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The Ecological Distribution and Physical Characteristics of *Mondia whitei* (Hook F.) In the Bamboutos and Mayo Banyo High Lands of Cameroon

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Abstract

Purpose: The aim of this study is to assess the distribution and the physical characteristics of *Mondia whitei* (Hook F) in the Bamboutos and Mayo Banyo highlands in Cameroon. *Mondia whitei* (Hook F) is an African medicinal plant species found in Cameroon that humans have gained benefits from.

Materials and Methods: This study employed a purposive sampling technique were plots of 100m by 100m were set guided by occurrence sites obtained from semi structured questionnaires and focus group discussions. In each plot, all *Mondia whitei* trees, diameter at breast height and height were recorded. Liana stem diameter was measured at 130cm from rooting point and plants grouped in to exclusive DBH classes of ≤1.2 and 1.2 to 3.5. Descriptive statistics, maps and nonparametric test were done.

Findings: The result showed that a total of 346 trees of *Mondia whitei* were recorded on a total surface area of 65 hectares on the Bamboutos high land. While 280 trees of *Mondia whitei* were recorded over a surface area of 36 hectares at Mayo Banyo. Areas of high abundance was within elevations of 1542 to 1738m at Topelu and Bamegnia in Bamboutos high land at the Babajou subdivision with density of 8.0(stem/ha). On the other hand at Mayo Banyo highlands *Mondia whitei* had the highest occurrence of tree density of 29.2(stem/ha) at elevations of 860-1070 found within Bankim subdivision. Both Bamboutos and Mayo Banyo had more adults than juveniles' plants of *Mondia whitei*. There was no significant difference value between the adults and juveniles of *Mondia whitei* within elevations of Bamboutos. Mayo Banyo had a significant difference in adults and juveniles of *Mondia whitei* within elevation. Bamboutos and Mayo Banyo, had a greater proportion of non-exploitable as compared to exploitable plants of *Mondia whitei*

Unique Contribution to Theory, Practice and Policy: Further studies on the influence of climate and edaphic factors on distribution pattern within the area in order to project possible distribution sites.

Keywords: *Mondia Whitei, Physical Characteristics, Distribution, Bamboutos, Mayo Banyo*

INTRODUCTION

Mondia whitei (Hook F.) is a forest floor plant having aromatic rhizomatous roots belonging to the Apocynaceae family (Vihotogbé *et al*., 2021). It is a perennial woody twining liana with stems which exude a white latex when cut. The plant is locally referred in Cameroon as "Megamte" and "lete" in West region, "Gai gai" in Adamawa region, "Fehghanghang" by Meta clan and "la racine sucre" in French"(Djiazet *et al*., 2019). The plant grows from a large, tuberous rootstock with the roots having a very distinct vanilla aroma attributed to the presence of 2-hydroxy-4-methoxybenzaldehyde (Kubo and Kinst-Hori, 1999; Koorbanally *et al*., 2000; Mukonyi and Isaiah., 2001). The roots grow laterally and may spread out just beneath the soil surface covering large areas, making them easy to harvest (Ross, 1978; Van Wyk and Gericke, 2000; Aremu *et al.*, 2011). *Mondia whitei* is a genetic resource in Cameroon as well as a popular medicinal and aromatic native plant (Aremu *et al*., 2011). This plant has enormous uses from a source of fragrance to its value for treating various diseases (Patel, 2015). A number of biological investigations have proven the aphrodisiac, antimicrobial (Idayat and Sakiru, 2015; Bongo *et al.*, 2017), anti-diarrheal (Ndukui *et al.*, 2013) anti-inflammatory (Githinji *et al.*, 2012), antisickling and antioxidant activities (Bongo *et al.*, 2017; Gbadamosi and Aboaba, 2016) of the plant *Mondia whitei.* According to the South African National Biodiversity Institute (SANBI) 2009, *Mondia whitei* is widely distributed in tropical Africa from Guinea through Cameroon to East Africa and wide spread in Zimbabwe and South Africa. The plant predominantly occurs in vegetation types that range from swamp forest, swampy shrubby grassland and riverine forest to disturbed forest, at altitudes from sea level to 1800 m (Venter *et al*., 2009). The plant grows in dense bush, in a variety of wood land and forest habitat including shrubby swamp grass land (Venter *et al.*, 2009). *Mondia whitei* has been for a very long time used in traditional medicine in Sub-Saharan Africa in the management of male erectile dysfunction and treating many diseases (Agbeve *et al*., 2014).

The roots of *Mondia whitei* are intensively collected and marketed for diverse medicinal uses in Sub-saharan Africa (Quiroz *et al.*, 2014). *Mondia whitei* (Hook.F) skeels (Apocinaceae) is a priority medicinal liana in sub-Saharan Africa (Cunnigam, 1993; Venter *et al*., 2009). The roots are equally the most used part and commercially available part of the plant accessible in local markets in Cameroon, used as spice for 'Achu Soup' and 'Nkwi', aphrodisiac and appetizer. In Cameroon *Mondia whitei* is classified as category C of secondary non timber forest product as per article 6 of decision N°0209/d/MINFOF/CAB of 26/04/2019 carrying the classification on special forest product and NTFPS by Ministry of Forestry and Wild life. Its classification as category C of NTFPS in Cameroon is largely linked to an ecological relevance stand point of view than commercial and socio cultural value. It is extinct in many regions within its geographical range like South Africa (Cunnigam, 1993). Despite the fact that African health care system depends upon indigenous medicinal plants mostly harvested in the wild for varied uses like income generation, they are highly threaten by human activities. Land fragmentation, natural habitat alteration, vegetation fire, over grazing, climate change, agricultural activities etc. represent important factors and threats to establishment of *Mondia whitei* in Cameroon. This plant is equally one of those plants threatened by over exploitation climate change on unsustainable land use management (Vihotogbé *et al*., 2021). Also the impact of variations in climatic variable patterns of temperature and rainfall affect all biomes (grass lands, forest and aquatic ecosystems, with direct impacts on the land cover (Kigen *et al.*, 2013) influencing plant distribution.

The commercialisation of plants has been observed in their uses by many industries such as the cosmeceutical, fragrances, food additives, plant protection agents, nutraceutical and

pharmaceutical, has gained popularity (Aremu *et al*., 2011) which is the case of *Mondia whitei* in Cameroon. The current solicitation of *Mondia whitei* roots in Cameroon by the company 'V. Mane Fils,'for exploitation combined with the unstainable harvest methods by communities within native ranges of the plant establishment possess threat to it regeneration and establishment. Also *Mondia whitei* in Cameroon is not a cultivated specie at such naturally regenerates in the wild through wind seed dispersal mechanism and resprout which could be affected by geographic barriers and anthropogenic disruptions. There is equally limited information on this plant species population and distribution pattern which is a major setback for the sustainability and fostering policy on the conservation of *Mondia whitei* in Cameroon. Biodiversity assessment is recognized globally as a fundamental activity to sustainable biodiversity conservation, management and planning (Humphries *et al.*, 2003; Margules and Pressey 2000). This makes available data necessary to understand species diversity and distribution within ecosystems. However, its application is often neglected particularly in tropical countries, including Cameroon, where a substantial fraction of the world's unique species are found (Gordon and Newton, 2006). Detail knowledge is lacking on species conservation driving force and preservation of its ecological niche within fragile ecological regions. For many species, poor ecological knowledge limits the prediction of population response to climate change and land use. This study was aimed at assessing and providing information on the ecological distribution of *Mondia whitei* with respect to the physical characteristics such as tree density, height, diameter at breast height, adult and juvenile plants along elevational gradient in other to inform policy makers and conservation efforts.

MATERIALS AND METHODS

Description of the Study Area

The Bamboutos highland is found in the West region while Mayo-Banyo highland is found in of the Adamawa region of Cameroon. Bamboutos lies between 5-6° N and between 9-11° while Mayo-Banyo is located within 6°34'52.97" N and 11°44'6.79" E of Cameroon. Bamboutos is one of the eight divisions which make up the West Region of Cameroon. Both sites are found within plateau regions of Cameroon located within transitional zones between the forest and savannah regions of the country. The vegetation transits from forest, wooded savannah and shrubby savannah to grassland savannah with gallery forest along water courses. The two areas, experience two seasonal changes but with variations of intensities of rainy and dry season. Bamboutos average temperatures range between 23^0C during the dry season and 18^0C in the rainy season with a mean annual rainfall of 1800mm (CDP for Mbouda, 2011; MeteoTrend.com, 2023). Bamboutos highlands has an equatorial monsoon climate MINEPDED (2015) with more of tropical humid expression (MINEF, 1999). On the other hand Mayo-Banyo highland has tropical sudannian climate at Mayo Darle and Banyo with more of a humid equatorial climate expression at Bankim.

