae and Moraceae come third with 8 species each, or 7.84%. Followed by the Fabaceae family with 7 species, or 6.86%. These results corroborate those of [27] who identified these same families as the most represented families in the Kalfou forest reserve located in the same ecological zone as the Mandara Mountains. These same results were obtained by [29] in his study entitled impact of deforestation on the dynamics of vegetation in the Sudano-Sahelian zone of Cameroon.

Seven species of Loranthaceae parasites of woody plants have been inventoried and identified on the Mandara Mountains. They are: *A. dodoneifolius, G. braunii, P. capitata, T. bangwensis, T. belvisii, T. globiferus and T. ophiodes*. They are divided into 4 genera, namely *Agelanthus, Globimetula, Phragmanthera and Tapinanthus*. The genus of *Tapinanthus* contains 4 species. The results of our study are inferior to those of [30] who inventoried 9 species of Loranthaceae in the Diamaré plain of the Far North Region of Cameroon. On the other hand, our results are superior to those of [31] who inventoried 5 parasitic species in the Sudano-Guinean Savannahs of Adamawa, Cameroon. These differences observed in the taxonomic composition of Loranthaceae are thought to be due to the ecological and climatic conditions of the study environments. Indeed, our study was carried out on the hills with particular climatic and ecological conditions whereas these authors carried out their studies in the plain with low altitudes and ecological conditions different from those of the hills. Among these inventoried parasitic species, *T. globiferus* (609.75 ind./ha), *A. dodoneifolius* (549.97 ind./ha) and *T. ophiodes* (439.95 ind./ha) are the most abundant. On the other hand,*P. Capitata* (314 ind./ha) and *G. braunii* (132.18 ind./ha) have a weak distribution on the hills. Loranthaceae species have different ecological requirements. The first species, which are the most abundant, do not seem to present any particular ecological requirements in mountainous areas for their distribution. They are ubiquitous species that are not specific to a given vegetation and would suit all ecological variations. This would be the reason why they are more abundant on all the hills. In contrast, low abundance species seem to have ecological and climatic requirements. Similar results were obtained by [32] who showed that certain species of Loranthaceae such as *T. bangwensis* and *P. capitata* are found everywhere in Ivory-Coast, especially on dry land, while *T. belvisii* is confined to the South of the country on the coast. According to [33], the significant expansion of certain species of Loranthaceae from one locality to another is due to the variability of the ecological conditions of the environments.

**State of infestation of inventoried phorophytes**

For the degree of phorophyte infestation, the rate and intensity of parasitism vary significantly (F = 153.24 and P = 0.000) depending on the host plants; from 6.86% to 75.43% for the parasitic rate and from 1.25 to 20.47 tufts / plant for the intensity of infestation (Table 1). This variation among host species could be explained by the degree of susceptibility of each host species to the parasitism of Loranthaceae species. Indeed, the degree of sensitivity to parasitic Loranthaceae varies according to the phorophytes. There are very sensitive host plants, moderately sensitive host plants and host plants not very sensitive to parasitism from parasitic species. These results confirm those obtained by [1] who showed that the rate and intensity of infestation vary according to the host plants in their study entitled evaluation of the infestation of Loranthaceae on woody plants of agroecosystems of the Sud-Comoé region (Ivory-Coast).

For parasitic rate, the taxa with the highest infestation rates respectively are *Ziziphus mauritiana* (75.43%), *Diospyros mespiliformis* (66.43%), *Khaya senegalensis* (62.71%), *Tamarindus indica* (61.40%), *Haematostaphis barteri* (51.48%).As for the intensity of infestation, the highest infestation intensities are respectively recorded in *Z. mauritiana* (20.47 tufts / plant), *H. barteri* (18.76 tufts / plant), *K. senegalensis* (16.53 tufts / plant), *D. mespiliformis* (16.01 tufts / plant) and *T. indica* (15.01 tufts / plant). It should be noted that all the host plants mostly attacked by Loranthaceae are plants that flowers, fruits and shade are sought and appreciated by birds which are agents of seed dispersal of Loranthaceae. This high rate of infestation in these host species is thought to be due to the frequentation of these host plants by dispersal agents such as birds, but also to the sensitivity of these species to the parasitism of Loranthaceae. These results are different from those obtained by [32] who showed in their study entitled evaluation of the infestation of Loranthaceae on woody plants of agroecosystems of the Sud-Comoé Region (Ivory-Coast) that *Cecropia peltata* (84.95%) and *Acacia mangium* (71.42%) present the highest rate and intensity of interference. These observed differences would be due to the fact that these authors conducted their study in agroecosystems while our study was conducted in natural ecosystems. Indeed, the floristic composition of agroecosystems is different from that of simple ecosystems.

