International Journal of Botany

ISSN: 1811-9700

science alert

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International Journal of Botany 6 (3): 243-250, 2010
ISSN 1811-9700

Altitudinal Distribution of *Vepris heterophylla* (Engl.) R. Let. (Rutaceae): A Multifunctional Plant of the Sudano-Sahelian Zone of Cameroon

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Abstract: With the aim to contribute to the valorization of the socio-economic interest plants, an ecological survey was carried out on the altitudinal distribution of *V. heterophylla* in 10 mountainous massifs of the Sudano-sahelian zone of Cameroon. To achieve this, quadrats of 250×10 m^2 were established from the base to the summit of each mountain and on the north and south slopes with 100 m of interval between them. All individuals of *Vepris heterophylla* were counted and their dbh were performed. The results show that the population of *V. heterophylla* presents a good regeneration. Eighty three percent of individuals had a height less than 4 m. In the two regions of site of study, the significant size class was 0.5 to 4 cm of diameter at breast height (183 and 179 individuals respectively for Sahelian and Sudanian regions). The area of distribution of *V. heterophylla* extends from 150 to 950 m with one point of high density (115.2 and 18.6 individuals ha^{-1}, respectively for the north side and the south slopes) between 550 and 650 m for the sahelian region. On the contrary in the sudanian region, this area is located between 150 to 1250 m with an optimum (52.8 and 18.6 individuals ha^{-1} for the north slope and the south slope, respectively) reaches between 650 and 750 m. Following the opposition of the sides, the density of the population of *V. heterophylla* is higher on the north slope (22.96 individuals ha^{-1}) than on the south slope (5.8 individuals ha^{-1}) for the whole sudano-sahelian zone. The surexploitation and the loss of the habitat militate for the disappearance of the resource. However adequate measures are needed to encourage its conservation. Domestication would be a better solution to solve this problem.

Key words: *Vepris heterophylla*, distribution, altitude, opposition of the slopes, Sudano-sahelian zone

INTRODUCTION

Vepris heterophylla (Engl.) R. Let. is a very useful woody plant that is found in the mountainous massifs in the northern part of Cameroon (Letouzey, 1968). It is one of the most valued species in some domains of the life of the populations of the region of the northern Cameroon (Ngamo *et al*., 2001). This species whose vernacular names are Kounikoutchoum (Guiziga, Mofou), Hohoum (Zoulgo), Gougouvetche (Mafa), Kotokolhi (fulfulde) testifies the importance that it has in this region. It intervenes in the treatment of the malaria, high blood pressure, the conservation of the foodstuffs (Ngamo *et al*., 2001; Anonymous, 2002). Because of the extent of problems (illnesses, undernourishment, etc.) that the population lives, several studies have been carried out to bring out some solutions in order to fight efficiently against the devastators of foodstuff and to treatment of some illnesses. *V. heterophylla* appears among these solutions. The medicinal virtues of this Rutaceae have already been pointed out by several authors: Letouzey (1968), Moulis *et al*. (1994) and Keita and Ouattara (1995) on the high blood pressure and the malaria. The insecticide effects were also noted on *Tribolium castaneum* (Herbst.), foodstuffs parasite (cereals, niébé, etc.) (Ngamo *et al*., 2007a).

The human activities linked to grazing, to the slash and burn agriculture and the cutting of fire-wood have led to the fragmentation of the natural ecosystems hence threatening the biodiversity. Concerning *V. heterophylla*, the pressure remains a bit high. The harvesting of the leaves, the barks, etc., on the individuals of large size is done very often following the cutting of the shrub. The increasing importance, carried of this species in the region for its therapeutic and insecticide virtues is such that it is highly recommended to develop strategies of sustainable exploitation that take into account the renewal of the resource. In Northern zone as elsewhere, the plant is on

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decline and in considered as threatened (Hawthorne, 1995) and classified on the red list of the UICN under the reference EN AL_C, $B1+2_C$ (Ngamo *et al*., 2007a).