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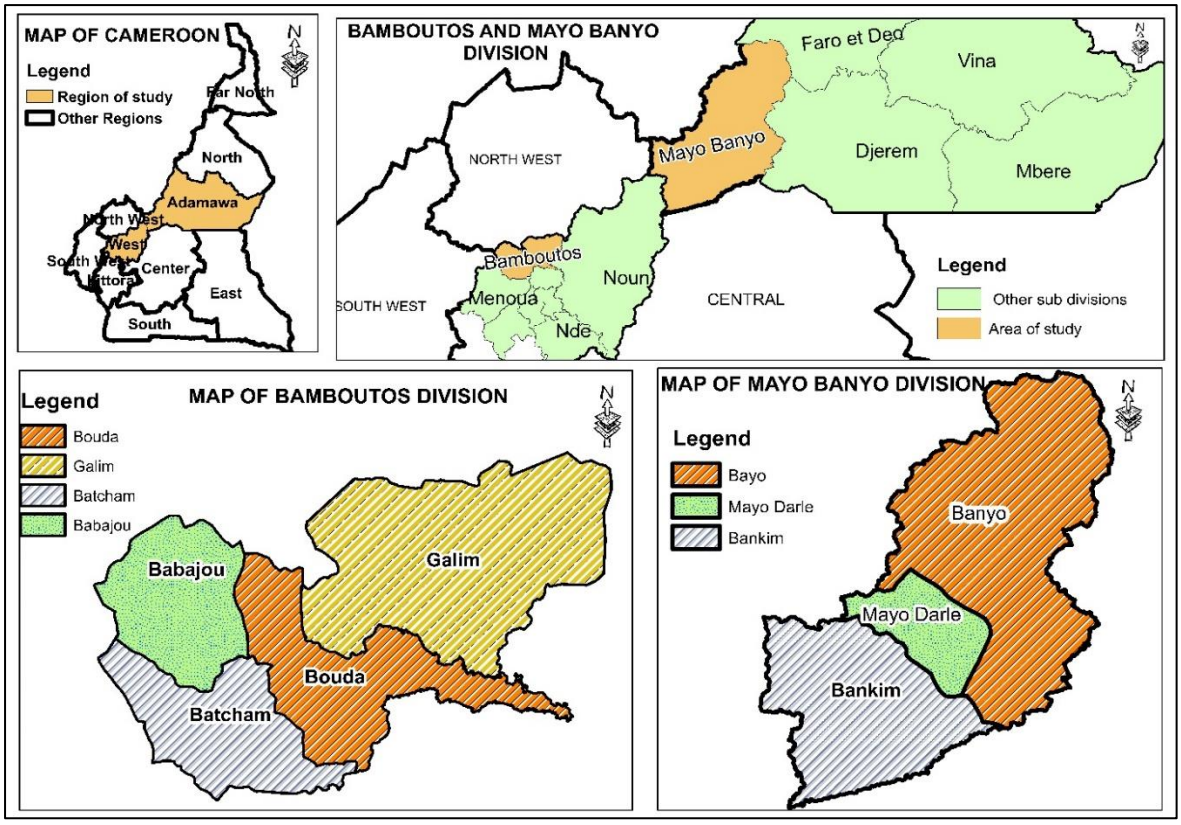

Figure 1: Location Map of Bamboutos and Mayo Banyo

Study Design

This research employed a combination of descriptive (Jeet and Kumar, 2015) and exploratory research design (Shrivastva and Rogo, 1958), to adequately evaluate the distribution of *Mondia whitie* within the study area.

Population

The study targeted juvenile and adult plants of *Mondia whitei* (Hook.F) within the study sites.

Sampling Techniques

An exploratory field work employing an opportunistic random scheme and purposive sampling technique (Martin 1995) was used in the study. Semi structured questionnaires and focus group discussion was employed were employed to identify occurrence sites. Square plots of 1 ha (100m × 100m quadrat) were laid at occurrence sites of *Mondia whitei* establishment. 65 plots were established at Bamboutos and 36 plots at Mayo Banyo based on availability of plant. These plots were subdivided into 4 non-overlapping square quadrat subplots of 25 × 25m to ease inventory coordinates were collected using a Garmin 64 GPS. The sampling was done from the southwest corner of the study area and continued to the northeast corner to preserve the geographical integrity of this liana distribution across the plots established (Condit *et al.*, 1996).

Data Collection

Plant inventory on *Mondia whitei* was carried out in Bamboutos and Banyo division. Before establishing plots an informal survey using focus group discussions and semi structured questionnaires based on expert knowledge of participants was used to identify representativeness occurrence sites of plant. Information of localities in community maps were

used to guide strategic information gotten from socio professional groups of medicinal plant collectors, *Mondia whitei* corporative, sellers, local farmers, traditional healers, cattle rearers on location sites of the plant. Socio professional groups were considered because they are the direct users of the indigenous medicinal plant species. Field plant identification of species was done using a combination of techniques, such as the general form of the liana (slash colour, smell, exudates, leaf type and shape). Plant identification was done at the Cameroon National Herbarium (HNC) in Yaoundé in comparison with the Herbarium Voucher specimen Nº42920/HNC.

Aspects of plot dynamics such as life stage adults, DBH, Height, tutor plants, tree health were recorded**.** Plants were identified to be either juveniles (less than 1m height) or adults (above a meter of height), adopted from studies on *Mondia whitei* (Hook.F.) by (Vihotogbé *et al.,* 2021). Plant Diameter and height recorded were exclusive to ground lianas of this specie also named young plants or Juveniles who were less than 1m height, some without tutor plant and could not meet the diameter cut off measurement point requirement census. Height of plant was estimated with the use of a clinometer, tree diameter was also measured with a caliper for all adult plants. Liana stem diameter was measured 130cm from the rooting point of plants as they ascend canopy according to liana census protocol (Gerwing *et al.,* 2000) and (Schnitzer *et al.*, 2008) with slight modification. This criteria exempted all Juveniles of *Mondia whitei* whose heights were beneath DBH measurement point. All rooted lianas were grouped in to exclusive classes of ≤1.2 and 1.2 to 3.5 cm of DBH. This diameter classes were chosen by this study to represent estimates of exploitable (1.2-3.5 cm) and non-exploitable (≤1.2) *Mondia whitei* plants. This exploitation limit was based on field measurements of exploited plant as well as harvest considerations of a minimum of at least three years to get mature roots sizes of *Mondia whitei*. In occurrence sites fruiting, flowering and threats to plant establishment were noted. DBH and height measurement was inclusive to all independently rooted stems of adult plants. Soil excavation was avoided at all times since study was conservative in nature. If the stems where connected below the soil surface then study consider them to be independent stems (Schinider *et al.,* 2008). Also multiple stems that were connected to the ‘‘principal’’ stem were considered a single individual. In this case instead of recording different branches for individual of the same species due to irregularities, the largest stem branch was rather recorded (Schinider *et al.,* 2008). In cases of irregularities where plant branched or split below measurement point, the branch stem with the largest diameter was inventoried with POM (position of measurement) 130cm from rooting point. This was a slight modification of case C and G liana growth forms (Gerwing *et al*., 2006) and case J (Schinider *et al.,* 2008) to maintain homogeneity of DBH, POM and ease replication by other researchers as seen on figure 2.