**Table 1:-** Woody flora and infestation status of host plants.

| Families | Genera and species | **Obs ind** | **Inf ind** | **Hlthy ind** | **Num tf** | **TP (%)** | **II (tf/plt)** |
|---|---|---|---|---|---|---|---|
| Anacardiaceae | *Haematostaphis barteri* Hook f. | 237 | 122 | 115 | 2289 | 51.48 | 18.76 |
| | *Sclerocarya birrea* (A. Rich.) Hochst. | 62 | 18 | 44 | 155 | 29.03 | 8.61 |

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|---|---|---|---|---|---|---|---|
| | *Lannea acida* A. Rich.s.l. | 19 | 4 | 15 | 21 | 21.05 | 5.25 |
| | *Lannea fruticosa* (Hochst. ex A. Rich.) Engl. | 58 | 8 | 50 | 15 | 13.79 | 1.88 |
| Annonaceae | *Annona senegalenis* Pers. | 113 | 24 | 89 | 76 | 21.24 | 3.17 |
| | *Hexalobus monopetalus* (A. Rich.) Engl. & Diels | 113 | 45 | 68 | 77 | 39.82 | 1.71 |
| Bignoniaceae | *Stereospermum kunthianum* Cham. | 123 | 17 | 106 | 38 | 13.82 | 2.24 |
| Burseraceae | *Boswellia dalzielii* Hutch. | 257 | 97 | 170 | 465 | 37.74 | 4.79 |
| | *Commiphora africana* (A. Rich.) Engl. | 63 | 24 | 39 | 65 | 38.1 | 2.71 |
| | *Jatropha gossypiifolia* L. | 42 | 17 | 25 | 43 | 40.48 | 2.53 |
| Caesalpiniaceae | *Bauhinia rufescens* Lam. | 80 | 21 | 59 | 67 | 26.25 | 3.19 |
| | *Daniellia oliveri* (Rolfe) Hutch. & Dalz. | 131 | 35 | 96 | 67 | 26.72 | 1.91 |
| | *Piliostigma reticulatum* (DC.) Hochst. | 102 | 40 | 62 | 67 | 39.22 | 1.68 |
| | *Piliostigma thonningii* (Schum.) Milne-Redh. | 79 | 19 | 60 | 45 | 24.05 | 2.37 |
| | *Tamarindus indica* L. | 386 | 237 | 149 | 3558 | 61.4 | 15.01 |
| Capparaceae | *Boscia angustifolia* A. Rich. | 120 | 18 | 102 | 79 | 15.00 | 4.39 |
| | *Boscia senegalensis* (Pers.) Lam. ex Poir. | 91 | 30 | 78 | 58 | 32.97 | 1.93 |
| | *Capparis fascicularis* DC. | 102 | 19 | 83 | 68 | 18.63 | 3.58 |
| | *Capparis sepiaria* L. | 79 | 12 | 67 | 35 | 15.19 | 2.92 |
| Combretaceae | *Anogeissus leiocarpus* (DC.) Guill. & Perr. | 570 | 164 | 406 | 498 | 28.77 | 3.04 |
| | *Combretum adenogonium* Steud. ex. A. Rich. | 80 | 20 | 60 | 38 | 25.00 | 1.9 |
| | *Combretum glutinosum* Perr. ex DC. | 69 | 17 | 52 | 45 | 24.64 | 2.65 |
| | *Combretum lecardii* Engl. & Diels | 102 | 7 | 95 | 28 | 6.86 | 4.00 |
| | *Combretum micranthum* G. Don | 90 | 14 | 76 | 38 | 15.56 | 2.71 |
| | *Combretum molle* R. Br. ex G. Don | 59 | 9 | 50 | 15 | 15.25 | 1.67 |
| | *Guiera senegalensis* J.F. Gmel. | 79 | 24 | 55 | 78 | 30.38 | 3.25 |
| | *Terminalia glauscesens* Hochst. | 64 | 12 | 52 | 23 | 18.75 | 1.92 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Terminalia macroptera* Guill. & Perr. | 28 | 7 | 21 | 19 | 25.00 | 2.71 |
| | *Terminalia mantaly* H. Perr. | 48 | 20 | 28 | 75 | 41.67 | 3.75 |
| Ebenaceae | *Diospyros mespiliformis* Hochst. ex A. Rich. | 417 | 277 | 60 | 4435 | 66.43 | 16.01 |
| Euphorbiaceae | *Croton macrostachyus* Hochst. ex Del. | 89 | 21 | 68 | 65 | 23.6 | 3.1 |
| | *Croton psedopulchellus* Pax | 62 | 8 | 54 | 20 | 12.9 | 2.5 |
| | *Euphorbia kamerunica* Pax | 13 | 3 | 10 | 9 | 23.08 | 3 |
| | *Phyllanthus muellerianus* (O. Ktze) Exell | 184 | 32 | 152 | 46 | 17.39 | 1.44 |