V. heterophylla (Engl.) R. Let. has been a subject of several studies (Moulis *et al*., 1994; Keita and Ouattara, 1995; Ngamo *et al*., 2007b). The present study that inscribed in the framework of the valorization of the socio-economic interest plant, has as main objective to evaluate the existing potential of the plant in the sudano-sahelian zone of Cameroon with the perspective to have a good mastery of the plant and to make an rational and sustainable use of the resource whose importance leading to its disappearance.

MATERIALS AND METHODS

Site of study: The present study took place in the regions belonging to the sudano-sahelian zone of Cameroon situated between the 8th and 13th degree of North latitude. It extends from Adamawa to the banks of the Lake Chad on about 100 000 km^2, that is more of the fifth of the surface of Cameroon. The study took place in the localities presented in the Table 1.

The sudanian part is covered in some areas by the lined spiny of *Mimosa asperata*. Floating prairies of *Echinochloa stagnina* and *Laersia* sp. cover the ponds but falls on soil during the dry season. On the halomorph soils grows a less dense vegetation constituted of *Anogeissus leiocarpus*, *Balanitises aegyptiaca*, *Annona senegalensis*, *Adansonia digitata*, *Acacia albida* and *Boswellia dalziellii*. The sahelian part is characterized by a large variety of natural landscapes. Vegetation is made up of steppes to sahelian spiny. There is a noted characteristic presence of the plants such as *Anogeissus leocarpus* on the uncleared soft soils and *Boswellia dalziellii* on the rocky soils as well as *Balanitises aegyptiaca* (Boutrais, 1984).

Its relief is made up of an alternation of plateau with average height varying between 500 and 1000 m, peneplains with height varying 200 and 300 m overhang by some mountainous massifs and inondable plains or yaérés scattered inselbergs.

The low rainfall in the region has created a network of rivers that flows toward the Lake Chad (Mayo Tsanaga, the Logone) and toward the Katsena (Deo, Benue). The rivers are permanent for the some (Benue, Déo and Logone) and seasonal for the other (Mayo Tsanaga).

Methods: The fieldwork for this study was carried out between March 2007 and December 2009 adopting two methodological phases. A phase of investigation and an ecological study phase. The first phase served as preliminary investigation phase in which it has been noticed that *Vepris heterophylla* develops preferentially on the mountainous highlands. Thus, in each explored village, all mountainous highlands were identified and georeferenced (altitude, longitude and latitude). In all 10 villages were retained, five from each ecological region. They include Bilguim, Kalliao, Ndougour, Mbélessé (Kotorba), Mokolo massifs in the sahelian part; the mounts of Tinguilin, Lagdo, Nakalba, Fignolé and Tcholliré in the sudanian part. In order to better appreciate the ecological behavior of the plant, we evaluated the influence of the opposition slope and the altitude on the population of *V. heterophylla*. According to the works of Achoundong (1996), the North and South slopes were retained. As such, the universal compass was used to identify the two slopes. With regard to the altitudinal variation on each highland, the sampling was done by use of quadrats of 250×10 m^2 from the base of the mountain to the summit with an interval of 100 m between the quadrats. The sampling concerned the two previously slopes retained. The GPS permitted the georeferencement of each mountain. In order to facilitate the numbering, sub-quadrats of 2×5 m^2 were been established. In the sub-quadrats, all individuals of *V. heterophylla* were counted and marked to avoid the numbering mistakes and parameters such as the height of the individuals and their diameter in height of breast (dbh) were evaluated. All data were converted to hectare in order to compare the different populations by statistical analyses. The ANOVA was used to analyze data and the software XLSTAT was put to profit.