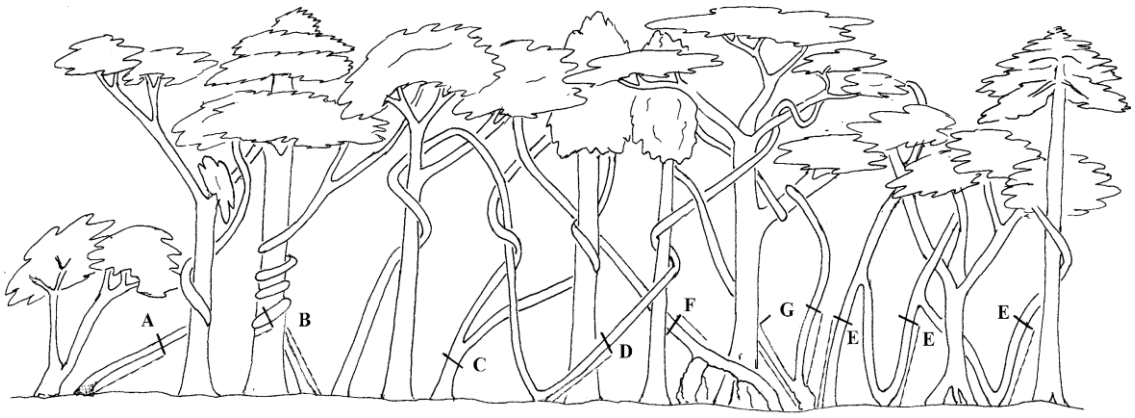

Figure 2: Liana Diameter Measurement Points

Source: Gerwing et al., 2006

(B) twining lianas are measured 130 cm from the rooting point measured along the stem of the liana; (C) lianas that branch below 130 cm from the rooting point are measured 20 cm below the branching point (G) lianas that branch below 130 cm but with a very irregular main stem or branching close to the ground, measure the branches separately at 130 cm and note that they are multiple stems of the same individual.

Statistical Analysis

Distribution

An elevation distribution map of plant was produced based on GPS occurrence point of plant collected from field work. The elevation classification of the landscapes were obtained from elevation mapping, using the DEM data, the data was obtained from USGS website. The landscape elevation of bamboutos was grouped into to elevations of 1075 to 1224m, 1225 to 1363m, 1364 to 1541m, 1542 to 1738m, 1739 to 1979m, 1980 to 2279m, 2280 to 2705m. While Mayo Banyo was grouped into elevation classes of 682 to 859m, 860 to 1070m, 1071 to 1309m, 1310 to 1615m and 1616 to 2419m.

Tree Density

Density estimates was done using the formula (in ha)

$$D = \frac{\text{Number of individual}}{surface\ area}$$

Compare Life Stage Distribution Plant

A Mann-Whitney u test and bar chart representation was used justify differences in distribution of adults and juveniles of *Mondia whitei* within and between study sites.

Comparison of Height and Diameter of *Mondia Whitei* along Elevation

Descriptive statistics and Kruskal Wallis test was used to determine if there was a significant difference in plant height across elevation categories in study sites. It was also used to determine if there was a significant difference in plant diameter across elevation categories. A bar chart representation was used comparing the difference in exploitation status of *Mondia whitei* between study sites.

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FINDINGS

Distribution of *Mondia Whitei* in the Bamboutos

A total of 346 trees of *Mondia whitei* were recorded on a total surface area of 650,000m^2 (65 hectare) on the Bamboutos high land of the West region of Cameroon. Fig 3 indicates its distribution within the four sub divisions of Galim, Mbouda, Babajou and Batcham along elevation variations within Bamboutos division. The distribution of the genetic resource *Mondia whitei* within the whole land scape was generally sparse, with a nucleated pattern amongst communities within specific elevational classes in the landscape. The plant was located growing within five elevation namely 1075 to, 1224m, 1225 to 1363m, 1364 to 1541m, 1542 to 1738m and 1739 to 1979m with variations in population. The plant had a high population in Bametougoung, Topelu and Bamenji communities. The least abundance in plants was found in communities of Galim, and Batcham. At much higher elevations of 1980 to 2279, 2280 to 2705 located in the community of Zavion 1 and Zavion 2, the plant was not seen growing.

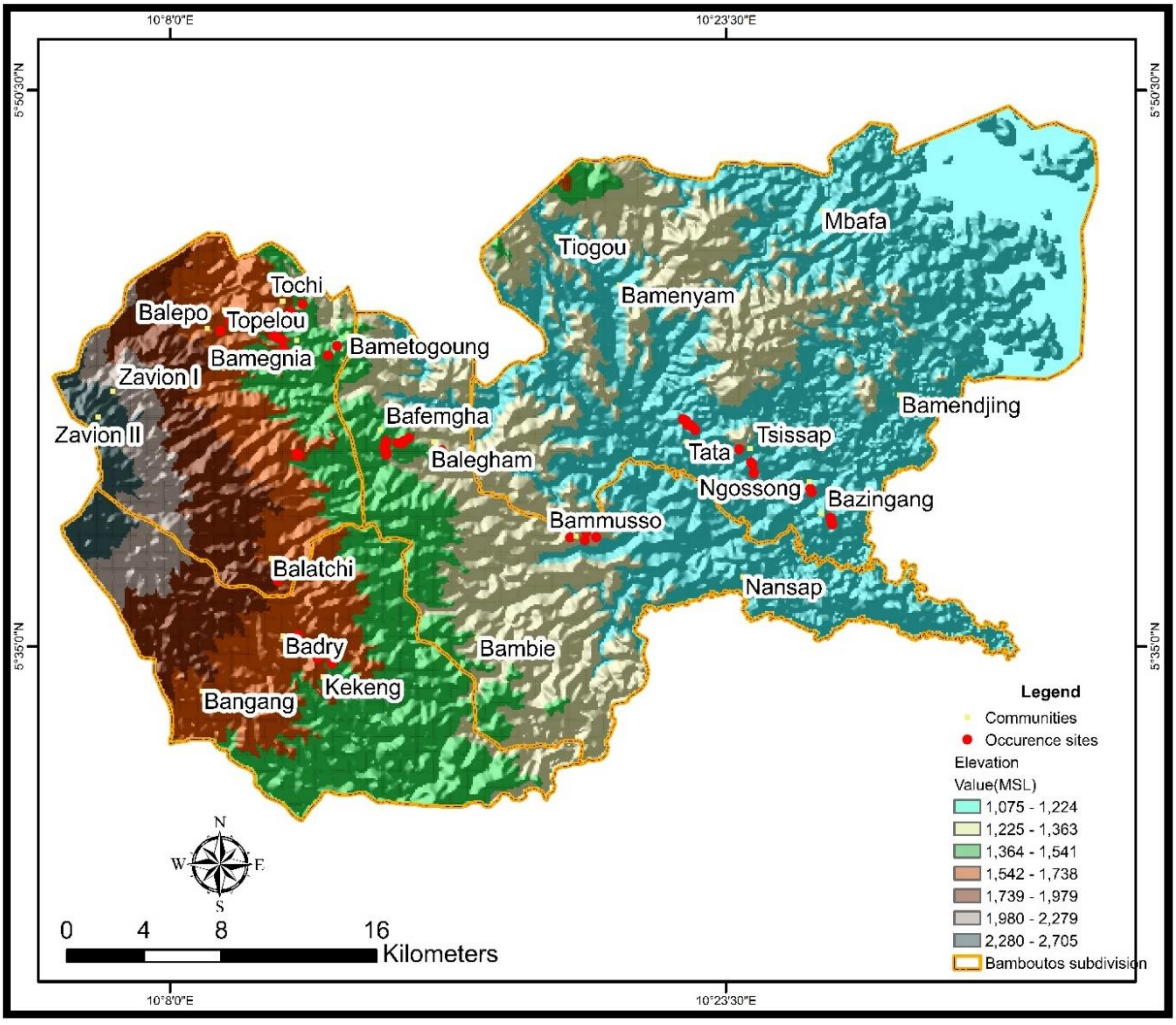

Figure 3: Distribution of Mondia Whitei in Bamboutos Highland

Distribution of *Mondia Whitei* in Mayo Banyo Highland

Mondia whitei was found growing within three sub divisions of Mayo Banyo including Bankim, Mayo Darlé and Banyo. The distribution of the genetic resource *Mondia whitei* within

the whole land scape is generally sparse, and nucleated specifically at Bankim division within the community of Sarkibaka as indicated by fig 4. Amongst five elevational class in Mayo Banyo highlands the plant was located growing within three elevation classes of 682 to 859m, 860 to 1070m, 1071 to 1309m, with variations in populations and density. A greater proportion of this plant was located in Bankim sub division 201(71.78%), seconded by Banyo sub division 52(18.57%) and lastly Mayo Darle subdivision with 27 plants (9.64%). The plant at Bankim subdivision was mostly found within within communities of lingam, Sonkolong, Magna, Songo, Tchamba, Nyabonya and Yimbere. Within elevations of 860 to 1070m the plant was found with higher populations at Sarkibaka with lower population within 1071 to 1309m elevation within communities of Mayo Dinga, Pagarri and Gwaya.