| Fabaceae | *Dalbergia boehmii* Taub. | 72 | 23 | 49 | 45 | 31.94 | 1,96 |
| | *Dalbergia melanoxylon* Guill. & Perr. | 182 | 69 | 113 | 488 | 37.91 | 7.07 |
| | *Dalbergia sisso'o* Roxb. | 47 | 13 | 22 | 74 | 27.66 | 5.69 |
| | *Pterocarpus erinaseus* Poir. | 47 | 9 | 38 | 29 | 19.15 | 3.22 |
| | *Pterocarpus lucens* Guill. & Perr. | 23 | 3 | 20 | 18 | 13.04 | 6.00 |
| Flacourtiaceae | *Flacourtia indica* Willd. | 83 | 16 | 67 | 28 | 19.28 | 1.75 |
| Loganiaceae | *Strychnos spinosa* Lam. | 80 | 22 | 58 | 35 | 27.5 | 1.59 |
| Meliaceae | *Khaya senegalensis* (Desr.) A. Juss. | 362 | 227 | 205 | 3753 | 62.71 | 16.53 |
| Mimosaceae | *Acacia albida* Del. | 281 | 124 | 157 | 945 | 44.13 | 7.62 |
| | *Acacia amythethophylla* Steud. ex A. Rich. | 31 | 8 | 20 | 25 | 25.81 | 3.13 |
| | *Acacia ataxacantha* DC. | 187 | 24 | 163 | 77 | 12.83 | 3.21 |
| | *Acacia ehrenbergiana* Hayne | 102 | 12 | 90 | 18 | 11.76 | 1.5 |
| | *Acacia erythrocalyx* Brenan | 69 | 14 | 55 | 47 | 20.29 | 3.36 |
| | *Acacia hocki* De Wild. | 123 | 35 | 88 | 135 | 28.46 | 3.86 |
| | *Acacia nilotica* (L.) Willd. ex Del | 93 | 15 | 78 | 34 | 16.13 | 2.27 |
| | *Acacia seyal* Del. | 113 | 45 | 58 | 253 | 39.82 | 5.62 |
| | *Dicrostachys cinerea* (L.) Wight & Arn. | 93 | 30 | 38 | 68 | 32.26 | 2.27 |
| | *Entada africana* Guill. & Perr. | 117 | 44 | 73 | 55 | 37.61 | 1.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Moraceae | *Ficus abutilifolia* Miq. | 267 | 35 | 232 | 66 | 13.11 | 1.89 |
| | *Ficus asperifolia* Miq. | 37 | 7 | 30 | 18 | 18.92 | 2.57 |
| | *Ficus glumosa* Del. | 54 | 8 | 46 | 23 | 14.81 | 2.88 |
| | *Ficus platyphylla* Del. | 69 | 24 | 45 | 135 | 34.78 | 5.63 |
| | *Ficus sycomorus* (Miq.) C.C. Berg | 58 | 20 | 38 | 87 | 34.48 | 4.35 |
| | *Ficus thonningii* Blume | 38 | 13 | 25 | 39 | 34.21 | 3.00 |
| | *Ficus umbellata* Vahl. | 132 | 25 | 107 | 50 | 18.94 | 2.00 |
| Olacaceae | *Ximenia americana* L. | 297 | 34 | 263 | 55 | 11.45 | 1.62 |
| Polygalaceae | *Securidaca longipedunculata* Fres. | 26 | 5 | 21 | 18 | 19.23 | 3.6 |
| Rhamnacées | *Ziziphus abyssinica* Hochst. ex A. Rich. | 82 | 12 | 70 | 31 | 14.63 | 2.58 |
| | *Ziziphus mauritiana* Lam. | 407 | 307 | 149 | 6283 | 75.43 | 20.47 |
| Rubiaceae | *Feretia apodanthera* Del. | 79 | 17 | 62 | 25 | 21.52 | 1.47 |
| | *Gardenia aqualla* Stapf. & Hutch. | 147 | 53 | 94 | 89 | 36.05 | 1.68 |
| | *Sarcocephalus latifolius* (Smith) Bruce | 40 | 9 | 31 | 27 | 22.5 | 3.00 |
| Sapotaceae | *Vitellaria paradoxa* Gaertn. f. | 230 | 112 | 118 | 235 | 48.7 | 2.1 |
| Sterculiaceae | *Sterculia setigera* Del. | 91 | 21 | 70 | 33 | 23.08 | 1.57 |
| Tilliaceae | *Grewia barteri* Burret | 64 | 16 | 48 | 26 | 25.00 | 1.63 |
| | *Grewia flavescens* Juss. | 51 | 8 | 43 | 33 | 15.69 | 4.13 |
| Verbenaceae | *Vitex doniana* Sweet. | 194 | 25 | 169 | 67 | 12.89 | 2.68 |
| | *Vitex madiensis* Oliv. | 37 | 6 | 31 | 19 | 16.22 | 3.17 |
| Zygophylacaeae | *Balanites aegyptiaca* (L.) Del. | 185 | 65 | 120 | 315 | 35.14 | 4.85 |
| Total | | 8901 | 2997 | 5920 | 26521 | 1996.33 | 297.05 |
| Average | | 121.93 | 41.05 | 81.10 | 363.30 | 27.35 | 4.07 |