Table 1: The different sites retained in the setting of this study

Sites	Latitudes	Longitudes	Altitudes (m)
Kalliao	10°61508 N	014°201220 E	437
Bilguim	10°69807 N	014°24838 E	165
Ndougour	10°7241 N	014°21632 E	488
Kotorba	10°84486 N	014°2814 E	702
Mokolo	10°74786 N	013°80 819 E	698
Tinguilin	09°45326 N	013°5009 E	146
Lagdo	09°05678 N	013°66756 E	242
Nakalba	08°53985 N	012°62386 E	357
Fignolé	08°55957 N	013°04565 E	371
Tcholliré	08°39861 N	014°16403 E	385

RESULTS

Dendrologic distribution of the population of *Vepris heterophylla* (Engl.) R. Let: The mean diameter and the height of *V. heterophylla* in the sudano-sahelian zone of Cameroon are of 4.62 cm and 2.74 m, respectively. Figure 1 presents the distribution of the individuals of *V. heterophylla* by height class. It emerges from the analysis of the figure that the young individuals are dominant. On the contrary, the old individuals are little

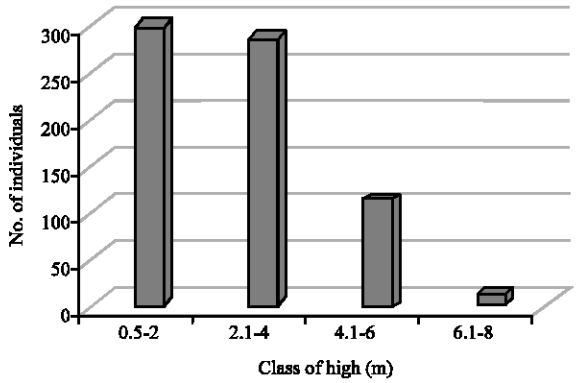

Fig. 1: Distribution of the individuals of *V. heterophylla* by height class

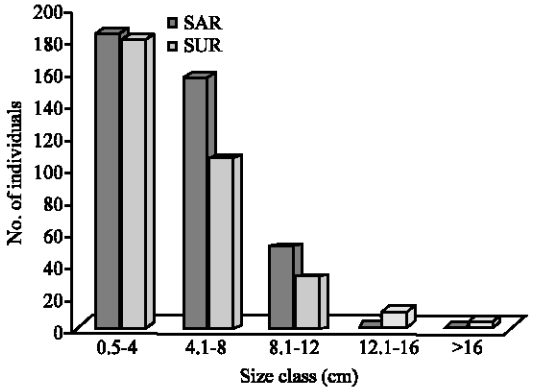

Fig. 2: Diametric structure of the population of *V. heterophylla* in the sudano-sahelian zone: sahelian region (SAR) and sudanian region (SUR)

represented. This abundance of young individuals indicates a good regeneration of the species.

The histogram of distribution of the population of *Vepris heterophylla* in the sudano-sahelian zone presents a shape in an L form (Fig. 2). This result indicates that in the region, the shrub regenerates well but the old individuals do not maintain themselves. The dominance of young individuals indicates a good regeneration of the species. In the sahelian region, the individual class of more than 12 cm is remarkably absent whereas this category of individuals is highly present in the sudanian zone.

Altitudinal distribution of the population of *Vepris heterophylla* at the regional level: At the regional level, the distribution of *V. heterophylla* according to altitude present curves in bell form whose peak varies with the ecological area and the slope of the mountain (Fig. 3). For the mountains of the sahelian region, the peak is situated between 450 and 850 m for the North slope against 550

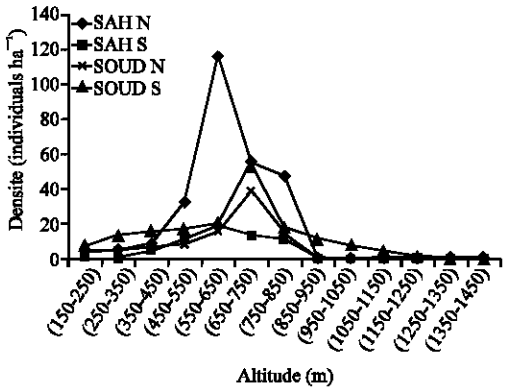

Fig. 3: Distribution of the populations of *V. heterophylla* (Engl.) R. Let. according to altitude in the sudano-sahelian zone

and 850 m for the South slope. A total of 116 individuals was recorded for the first peak against 19 for the second. In sudanian region, the maximum individuals that is 53, is obtained at altitude between 650 and 750 m for the north slope and the second that is 39 individuals between 550 and 850 m for the South slope. From these optima, the density of the population decreases and ends around 950 m of altitude for the two slopes in the sahelian region whereas in the sudanian region, the maximal altitude at which *V. hetrophylla* cannot be encountered is located around 1350 m for the North side and around 950 m for the South slope.