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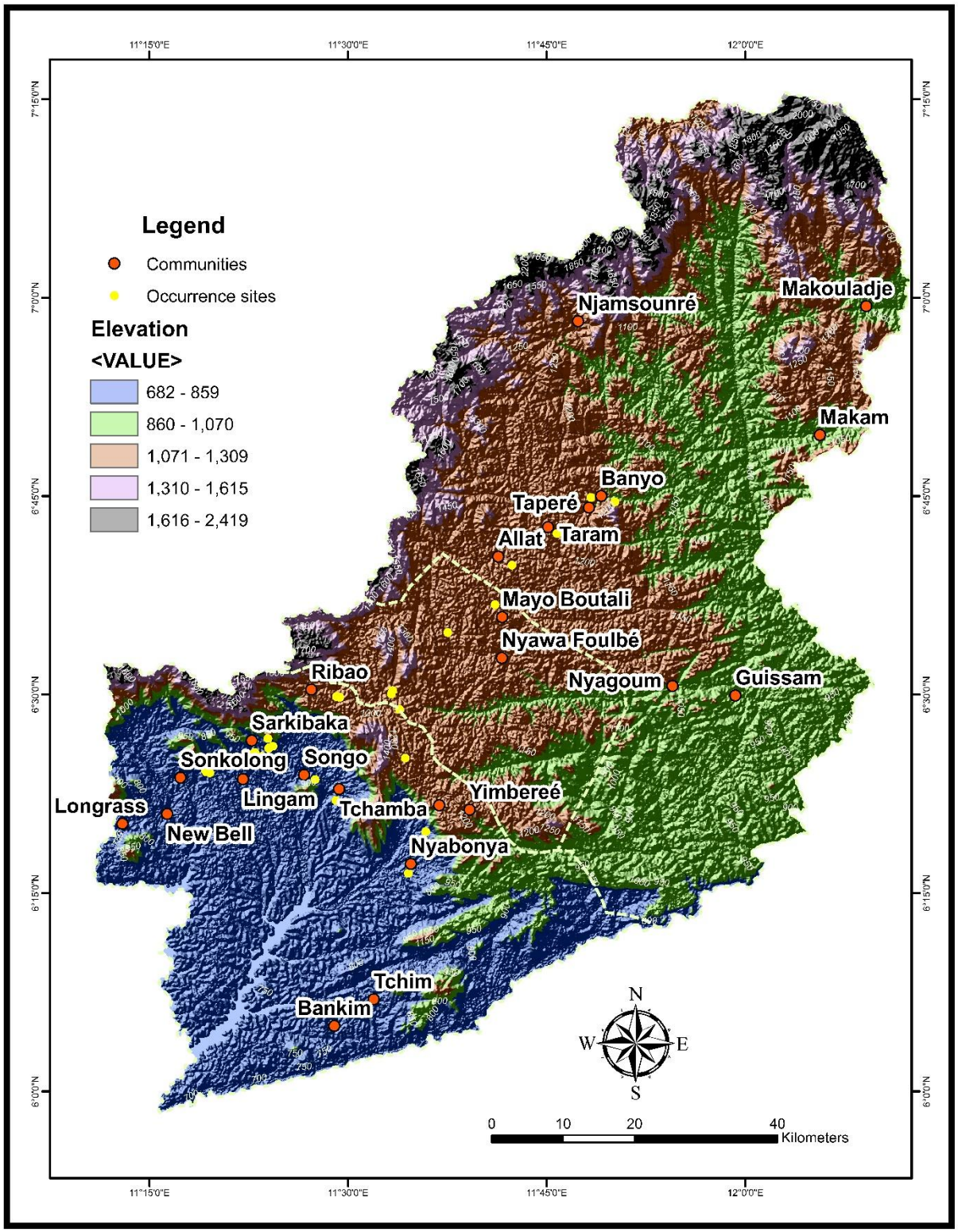

Figure 4: Distribution of Mondia Whitei in Mayo Banyo Highlands

Tree Density

The lowest tree densities was recorded with elevation of 1225 to 1365 and 1075 to 1224 (2.8 and 3.08) respectively at Bamboutos highland as seen on table 1. However, the average density of the entire study area was 5.32 (stem/ha) at Bamboutos and 7.7 (stem/ha) at Mayo Banyo.

Elevations of 860-1070 had the highest occurrence of tree density of 29.2(stem/ha) at Mayo Banyo highland.

Table 1: Density Distribution of *Mondia Whitei* within Elevation Gradient

Area	Elevation Class	Number of Trees	Surface Area(ha)	Tree Density(stem/ha)	Average Density
Bamboutos	1075-1224	37	12	3.08	
	1225-1365	14	5	2.8	5.32
	1364-1541	174	31	5.42	
	1542-1738	109	14	8.07	
	1739-1979	12	3	4	
Mayo Banyo	682 to 859m	54	15	3.6	
	860-1070	147	5	29.4	7.7
	1071-1309m	79	16	4.9	

Distribution of Adults and Juveniles plants Between Bamboutos and Mayo Banyo Highlands

Out of 346 plants in Bamboutos 113 plants (32.7%) were juveniles and 233 plants (67.3%) were adults. At Mayo Banyo high lands, out of 280 plants a majority of plants were adults 169(60.4%) while fewer plants were juveniles 111(39.6%). In terms of population there were more adult and juveniles' plant in Bamboutos than Mayo Banyo highlands as illustrated on fig 5. A Mann-whitney u test indicated non-significant difference in size of adults and juveniles of *Mondia whitei* within study sites with reported p value of 0.07 were $p \geq 0.05$.

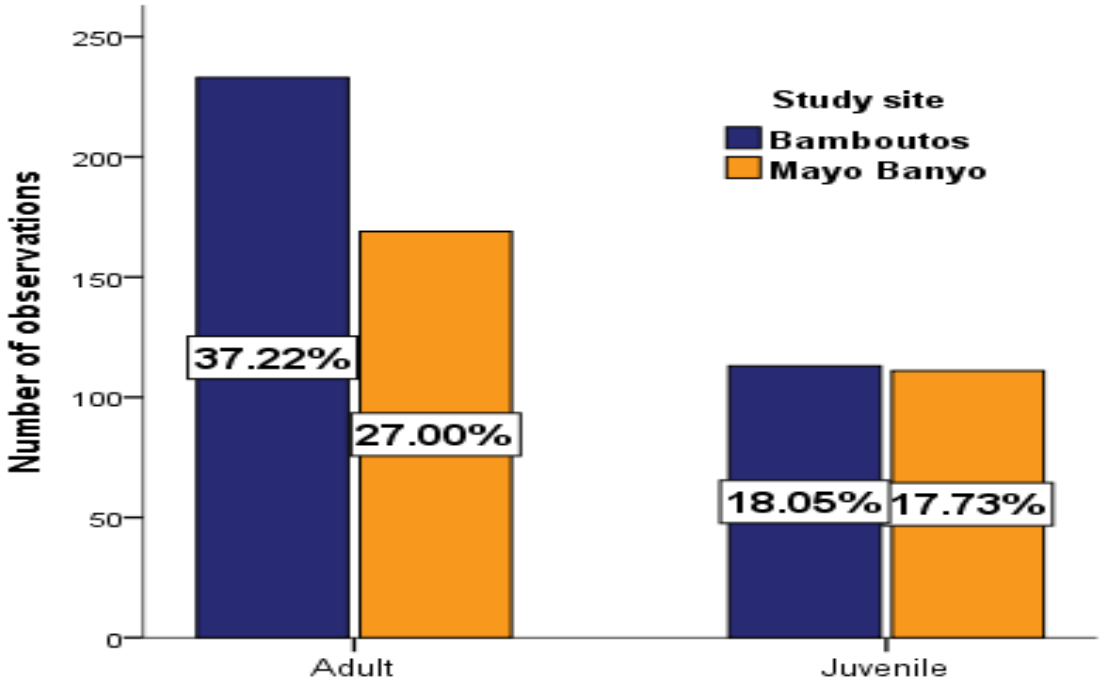

Figure 5: Adults and Juveniles between Study Sites

[U=45057.00, P = 0.070].

