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The Status of an Ethiopian Endemic Plant *Vepris dainellii* (Pichi-Serm.)Kokwaro, in Arba Minch Natural Forest, Southern Ethiopia

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I. Introduction

Globally, forests are believed to contain more than 80% of terrestrial biodiversity (FAO 2012) and have consequently been the focus of particular conservation concern in recent years (Newton 2007a). In many areas, native forests are being subjected to intensive human disturbance, through activities such as cutting, burning and browsing by livestock. Such processes can result in forest clearance, degradation and fragmentation, and consequent loss of biodiversity (Newton 2007b; Newton et al. 2009). The nature of forest communities depends on the ecological characteristics in sites, species diversity and regeneration status of species (Habibur et al., 2011).

Natural forests in Ethiopia are declining rapidly due to their conversion to arable lands coupled with unwise and excessive utilization triggered by increasing population growth. This had and continues to have serious consequences on various ecosystems in Ethiopia (Kitessa Hundera, 2010). From the time immemorial people started exploiting the natural environment as the source of their livelihoods. Different wild plant species have been used as source of food, medicine, clothing, firewood, sources of different household utensils (Dereje and Desalegn, 2013). Wild plants continue to play a central role in the livelihood of large proportion of the world's population. This is particularly true in developing countries, where wild collected food and medicine have a long and uninterrupted history of use (Koduru *et al.,* 2007).

Nech Sar National Park is one of the important conservation sites in the country with diverse component of biological resources which are ecologically and economically important. Along with the fast population growth and the development of Arba Minch town there is a high demand for fuel wood and timber production by the urban dwellers and big institutions. For all these institutions the only source of heat and light energy for almost every household in Arba Minch town and for villagers who live near the forest is the Arba Minch forest. It is also used for construction of farm implements, fences, furniture and houses, serve as a source of food, feed and bee fodder, and provide other environmental and social services to the community (Lemlem & Fasil, 2006; Aramde et al., 2012). However, the ongoing consequences of deforestation, cattle grazing, human settlement and over fishing in the park have brought severe stresses and degradation of park ecosystems, positioning the sustainability of the park in question (Svitálek, 2008).

The Arba Minch Natural forest is the best component of Nech Sar National Park and is unique in its vegetation formation from which the miracle forty springs emanate. It included riverine forest, underground water forest, savannah bushland and tree dominated bushland. The PRA survey conducted in the Nech Sar National Park and the woody plant inventory of Arba Minch forest study revealed that there are about 32 tree and 23 shrub species in Arba Minch natural forest (Lemlem & Fasil, 2006). People use these tree and shrub species for several purposes, both for market and household consumption. Currently, this forest is under great threats from the surrounding community particularly from Arba Minch Town. With increasing human population, demand for fuel and other forest products is also progressively increasing (Mateos, 2003; Demeke et al., 2007; Aramde et al., 2012). *Veprls dainellii* is among the gift of nature for the people live in and around the forest. It is used as firewood, timber, local construction, farm implements, handle for implements and food for human and wildlife. The major objective of this study was, therefore, to assess the

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population status, regeneration status and population structure of the plant in its natural habitat.

II. Methodology

a) Description of the Study area

The Arba Minch Natural forest is the best component of Nech Sar National Park, is located in the eastern edge of Arba Minch town, at about 500 kms south of Addis Ababa. The Park lies within the floor of the Ethiopian Great Rift Valley and extends from 5°51'N to 6°50'N and from 37°32'E to 37°48'E with an elevation varying between 1,108-1,650 meters above sea level. It covers an area of 514 km2 of which 85% is land and 15% is water (Israel and Mundanthra, 2016) and is unique in its vegetation formation. The study area comprised the riverine forest, underground water forest, savannah bushland and tree dominated bushland and it has an area of 60 km^2. The temperature of the area ranges between (17-30°C). Rainfall distribution is bimodal mostly occurring in March, April and May and between September and November. Annual rainfall averages around 900 mm. The wet season includes March, April, May, September, October and November and the dry season includes December, January and February.

b) Rational for selecting species

The rationale behind the selection of Ethiopian endemic plant *Vepris dainellii* was basis of their IUCN Red list status (Vivero et al*.,* 2005) and the danger of over collection due to high demand from the study area by local community (NNP annual report, 2015).