Obs ind: Observed Individuals, Inf ind: Infested Individuals, Hlthy ind: healthy Individuals, Num tf: Number of Tuft, TP: Infestation rate, II: Infestation Intensity, Pte: Plant.

**Distribution of Loranthaceae tufts as a function of height, Diameter at Breast Height and Crown Area by family**

Table 2 presents the parasitism of Loranthaceae on woody plants as a function of height. The average number of tufts varies significantly (F = 42.06 and P = 0.000) between the plant families. The numbers of tufts range from 5.17 to 10.40 tufts per family. Depending on the heights, the Bombacaceae family is the most infested by parasitic species with an average number of 10.40 tufts. It is followed by the Meliaceae family which has an average clump count of 9.99 and the Sterculiaceae family comes next with an infestation intensity of 9.83 clumps.

These first 3 plant families most parasitized by Loranthaceae species are families in which the individuals are large. Loranthaceae species are more parasitic on tall trees. This could be explained by the fact that the fruit-eating birds which cause the dissemination of Loranthaceae seeds are much more frequent on large trees. It is for this reason that the taller the tree, the more parasitized it is by parasitic species. The height of the phorophytes influences the intensity of parasitization. Our results are different from those obtained by [5] who showed that the Sapotaceae and Caesapiniaceae family are the most attacked by Loranthaceae species in their study entitled Loranthaceae, parasites of trees and shrubs: case of Katiola Division, in the North of Ivory-Coast. This difference is believed to be due to ecological conditions and the extent of the study environments. Indeed, these authors carried out their study in the

plain whereas we carried out our study on the hills at high altitudes with particular ecological and environmental conditions.