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Comparing plant life stage within elevation categories in study site, Bamboutos within elevations of 1542 to 1738, and 1364-1541 had more adults with population of 121 and 73 respectively as seen in fig 6. The least number of adults were found within elevation of 1739-1979 with 5 plants. Juveniles of *Mondia whitei* were equally more within elevation classes of 1542 to 1738, and 1364-1541 with populations of 53 and 36 respectively. Kruskal Wallis test indicated no significant difference in size between adults and juveniles within elevation with reported p value of 0.170 were p≥0.05 within the Bamboutos landscape.

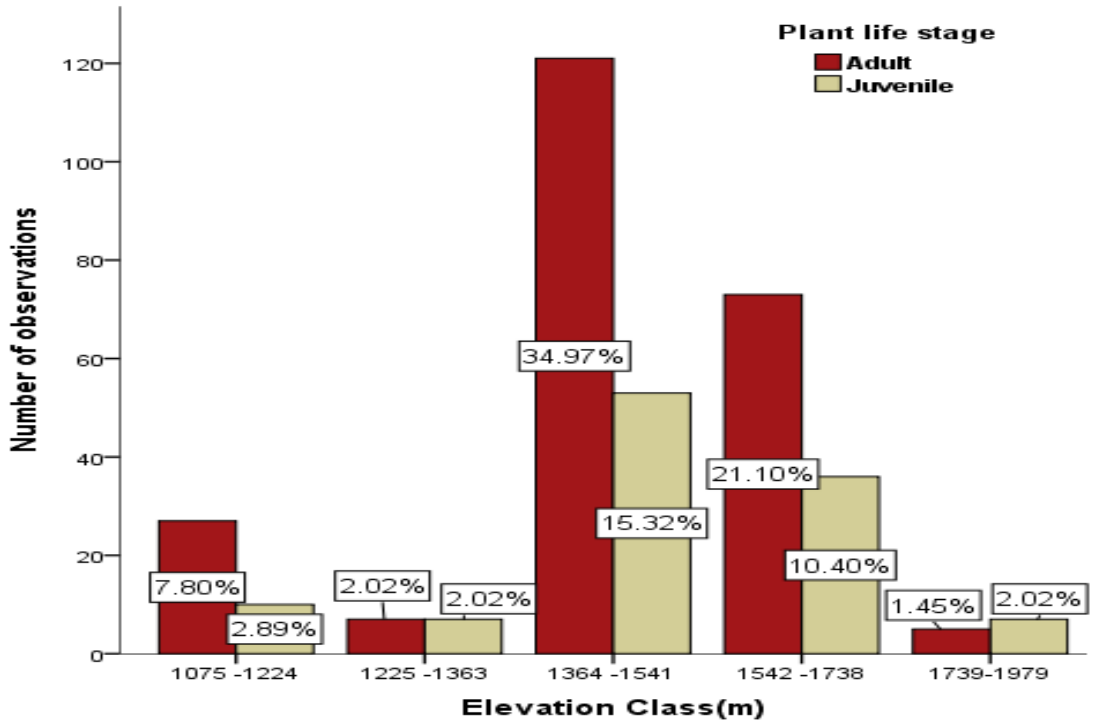

Figure 6: Plant Distribution within Elevations at Bamboutos

p=0.170 X^2 (4, N=346= 6.415, P<0.05)

At Mayo Banyo although there were more adults than juvenile populations, elevations of 860-1070m had more adult (101) and juveniles (46) compared to other elevation categories? Also elevations of 682-859m (33), 860-1070m (46) had more juveniles than elevation of 1071-1309m as seen in fig 7. There was a significant difference in the life stages of Mondia whitei within elevation with reported p value of 0.001 were p<0.05. Kruskal Wallis test indicated statistical significant difference was accounted for by adult and juvenile plants within elevations of 682-859m and 860-1070.

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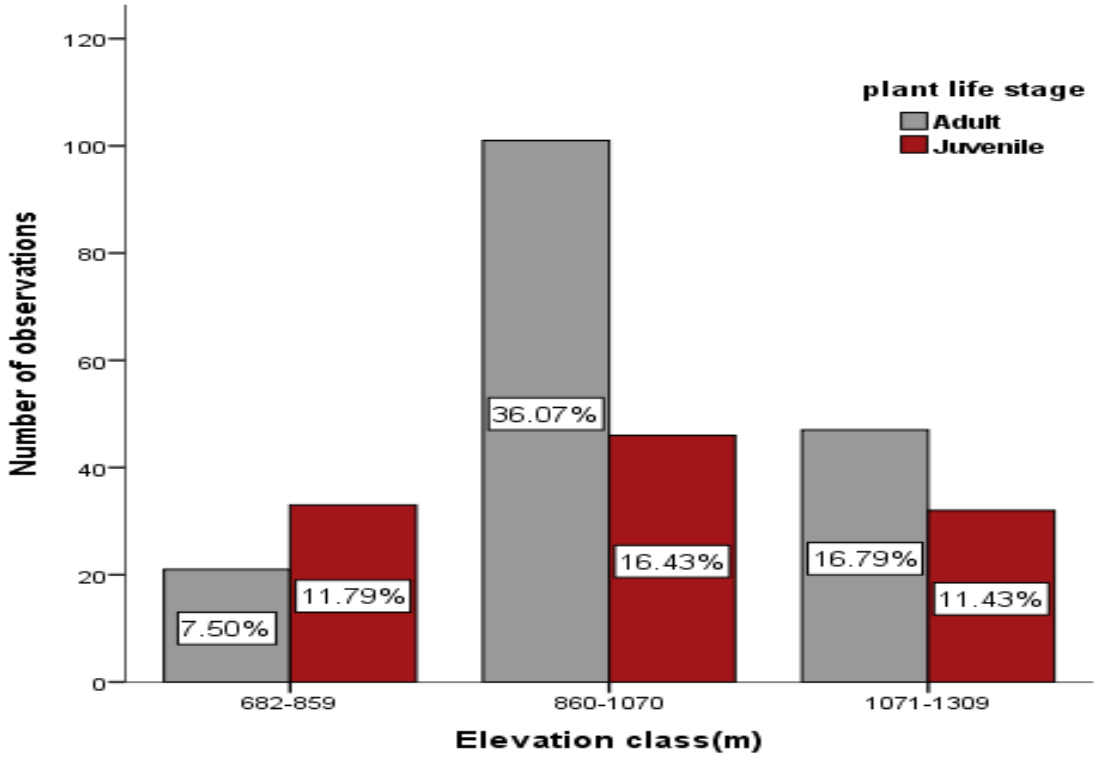

Figure 7: Plant Distribution within Elevations at Mayo Darle

p=0.01 X^2 (2, N=280= 14.710, P<0.05).

Comparison of Height of *Mondia Whitei* along Elevation in Bamboutos Mayo Banyo Highland

Mondia whitei had a general mean height of 3.54 within the Bamboutos and 3.50 at Mayo Banyo high lands. Bamboutos had a lower mean height of 2.911±0.851 at elevation of 1542-1738m as reported on table 2. The highest height of plant of 18m was seen at elevation of 1542-1738m, this elevation equally had the highest mean height of 3.863±0.294. Elevations of, 1225-1365m, 1364-1541m, 1542-1738m, 1739-1979m had 50% of its population with height above and below 3m. On the other hand at Mayo Banyo, a higher mean height was observed within elevations of 860 to 1070m with mean height of 3.695±1.330, while the lowest mean height of 3.402±1.213 was observed at elevation of 1071 to 1309 m equally 75% of the plant population had height below 4m within elevations of 682-859m and 1071-1309m. Also half of the plant population within elevation of 682-859m and 1071-1309 had height above and below 3m at Mayo Banyo. Kruskal Wallis test confirmed that there is no significant difference of height in m across elevation categories within the Mayo Banyo with p=0.486 X^2(4, N=314=1.443, P<0.05) as well as Bamboutos with p=0.344, X^2(4, N=233=4.491, P<0.05).

Table 2: Comparison of Height Distribution along Elevation of *Mondia Whitie* in Mayo Banyo

Area	Elevation Class	Minimum Height	Maximum Height	ME±SE
Bamboutos	1075-1224	2.00	5.40	2.911± 0.163
	1225-1365	2.50	7.00	3.614±0.620
	1364-1541	2.00	12.00	3.501±0.164
	1542-1738	1.8	18.00	3.863±0.294
	1739-1979	2.6	5	3.480±0.449
Mayo Banyo	682-859	2.5	5	3.405±0.165
	860-1070	2	8	3.695±0.132
	1071-1309	2	7	3.402±0.177

Diameter Class Distribution of *Mondia Whitei* in Bamboutos and Mayo Banyo.