Altitudinal distribution of the population of *V. heterophylla* at the local level: The curves of the Fig. 4 shows the distribution of the population of *V. heterophylla* in the different localities of the sahelian region. All curves present a shape in a bell form illustrating the increase of the density of the population of *V. heterophylla* according to altitude. However the curves show some diverse optimum values. In Bilguim, the optimum is reached at an altitude a bit lower (between 450 and 550 m) (Fig. 4b). On the other hand in Kotorba, the peak is located at an altitude situated between 750 and 850 m (Fig. 4d). The other localities present an optimum altitude between these two extremes (Fig. 4a, c, e). This phenomenon is observed on the two slopes. The density of the population of *V. heterophylla* decreases from this optimum to end at a maximum altitude that varies from one locality to another. It is located around 850 m in Kalliao, Bilguim and Ndougour whereas in Kotorba and Mokolo this limit is located around 1050 m. It is necessary to notice that this altitudinal variation does not present the same appearance on the south slope. Apart from Kalliao and Kotorba whose two slopes present the same maximum

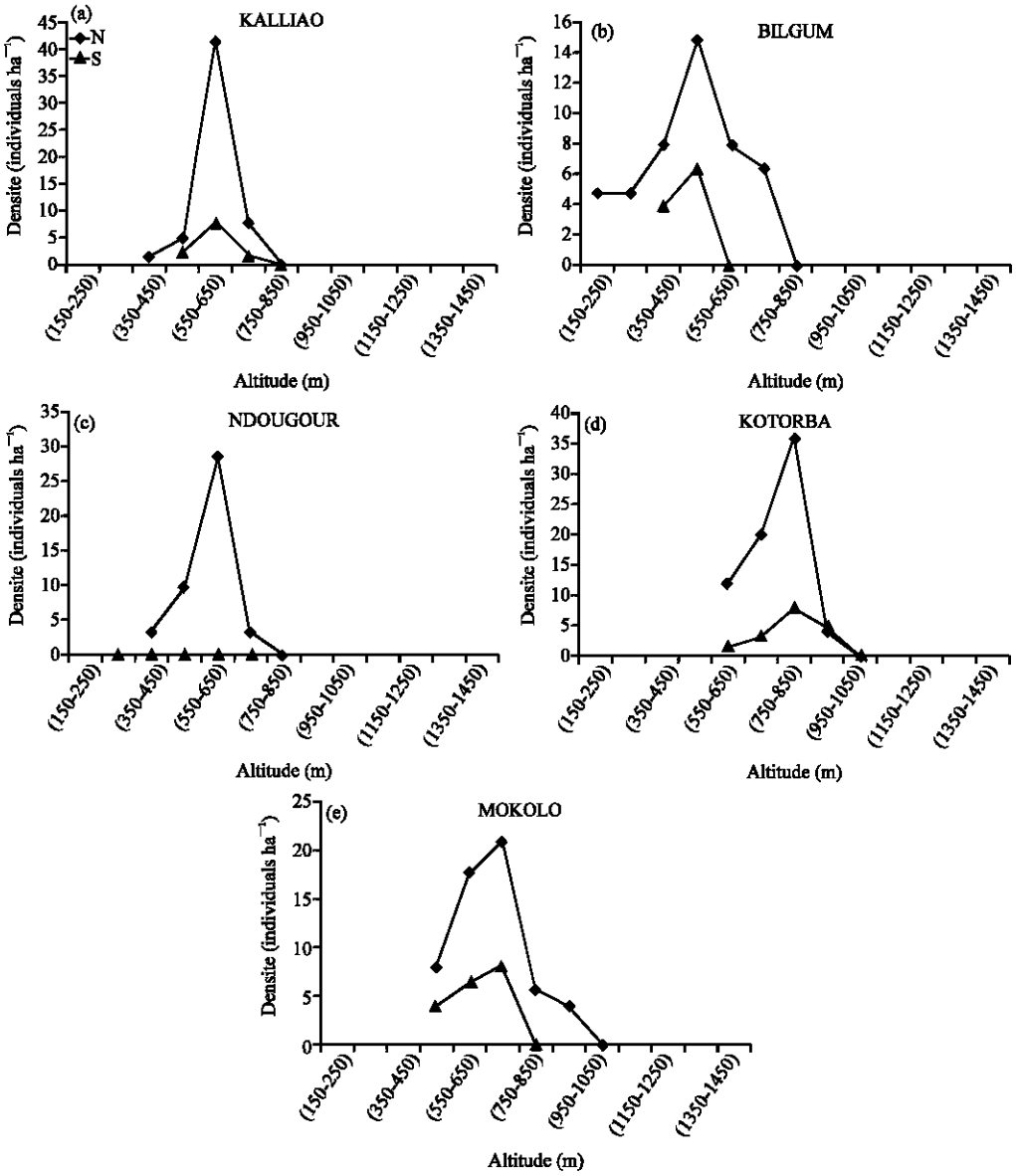

Fig. 4: Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in the different localities of the sahelian region. (a) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Kalliao; (b) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Bilguim; (c) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Ndougour; (d) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Kotorba and (e) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude In Mokolo

altitude, in the other localities, the maximum altitude for the two slopes presents different values.

The altitudinal variation of the density of the population of *V. heterophylla* in the sudanian region is presented in Fig. 5a-e. In all localities, the curves show also a bell shape indicating the increase of the density according to altitude on the two slopes except in Tinguilin whose south slope does not present any individual (Fig. 5a). In this ecological zone, there is not standardization of the optimum altitude. In Lagdo, *V. heterophylla* is encountered from 150 m on the two slopes (Fig. 5b) on the contrary in Tinguilin, only the north slope presents the individuals which begin to appear at an altitude situated between 650 and 750 m.