The results of distribution of Loranthaceae tufts as a function of Diameter at Breast Height (DBH) according to each family are contained in Table 2. Depending on the DBH of individuals of each family, the number of tufts varies significantly (F = 14.69 and P = 0.000) from 17.56 to 37 tufts. The most parasitized plant families are Bombacaceae with an average number of 37 tufts; followed by the family of Sterculiaceae (34.5 tufts) and Rubiaceae (23.75 tufts). Parasitic species attack trees with large DBH much more. This could be explained by the fact that trees of large DBH have large branches that tissues are favorable for the establishment of the endophytic organ. This organ is a structural and physiological bridge allowing the transit of nutrients from the host plant to the parasitic plant. It is for this reason that trees with large trunks are more infested by Loranthaceae species. The number of parasitic clumps increases with the increase in DBH of the host plants. The larger the DBH of the tree, the more attacked it is by Loranthaceae species. The DBH of host plants influences the distribution of Loranthaceae tuft numbers. These results are similar to those of [34] who showed that the parasitism rate varies according to the circumference in their study entitled level of parasitism of rubber trees by Loranthaceae in the South-West Region, Cameroon.

For the distribution of Loranthaceae tufts as a function of Crown Surface (HS) according to each plant family (Table 2), the results of our study showed that the intensity of infestation of phorophyte species varies significantly (F = 5.71 and P = 0.000) from 5.00 to 7.56 tufts. It increases as the Crown Surface (HS) of trees increases. Large SH trees are made up of large shadows giving rise to good shadows. These shades attract birds which are the main seed dispersers of Loranthaceae. Indeed, fruit-eating birds, after having consumed the fruits of Loranthaceae species, rest on trees of large SH [35]. This is how they transport the seeds of Loranthaceae from host plants to other phorophytes. The HS of host plants influences the intensity of phorophyte infestation. These results are similar to those obtained by [36] who showed that the number of Loranthaceae tufts varies according to the diameter classes in their study entitled parasitism of cocoa seed fields by Loranthaceae in the locality of Nkoemvone (South Cameroon).

**Table 2:-** Number of Loranthaceae tufts as a function of H, DBH and SH of each family.

| Families | NT in relationto H | NT in relationto DBH | NT in relationto SH |
|---|---|---|---|
| Anonaceae | 3.78±0.97 | 11.56±5.03 | 3.67±1.80 |
| Apiaceae | 3.80±1.64 | 16.80±5.36 | 4.60±1.08 |
| Apocynaceae | 5.17±2.54 | 23.67±1.03 | 6.67±2.25 |
| Asteraceae | 4.83±1.13 | 21.67±1.37 | 5.50±2.68 |
| Balanitaceae | 5.67±2.28 | 18.00±8.17 | 5.67±3.35 |
| Bignoniaceae | 7.83±3.79 | 19.06±8.78 | 5.60±2.42 |
| Bombacaceae | 10.4±4.04 | 37.00±22.38 | 6.20±2.86 |
| Burseraceae | 7.96±3.93 | 19.52±8.61 | 6.13±2.91 |
| Caesalpiniaceae | 8.28±4.03 | 21.15±11.51 | 6.08±2.90 |
| Capparaceae | 4.78±2.12 | 14.43±7.09 | 5.06±2.44 |
| Celastraceae | 4.20±1.48 | 14.00±4.90 | 4.50±1.66 |
| Chrysobalanaceae | 5.5±3.49 | 21.00±17.13 | 4.83±3.24 |
| Combretaceae | 6.32±3.17 | 17.56±8.62 | 5.69±2.79 |
| Ebenaceae | 9.57±3.94 | 23.24±11.76 | 6.41±3.18 |
| Euphorbiaceae | 5.84±3.82 | 15.37±7.68 | 5.00±2.84 |
| Fabaceae | 7.87±3.77 | 18.68±8.32 | 5.64±2.50 |
| Flacourtiaceae | 7.00±1.15 | 20.75±2.60 | 5.00±3.46 |
| Loganiaceae | 5.33±1.51 | 18.67±10.60 | 6.50±2.49 |
| Meliaceae | 9.99±3.97 | 23.69±12.42 | 6.57±3.12 |
| Menispermaceae | 4.00±0.00 | 9.00±0.00 | 4.00±0.00 |
| Mimosaceae | 6.37±3.01 | 17.97±9.42 | 5.83±2.96 |