Mondia whitei had DBH ranging from 0.41 to 3.5cm Bamboutos and 0.44 and 2.45cm at Mayo Banyo high lands as seen on table 3. The mean tree diameter of plant was 1.10± 0.546 within the land scape of Bamboutos for 233 plants and 1.124±0.405 at Mayo Banyo for observed 169plants. Bamboutos had its lowest mean DBH of 0.956± 0.051 at elevation of 1075-1224m and highest DBH at 1542-1738m. On the other hand Mayo Banyo, had its highest mean DBH of 1.213±0.041 at elevation of 860 to 1070m and lowest mean DBH of 0.977±0.057 at elevation of 1071 to 1309 m. Kruskal Wallis Test confirmed that there was no statistical difference of DBH in cm across elevation categories at Bamboutos with p=0.079 X^2(4, N=233=8.374 P<0.05). On the other hand there was a significant difference of DBH in cm across elevation categories within the Mayo Banyo landscape with p=0.004, X^2(2, N=169=18.272, P<0.05). Elevation class 860-1070m and 1071-1309 accounted for this significant difference as well as less utilization of the plant.

Table 3: Comparison of DBH Distribution along Elevation of Mondia Whitie in Mayo Banyo

Area	Elevation Class	Minimum	Maximum	ME±SE
Bamboutos	1075-1224	0.57	1.59	0.956± 0.051
	1225-1365	0.89	2.55	1.619± 0.269
	1364-1541	0.41	3.50	1.070± 0.049
	1542-1738	0.57	3.50	1.175± 0.069
	1739-1979	0.76	1.34	1.070± 0.102
Mayo Banyo	682-859	0.50	1.27	1.026±0.052
	860-1070	0.38	2.45	1.213±0.041
	1071-1309	0.44	1.91	0.977±0.057

Distribution of exploitation status between study site Bamboutos (157) and Mayo Bayo (92) had more plants with DBH <1.2cm considered to be non-exploitable adult plants. On the other hand exploitable plants with DBH of 1.2 to 3.5cm were fewer as seen on fig 8.

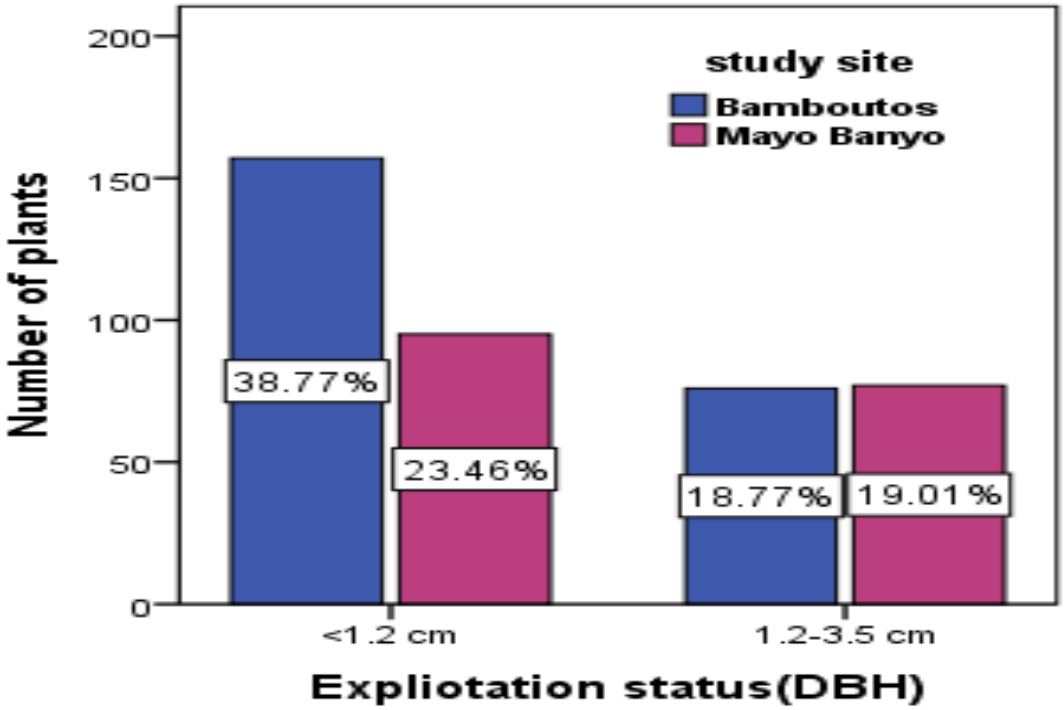

Figure 8: Variation of Exploitation Status of Mondia Whitei

Comparing exploitation status along elevations categories, Bamboutos at elevation class 1364-1541 and 1542 -1738 had the most exploitable plants with 38(16.31%) and 27(11.59%) plants respectively as seen on fig 8. While on the other hand elevation class 1225-1363 and 1739-1979 had the least number of exploitable plants with 3(1.29%) and 2(0.86%) plants respectively. Non exploitable plants were equally still abundant within elevations of 1364-1541 and 1542 -1738 with 83(35.62%) and 46(19.74%) plants. Elevations of 1225-1363 and 1739-1979 equally had the least number of non-exploitable plants. The p value of Chi-Square Tests was 0.645 were $p \geq 0.05$. The statistical test was not significant, meaning exploitation status of *Mondia whitei* was independent of elevation

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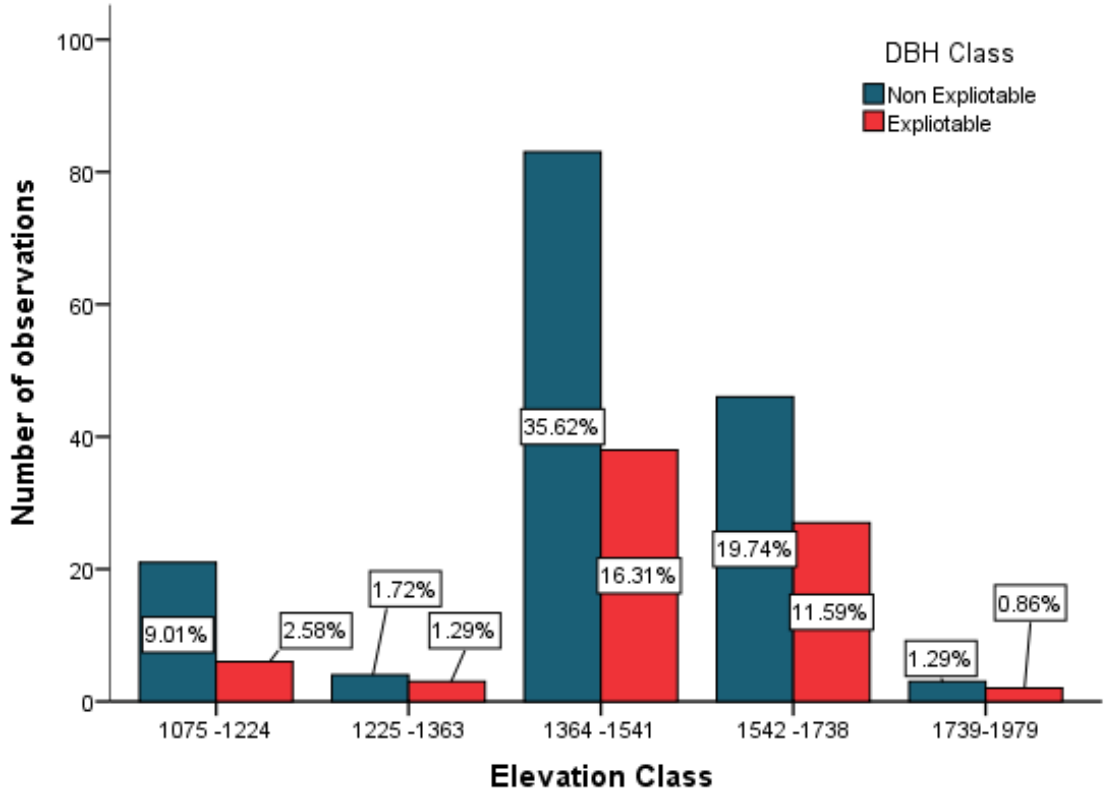

Figure 9: Exploitation Status of Mondia Whitei within Elevation Classes.

p=0.645 (Chi square value = 2.500[a], DF=4).