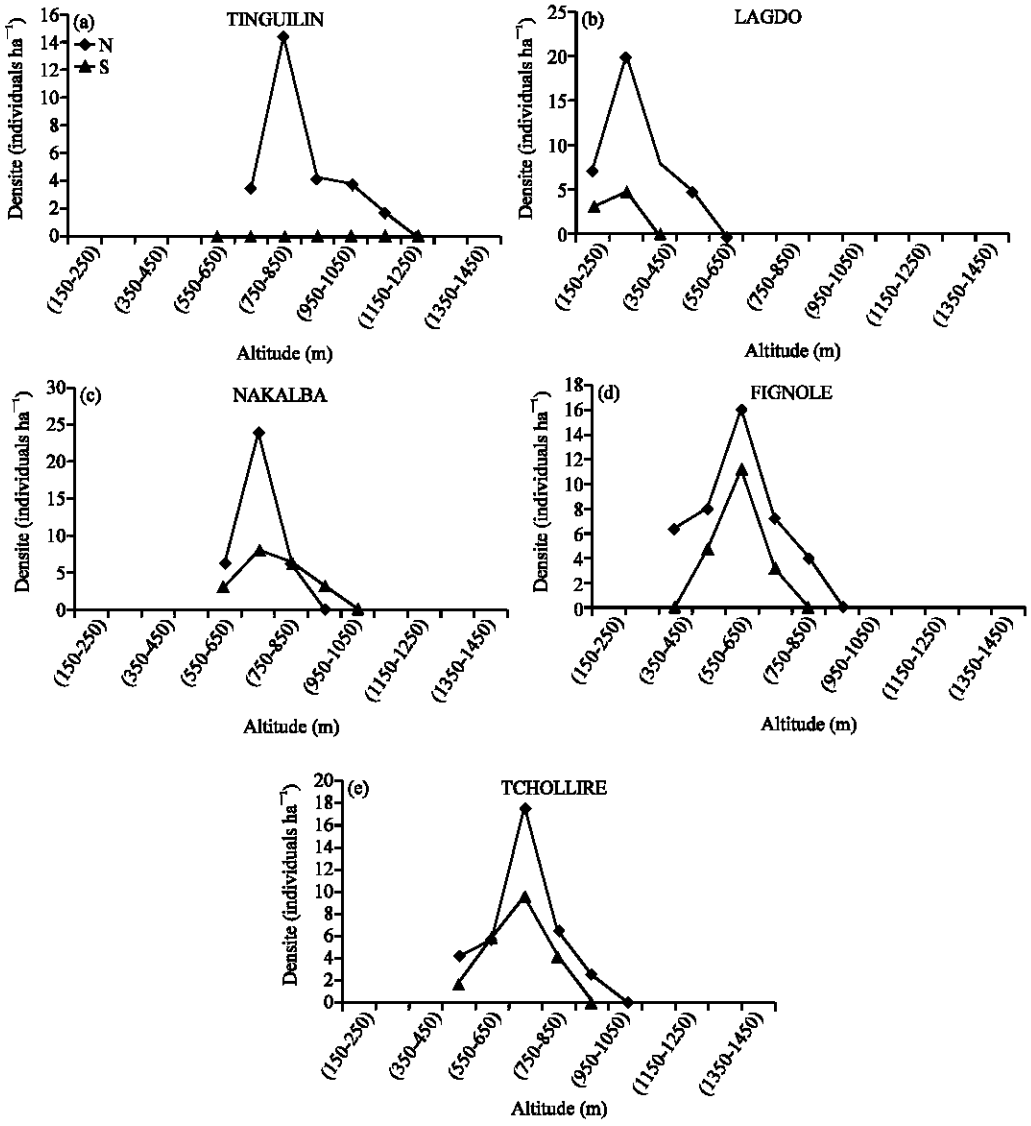

Fig. 5: Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in the different localities of the sudanian region. (a) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Tinguilin; (b) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Lagdo; (c) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude Nakalba; (d) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Fignolé and (5) Distribution of the populations of *Vepris heterophylla* (Engl.) R. Let. according to altitude in Tcholliré

Distribution of the population of *V. heterophylla* according to the sides of the massifs: On the whole, the distribution of the population of *V. heterophylla* varies according to the slopes. On average, the north slope is richer (23 individuals per hectare) than the south slope (6 individuals ha^{-1}). Figure 6 presents the