| | | | |
|---|---|---|---|
| Moraceae | 7.86±3.61 | 20.92±11.14 | 6.43±2.98 |
| Olacaceae | 4.84±2.01 | 18.48±6.85 | 5.46±2.15 |
| Oleaceae | 4.00±1.15 | 15.50±2.89 | 5.50±2.89 |
| Polygalaceae | 6.78±2.22 | 14.33±7.25 | 4.89±2.47 |
| Rhamnaceae | 9.26±3.94 | 22.59±11.29 | 6.66±3.31 |
| Rubiaceae | 8.88±2.33 | 23.75±10.32 | 7.06±3.12 |
| Rutaceae | 5.27±2.01 | 17.78±7.55 | 6.95±3.36 |
| Sapotaceae | 6.87±3.06 | 17.79±7.86 | 5.84±2.45 |
| Sterculiaceae | 9.83±5.41 | 34.67±9.31 | 9.33±2.07 |
| Tiliaceae | 3.56±1.24 | 13.44±5.41 | 3.72±2.00 |
| Verbenaceae | 7.23±2.92 | 18.70±9.95 | 5.81±2.81 |
| F | 42.06 | 14.69 | 5.71 |
| P | 0.000 | 0.000 | 0.000 |

NT: Number of Tuft, H: Height, DBH: Diameter at Breast Height and SH: Surface area of crown

**Distribution of number of tufts as a function of altitude**

Figure 2 shows the intensity of the infestation over the 3 altitude levels (<350 m, 350-700 m and> 700 m) of the hills of the Mandara Mountains. The parasitic intensity of phorophytes varies significantly (F = 185.86 and P = 0.000) between altitude levels. The interference intensity values gradually increase from the bottom to the top of the hills. The top (> 700 m) of the hills has the highest number of tufts (24.96 tufts); the middle (350-700 m) of the hills come next with an infestation intensity of 20.52 tufts and the lower (<350 m) of the hills present the lowest parasitic intensity (18.18 tufts). The number of clumps of the different elevation levels shows that the floristic procession of Loranthaceae species colonizing the hilltops is significantly more diverse than that of the lower and middle hills. The high number of tufts recorded at the top of the hills is due on the one hand to the mild climate favorable to the development of Loranthaceae which reigns on the top of the hills and on the other hand to the abundance of the disseminators such as birds. Thus, the altitudinal gradient appears to be a factor strongly influencing the expansion of Loranthaceae species. Indeed, the hilltops present difficult conditions of access to the populations for agricultural practices and for the exploitation of natural resources which are the sources of destruction of plant species.It is for this reason that the spread of parasitic species is so high on the hilltops. These types of results showing the floristic variability of species along the altitudinal gradient of the hills were obtained by [37] in their study entitled Floristic Diversity of the Classified Forest and Partial Fauna Reserve of Comoé-Léraba, South-West Burkina Faso. Our study shows that the frequency of Loranthaceae species varies according to the difference in level, with hilltops as the preferred altitudes. The ecological and environmental conditions at the top of the hills may also justify the high level of infestation of phorophyte species. In fact, hilltops are relatively calm environments for birds, difficult to access for agricultural practices and deforestation, and rare wildfires [38]. These characteristics are favorable conditions for the establishment, development and multiplication of Loranthaceae species. Our results corroborate those obtained by [39] who found that Loranthaceae species evolve according to altitude levels in the Bafou group in Cameroon. These authors also reported that Loranthaceae species are characterized by their variable expansion from one level to another depending on the temperature fluctuation at altitude. On the other hand, our results are different from those of [34] who obtained an infestation intensity of 4.3 tufts / plant by studying the level of parasitism of rubber trees by Loranthaceae in the South-West Region of Cameroon. The observed difference would be due to the fact that these authors worked on a single species of phorophytes (rubber trees) whereas we carried out our study on all the species of phorophytes.