The *Mondia whitei* had more non exploitable plants than exploitable plants along varied elevation classes within the land scape of Mayo Banyo. Fig 9 indicates that there were more exploitable plants within elevations of 860 to1070m 53(31.36). Also elevations of 682 to 859m, had the least non exploitable 13(7.69%) and least exploitable 8(4.73%) plants. The p value of Chi-Square tests was 0.085 at $p<0.05$. The test statistics was insignificant, meaning exploitation status of *Mondia whitei* was independent of elevation at Mayo Banyo.

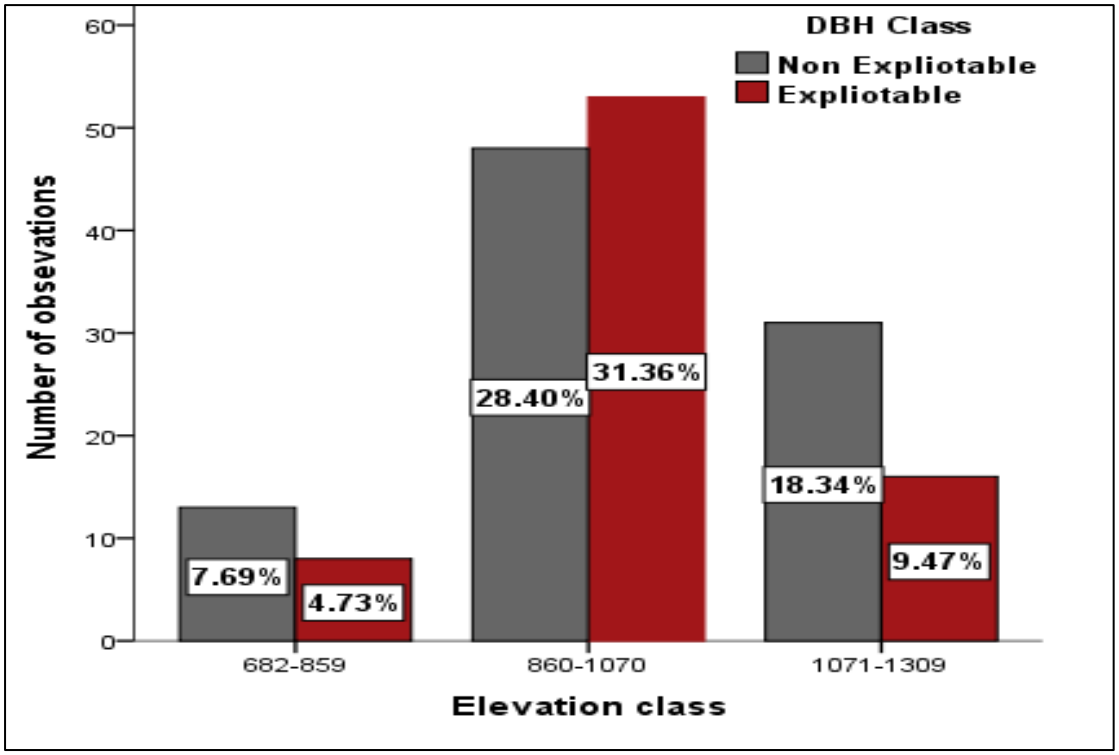

Figure 10: Exploitation Status of Mondia Whitei within Elevation Classes.

p=0.085 (Chi square value = 4.933[a], DF=2).

Summary

A Distribution of *Mondia Whitei* in the Bamboutos and Mayo Banyo High Lands of Cameroon

Bamboutos and Mayo Banyo are found within the discontinuity between forest zone and semi-arid zones of Cameroon. *Mondia whitei* app which was widely spread within elevations of Bamboutos and Mayo Banyo high lands, which are ecological fragile zones is an indication that it is a helophilous (light loving) app. This is in line with studies of this plant carried out at Dahomey gap were the app was established at the broad savanna land that creates a discontinuity within west African coastal forest belt mostly on the republic of Benin and Togo (Vihotogbé *et al.*, 2021;Salzmann and Hoelzman 2005). Also the establishment of *Mondia whitei* in study site confirms previous studies which stated that the plant occurs in moist to dry forest and sub-Saharan countries like Guinae, Nigeria, Cameroon, Sudan, Uganda, Kenya, Tanzania, Zimbabwe, Malawi, Mozambique, South Africa, Swaziland, Angola, Benin, Togo, Cote d'Ivoire (Mukonye *et al* 2002, Quiroz *et al* 2014; Watcho *et al* 2005). Also, the distribution of this genetic resource within the whole land scape was generally sparse with 30% of plots recording less than 10 plants. This is an indication that although this plant is an indigenous specie, it is not easily seen with a one look within any area in Bamboutos and Mayo Banyo. This was in line with studies by (Nichols, 2005) who reported the plant to be scarce and difficult to locate in the wild. This study was equally similar to studies in KwaZulu-Natal, in South Africa where the species was scarce restricted to the midlands frost (Crouch et al., 1998a; Ndawonde et al 2007).

The plant was equally mostly found in communities within elevations of 1364 to 1541m and 1542 to 1738m at Babajou and Bouda subdivision at Bamboutos as well as elevations of 860 to 1070m at Sarkibaka within Mayo Banyo division is an indication of favourable soils and

climate which promote plant growth. Areas of higher occurrence in this study was characterized by loam clay soil which were soft, less stoney and deep which are conditions that could favours the adventurous tuber root system of *Mondia Whitei.* The study was in line with studies by Vihotogbé *et al*., (2021) who stated that the occurrence of *Mondia whitei* was prevalence throughout clay soils at the Dahomey Gap. Indicates this specie is water and nutrient dependent since it requires high water and colloid holding capacity soils (Vihotogbé *et al*., 2021). Also, the comparatively colder weather temperatures at Bankim and Babajou subdivisions than its neighboring subdivisions within study site could account for the greater proportion of the plant located within this area. This weather condition is beneficial in reducing water loss and increase availability of nutrients like nitrogen by plant as well as pest and disease control.

Equally much higher elevations of 1980 to 2279, 2280 to 2705 located in the communities of Zavion 1 and Zavion 2 within Bamboutos highlands, had no *Mondia whitei* growth plants. This could be accounted for by geographic barriers of extremely cold weather temperature and perturbance of strong winds of the mount Bamboutos especially at Zavion 2. Studies by Pearsons and Baw 'son, (2003) ascertain that dispersion limitation & geographical barriers are one of the limiting factors to the distribution of *Mondia whitei* at the Dahomey Gap. Flowering plants individuals were observed at Bamboutos in June and July, fruiting period from mid-August to November and seed dispersal from December to February. At fruity stage, the specie had a height of at least 2m and 2.5 at fruiting stage. This is in line with (Vihotogbe *et al.,* 2021) who found 2.5m length fruiting plants in October mostly at the natural Volta forest and fallows of Togo. In this study younger Plants here were mostly tutored by plantains, Manihot esculenta and maize while adult plants tutored by acacia sp, arabica coffee and fruit trees like pear. This was in line with studies by Vihotogbe *et al*., (2021) where the species was equally tutored by maize (*Zoa mays*; poaccea;) and cassava (*Manihot esculenta* in croplands).

Tree Density

Plant tree density was higher in Bamboutos was highest within elevations of 1542 to 1738 had more abundance, followed by 1364-1541. Tree density was lowest within elevations of 1225 to 1363 and 1739-1979. The highest tree density was 8.07 and least density 2.8 with an average mean density of 4.67 per hectare. Previous studies mentioned that tropical lianas species can be locally considered scares, If their density is less than 1 individual/ha or on the conservative basis of rarity of tree and the average number peer tree creepers, 6.8 plants/ha (Avira *et al*., 2004). In our case *Mondia whitei* at all elevations fell below this threshold values which suggest scarcity of plant, except elevations of 1542 to 1738m with density of 8.07per hectare. This study was contrary to that of (Vihotogbe *et al.,* 2021) who had individuals of 281.5/ha in farm land, 305.9/ha in crop land and 323/ha in fallow suggesting the specie was not rare.