distribution of the population of this Rutaceae according to the slopes in the sudano-sahelian zone. In the sudanian region as in the sahel, the density of the population of *V. heterophylla* is higher on the north slope than on the south slope. On the ecological level, it is necessary to note that there is a difference between the slopes of two regions. The one in the sahel region is more densified (26 individuals ha^{-1}) than that the north slope of the region of the Sudanese region (20 individuals ha^{-1}).

The trend is respected for the different localities of two regions (Fig. 7). In the sahelian region, it emerges from the analysis of the histogram that in all localities, the

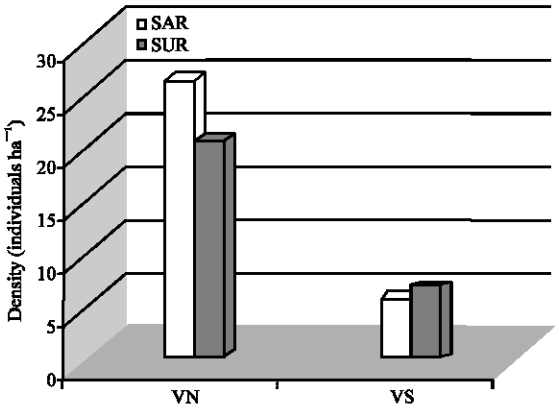

Fig. 6: Density of the population of *V. heterophylla* of the two sudano-sahelian zone: sahelian region (SAR) and sudanian region (SUR)