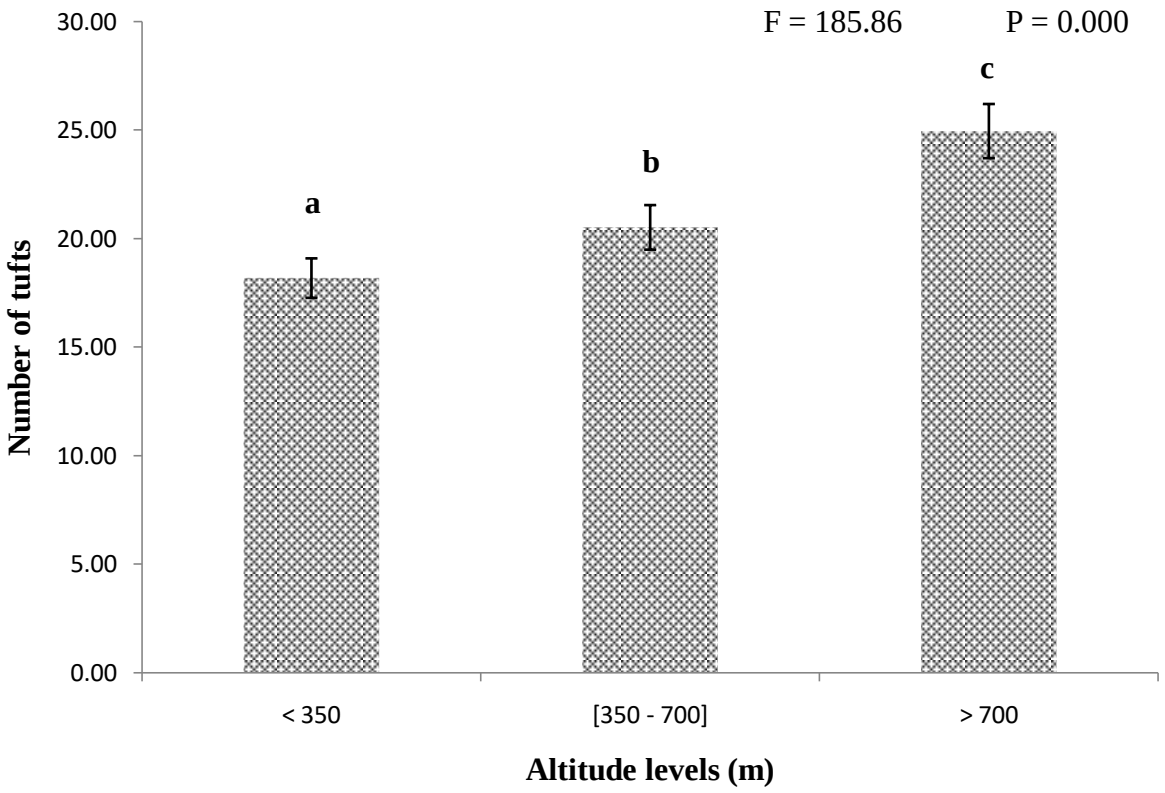


**Figure 2:-** Number of tufts according to altitude levels.

**Progression curves of number of tufts according to dendrometric parameters**

Figure 3 presents the distribution progression curves of the number of tufts of the real Loranthaceae (NT) and the number of tufts of the theoretical Loranthaceae (NT2) according to the dendrometric parameters on the Mandara Mountains. The plots carried out on the hills show that the average number of parasite tufts per family follows an upward curve. Our results are similar to those of [40] who obtained progression curves showing that the number of parasitized individuals and the average number of parasite tufts per individual have ascending curves, in their study entitled parasitism and ethnobotany of Loranthaceae in Lokomo (East Cameroon). The curve shows the fit of a progression model to describe the relationship between the number of tufts (NT) and the other three explanatory variables (Height (H), Diameter at Breast Height (DBH) and Crown Surface (SH)). The equation of the fitted model of the distribution of the number of tufts between these variables is:

**NT = -1.83 + 1.15 * H + 0.53 * DBH + 0.42 * SH;**

where NT = number of Loranthaceae tufts, H = Height, DBH = Diameter at Breast Height and SH = Crown Surface.