Areas with higher population and density per unit hectare was characterized by land uses of farm lands, abandoned farm lands and degraded secondary forest. Mayo Banyo *Mondia whitei* had the highest occurrence of tree density of 29.2(stem/ha) at elevations of 860-1070 found within Bankim subdivision. This could be accounted for by the fact that the plant was mostly found at in communities of Sarkibaka, Tapere and Banyo occupied by vegetation and land use of deciduous wood lands and deciduous shrub lands with sparse tress which provides as mechanical support for the plant to ascend to canopy. This is online with studies by Venter et al., (2009) where *Mondia whitei* was found in vegetation types that range from swamp forest, swampy shrubby grassland and riverine forest to disturbed forest, at altitudes from sea level to 1800 m. While little occupancy of this specie was found on fallow land and farm lands, deciduous shrub land due to destruction by farming, grazing and bush fires. *Mondia whitei* was

not seen here along gallery forest, wet plains, herbaceous dry plains, valleys, grazing lands another study by Venter et al, (2009) found *Mondia whitei* in vegetation types that range from swamp forest, swampy shrubby grassland and riverine forest to disturbed forest, at altitudes from sea level to 1800 m. Also this plant establishment was favourable in degraded forest and fallow lan,d the reason being the light intensity and percentage canopy cover was noticed to be less than 45% favouring its growth. This location sites were equally within land uses was further away from rural and urban dwellings, on stiff hilly terrain and low land areas of slopes.

Areas of least plant abundance were highly disturbed by human activities like at Galim within elevations of 1075 to 1224. Such sites were either located at close proximity to roads, settlement dwellings or on actively cultivated farmland some which have been deforested for this purpose. The area equally had large extensive farming of food crops like maize, Irish and carrots. The finding of this study are also in-line with those of MCGEOCH et al 2008) on the impact of land use on *Mondia whitei* in kakamesa forest, Kenya. This assertion of distribution zones was equally online with studies by (Okigbo *et al*., 2008; Zschocke *et al.,* 20000) who stated that increasing urbanisation and increased population demand has strained populations of medicinal plant resources. Also the lowest tree densities was found within elevations of 1225 to 1365 at Bamboutos and 682 to 859 at Mayo Banyo this is an indication that there is for more conservation efforts like regeneration of this specie within this site.

Distribution of Adults and Juveniles within Study Site and Elevation

Both Bamboutos and Mayo Banyo had more adults than juveniles' populations of *Mondia whitei*. This could be attributed to the fact the fact that the plant is less valorized commercially at such most land owners prefer keeping products of higher commercial potential such as market gardening products and maize. Also less juveniles than adults could be as a result of its vulnerability and variability during farming seasons due to farm clearing and bushfires activities for farm preparation dwindling its population. Equally this research inventory took place post cultivation period were most plants had been off rooted in farmlands. Elevation class 1542 to 1738, and 1364-1541in Bamboutos and at 682-859m with 860-1070m at Mayo Banyo with more adults was attributed the nature of vegetation within this elevation made up of fallow land, thick bushes or degraded forest which favoured light need of the plant. This is in line with studies by (Vihotogbe *et al*., 2021) who stated that *Mondia whitei* is a heliophilas light demanding specie.

Also a non-significant difference within population size of adults and juveniles of *Mondia whitei* within elevations of Bamboutos with p value of 0.169 was in contrast to studies of this plant at Dahomey gap with a significant difference with $p<0.0001$ (Vihotogbe *et al*., 2021). The insignificant difference here indicates that equal conservation with sustainability effort is needed for both adults and juveniles plants of *Mondia whitei* within all ecological elevations ranges of its establishment. On the other hand, this study was in line with (Vihotogbe *et al*., 2021) at Mayo Banyo with a p value of 0.001 were there was a significant difference in size of adults and juveniles within elevations. Although Bamboutos and Mayo Banyo are both accidented landscapes, the vegetation of a greater portion of Mayo Banyo consisted large massive extensions of wetland grass land and dry grass land. Here the population *Mondia whitei* is mostly concentrated on areas with practicable land with small patches of degraded forest, farm land and fallow land accounting for the significant difference of adults and juveniles plants. Also geologically Mayo Banyo is found within the Tikar plains and the stiff escarpments of Adamawa plateau. This land scape naturally favours the establishment of *Mondia whitei* at the plains within higher elevations that are not swarm habitat with soft and deep soils in contrast to step escarpment with more rocky soil with few plants.

Height Distribution of *Mondia Whitei* along Elevation in Bamboutos Mayo Banyo Highland

In regards to height of plants within the study Bamboutos had a higher mean height of 3.54m while Mayo Banyo had a height of 3.49m. There was equally no significant difference of height in m across elevation categories with p=0.486 a Mayo Banyo and p=0.344 at Bamboutos. This is an indication that plant height of this specie was not dependent on elevation within the landscape but other factors like sunlight, height of tutor plant, plant age and nature of vegetation. Also most tall plants were either found on either land owned by utilizers of the plant such as medicinal practitioners, degraded forest or in fallow land. This was equally in line with studies by Vihotogbe *et al.*, (2021) who found the specie with more than 2.5m at the natural Volta forest and fallows of Togo.

Diameter Class Distribution of *Mondia Whitei* in Bamboutos

Bamboutos with a mean DBH of 1.10cm and Mayo Banyo with a mean DBH of 1.124cm, was an indication that although they are many adult plants most plants within this landscape were not yet fit for exploitation. At such conservation efforts advocating for nondestructive harvest are imperative for the sustainable management of this plant. Also elevations of 860 to 1070m at Moyo Banyo with more exploitable plants and a less disturbed habitat, is a suitable site for exploitation. On the other hand elevations of 1071 to 1309 m need to be more prioritized for conservation and regeneration activities for the plant *Mondia whitei.* There was no statistical difference of DBH in cm across elevation categories at Bamboutos with p=0.079. This was an indication that younger and older adult plants were widely spread across all elevation range habitat of the plant at Bamboutos. On the other hand a significant difference of DBH in cm across elevation categories within the Mayo Banyo landscape with p=0.004, indicates either higher or lower concentration of either younger or older adult plants within elevations of 860-1070m and 682-859. It is equally an indication that the plant is under valorised and there is insufficient knowledge on multiple uses.

Bamboutos and Mayo Banyo, had a greater proportion of no exploitable as compared to exploitable plants of *Mondia whitei*. This is an indication that there are not many plants which could be harvested largely on the commercial scale. It is equally an indication that the community seen as holders of this plant genetic resource need to be informed on the conservation as well as engaged in the potential benefits that arise from its utilization in other to trigger their individual and combined effort to increasing the plant numbers. Also the destructive harvesting method of exploitation mostly practiced within communities, possess a threat to the species current population. There was equally no statistical significance of association between elevation categories and exploitation status of plant at Mayo Banyo and Bamboutos highlands at p=0.08.

CONCLUSION AND RECOMMENDATION

Conclusion

Mondia whitei was generally sparse in the Bamboutos landscape but had higher nucleations and density population within elevations of 1364 to 1541m and 1542 to 1738m of Babajou and Bouda subdivisions. Areas of high abundance in elevation was were Bametougoung, Topelu and Bamegnia communities at Babajou. At Mayo Banyo *Mondia whitei* had the highest occurrence of tree density of 29.2(stem/ha) at elevations of 860-1070 found within Bankim subdivision. Both Bamboutos and Mayo Banyo had more adults than juveniles' populations of *Mondia whitei*. There was no significant difference within population proportion of adults and

juveniles of *Mondia whitei* within elevations of Bamboutos while Mayo Banyo had a significant difference. Most areas of more population were crop lands, fallow lands and degraded forest. Crop land with higher occupancy of trees favoured adult growth forms of plant. The plants especially juveniles were tutored by maize and cassava plants.

Recommendations

This study recommends that since specie is scarce within the landscape conservation effort be put in place to sustainable manage the resource. Equally considering the low densities of *Mondia whitei* within the Bamboutos and Mayo Banyo highlands long term plans of conservation should be considered. This include addressing land ownership negotiations for conservation of the specie which are economically profitable to land owners by planting indigenous economic fruit trees which will serve as tutor plants to this species. So that conservation of species should not be seen as a sacrifice on the part of land owners. Also farm land conservation strategy of plant in cultivable lands should be promoted since tillage of the soils here favours resprout and juvenile life stages of the species. This study equally suggests the establishment of community nurseries, trainings on sustainable harvesting and seed banking of *Mondia whitei*.

Conflict of Interest Statement

Authors declare that they have no conflict of interest.

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