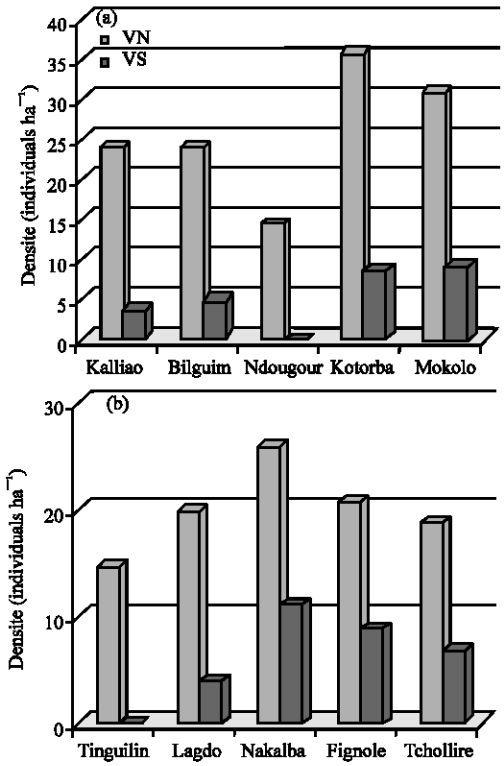

Fig. 7: (a) Distribution of the density of the population of *V. hetrophylla* according to the slopes of mountain in the different localities of the sudano-sahelian zone. (a) Distribution of the density of the population of *V. hetrophylla* according to the slopes of mountain in the different localities of sahelian region and (b) distribution of the density of the population of *V. hetrophylla* according to the slopes of mountain in the different localities of sudanian region

north slope is more diversified that the south slope with the highest value obtained on the north slope in Kotorba (36 individuals ha^{-1}) follow by of Mokolo (31 individuals ha^{-1}) (Fig. 7a). This result explains that *V. heterophylla* is highly submitted at the North slope in all localities of the sahelian region.

In the sudanian region, in all the localities, the north slope stands out by its high density. Nakalba is the locality where the density of the population is higher on the two slopes (26 individuals and 12 individuals ha^{-1}, respectively for the north slope and the south one) on the contrary in Tinguilin, the South slope does not present any density (Fig. 7 b).

DISCUSSION

Onana and Devineau (2002) think that the study of the populations of a plant species can be done from the distribution of the individuals in height or diameter the classes as an indirect indicator of the level of balance of the classes of ages and as witness of the phases lived by the population in terms of disruption or regeneration and symbol of the renewal in term of population. In the case of *V. heterophylla*, these indicators illustrate well the status of the population. The majority of population is young. The low proportion of the individuals of great height is explained by several reasons. Firstly, the pressure exerted on the resource in the area is high. To believe the local community, during the harvest of the leaves for the protection of the foodstuffs (cereals, niébé, voanzou…), the cutting of trunk for the construction and the peeling of the bark, great height individuals are preferred. Secondly, the demographic explosion and the expansion of the plantations entail retreat of vegetation. More the rhythm of clearing of vegetation of high more the vegetation disappears. Only the young individuals remain. Kémeuzé *et al.* (2009) report similar facts on *Clausena anisata* in the communal forests of Kilum-Ijim in the Northwest of Cameroon. In the sahelian region, the individual class of more than 12 cm is remarkably absent whereas this category of individuals is highly present in the sudanian zone. This difference is explained by the intensive exploitation of the resource by the local population. In the sudanian region, apart from veterinary medicine, the resource is used very little there. This explains the presence of some individuals of large height in the sudanian area. Besides, it is necessary to point out the climate as one of the factors responsible for the rarity of the large diameter shrubs.

In sudano-sahelian zone, the distribution of population of *Vepris heterophylla* according to the

altitude presents a curve that has a shape in bell form indicating the increase of individuals according to the altitude. The low altitudes present low densities in the two ecological areas. These results are explained by the presence and the proximity of the plantations (Tabuti and Mugula, 2007). These areas are under an intensive exploitation by the residents. Kémeuzé *et al*. (2009) made the same report while studying the altitudinal variation of *Clausena anisata* in the communal forest of Kilum-Ijim. At the high altitude, the low density of population of *V. heterophylla* can be explained by the conditions that reign there. This altitude shows the limit of the altitudinal distribution in Cameroon and its preferential or favorable altitude for the development of *V. heterophylla* in the two ecological zones (Domic and Capriles, 2009). However this species is mentioned at 2000 m in West Africa (Keita and Ouattara, 1995).