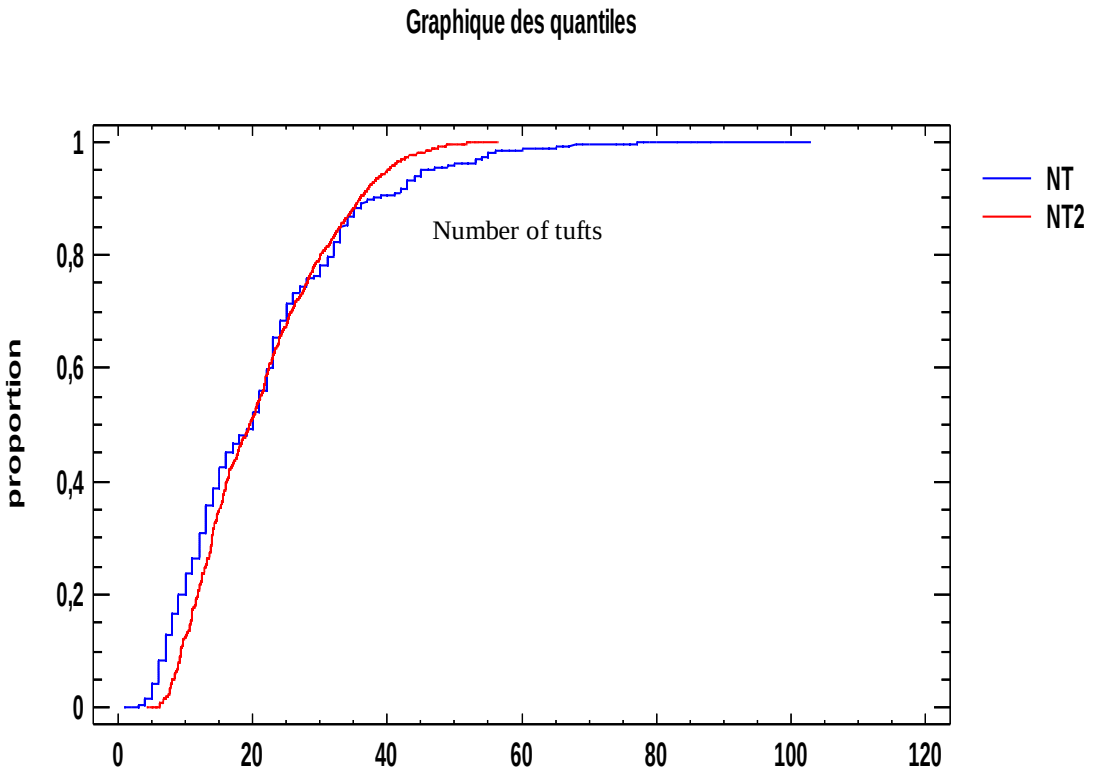


**Figure 3:-** Curve of progression of the number of tufts of Loranthaceae.
NT: real number of tufts, NT2: theoretical number of tufts

## Conclusion: -

The Mandara Mountains of the Sudano-Sahelian zone of Cameroon are home to 7 parasitic species. The degree of infestation of woody plants with Loranthaceae species is a function of dendrometric parameters. *T. globiferus* and *A. dodoneifolius* are the most abundant ubiquitous Loranthaceae species of the 7 parasitic species inventoried and identified on the Mandara Mountains. It emerges from this study that the woody flora of the Mandara Mountains is parasitized at varying levels of susceptibility to parasitism by parasitic species. For parasitic rate, the taxa with the highest infestation rates respectively are *Z. mauritiana*, *D. mespiliformis*, *K. senegalensis*, *T. indica*, *H. barteri*. As for the intensity of infestation, the highest intensities were recorded respectively in *Z. mauritiana*, *H. barteri*, *K. senegalensis*, *D. mespiliformis* and *T. indica*. Parasitism of woody plants by Loranthaceae species therefore represents a considerable threat to be taken into account for phorophytes. It would then be wise to explore the possible ways of fighting against Loranthaceae species, for the conservation of plant biodiversity which integrates sustainable development in the Far North Region, Cameroon.

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