The two ecological zones show difference between the maximal altitude in which *V. heterophylla* cannot grow. The existence of the longitudinal gradient could be responsible of it. In effect, these two ecological zones are situated at different longitudes. The climatic conditions of two distinct ecological zones present considerable variations (Ouchbani and Romane, 1995). The effect of these climatic amplitudes is transferred in general on vegetation and on the population of *V. heterophylla* in particular. The effect of the longitudinal gradient was noted by Ouchbani and Romane (1995) on the distribution of vegetation in the Beni Mellal Atlas in Morocco. These authors affirm that the longitudinal gradient is responsible for the lateral variation of vegetation. Several elements have been linked to this longitudinal gradient among which are the amount of the precipitations and the variation of the temperature. In the case of the sudano-sahelian zone, the more one moves toward the sahel, the more the precipitations decrease whereas the temperatures increase (Moudingo, 2008). These elements of the climate have a significant influence on the distribution of vegetation in general and of *V. heterophylla* in particular.

The optimum difference between the localities can be explained by the climatic amplitudes between these localities and the phenomenon of microclimate. Some localities present many conditions that help species to develop. Lagdo is a good example for explain this situation. There, *Vepris heterophylla* appears at 150 m. This is explained by the conditions that are favorable to the development of this species (presence of the water reserves). It is necessary to note also that in the locality of Lagdo, *V. heterophylla* is not known as a socio-economic interest species. Apart from firewoods, it is not exploited any other purpose. In addition, the residents have no other essential activities apart from fishing. In this locality, agriculture that elsewhere is responsible for the deforestation is not highly practiced here. The presence of the resource at the low altitude is due to this reason. Tinguilin stands out by its maximum altitude to which the density ends (between 1150 and 1250 m). The nature of the mountain can explain partially this situation. On this mountain, the rocks appear at about 1100 m. *V. heterophylla* is a species that develops better on a rocky mountain (Letouzey, 1968; Geerling, 1987).

The slopes influence also the distribution of species (Achoundong, 1996). In the case of sudano-sahelian zone, the north slope presents a high density of population of *Vepris heterophylla*. The intensive human activity can explain the low proportions of the population on the south slope. To this the climatic conditions are added on the two slopes. Achoundong (1996) highlighted the floristic abundance of the North slopes on the hills of Yaoundé and confirmed our results. Our personal observation during the study, the south slope is highly habited by the local community. The physical factors as rainfall and heat can have some influences on the species distribution. However some studies have to be made on this aspect for confirmation. However the localities in which we carried our research are situated at different geographical positions and therefore, present different physical characteristics. This is what explains the difference in densities between the localities of the sahelian zone.

CONCLUSION

This study highlighted the ecological distribution of *V. heterophylla* following an ecological gradient from the sudanian region to sahelian region. *V. heterophylla* is a species that presents a good regeneration in the milieu. The density of population varies according to altitude and the slope of the mountainous massifs. Its optimum is reached between 550 and 650 m in the sahelian region, between 650 and 750 m in the sudanian region, the altitude at which this density decreases to ends is around 950 m in the sahel for the two slopes and is 950 and 1350 m in the sudanian region for the south slope and the north slope. No matter the massif and the ecological region, *V. heterophylla* is highly submitted at the north slope. Despite of all advantages that this resource presents as regards to food and therapeutic security, *V. heterophylla* is in decline that it is necessary to look some strategies for its rational and sustainable exploitation.

ACKNOWLEDGMENTS

We thank the head of the station of Agronomic Research institute for the Development (IRAD) of Maroua

more particularly Dr. Ntoupka Mama who placed at our disposal the planimeter that allowed us to take the measures of the foliar surface which results are not presented in this document. We are also thinking about all our informants on the field and our anonymous readers.

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