c) Data Collection

The data collection was conducted from October to December 2014. A total of 80 quadrats (20 m × 20 m) lying far apart at 100 m was used for plant data based on aspect of the vegetation. The plant species encountered in each quadrate was recorded. In each major plot, subplots (1 m^2) were established at the center and corner for seedlings and saplings data. The plant with DBH ≥ 2.5 cm was recorded as mature plant. In each of these quadrats, the numbers of all seedlings that are less than 1 m in height were recorded. Individuals attaining 1 m and above with DBH less than 2.5 cm were considered as sapling and counted (Gemedo Dalle *et al*., 2006).

d) Data analysis

Density, Diameter at Breast Height (DBH) and frequency were used for description of vegetation structure. Bar graphs were developed using the DBH versus density of individuals for four arbitrary diameter classes (1 ≤ 20 cm, 2 = 20.1–40 cm, 3 = 40.1– 60 cm, and 4≥ 60 cm) of the forest as well as the selected dominant species. The structural parameters were analyzed using the following formula:

1. Diameter at Breast Height (DBH) = (C/π).
2. Density = (number of individuals of species A/area sampled).
3. Frequency = (number of plots in which species A occurs/total number of plots sampled).

Regeneration status of the forest was analyzed by comparing saplings and seedlings with the matured trees according to Dhaulkhandi et al. (2008) and Tiwari et al. (2010); that is, the status was good regeneration, if seedlings > saplings > adults; the status was fair regeneration, if seedlings > or≤ saplings ≤ adults; the status was poor regeneration, if the species survives only in sapling stage (saplings may be≤ or ≥ adults); and if a species is present only in an adult form it is considered as not regenerating.

III. Results and Discussion

a) Natural Distribution and Habitat

Vepris dainellii from *Rutaceae* family is medium-sized, shade tolerant afromontane tree species endemic to Ethiopia. It typically grows as an understory tree mixed with other small tree and shrub species in forests but sometimes seen growing at margin of afromontane forest and open forest areas recently modified by humans (Dereje and Desalegn, 2013). The plant occurs in altitudinal range of 1050-2500m above sea level. It is distributed in Kefa, Ilubabor, Wellega, Bale, Shewa, Sidamo, Gamo Gofa and Gojam in Ethiopia, but not known elsewhere in the world (Gilbert, 1989). In this study *Vepris dainellii* was recorded in all study site. The field observation during data collection clearly confirmed that the species is widely distributed in the riverine forest, underground water forest but less distributed in savannah bushland and tree dominated bushland. The explanation behind the widely distribution of the species is an indication of well adaptation to the ecological condition in riverine forest and groundwater forest.

b) Vegetation Structure of the species

i. *Density and Diameter at Breast Height (DBH)of the species*

The highest density (40.63/ha) of the species was observed for DBH class <20 and the lowest density (2.19/ha) of the species was observed in DBH class >60. The density of the species with DBH class as their contribution of the numbers of species were given in Table 1. The density of the species increases with decreasing number of individual species. So the general pattern of DBH class size distribution forms an inverted J-shape (Figure 2) for the species. Inverted J shaped pattern shows high distribution of individuals of a species in the lower diameter classes and a gradual decrease towards the higher classes. In other words, it shows good reproduction and recruitment potential of the species. This and field observation during data collection clearly confirmed the occurrence of high disturbance in matured tree of the forest by cutting of

trees for charcoal production, firewood, house construction, and fencing.

ii. *Height Class of the species*

The species in study area were divided into five arbitrary height classes. The percentage of the species decrease with increase in height class (that is the highest percentage of the species was found in the height class 1, but, the least percentage of the species was found in height class 3). In other words, the numbers of individuals in height class decrease with increase in height range. The general height class distribution pattern (Figure 3) indicates a normal distribution of the species and maximum values occurred in the first class and reduced gradually up to the third class. This pattern represents the dominance of small sized individuals in the forest which was the attribute of high rate of reproduction status and regeneration potential.

iii. *Regeneration Status of the species*

The effective criteria for successful conservation and management of the forest resources are determining the regeneration status of the forest on the basis of the composition, distribution and density of seedling and sapling (Teketay, 2005; Getachew, 2013). According to Dhaulkhandi et al. (2008), the density values of seedling and saplings are considered as regeneration potential of the species. The analysis of the species reveal that the individual density of seedling, sapling, and matured tree of the species were 82.50, 74.38, and 63.75 ha^{-1} respectively. Density ha^{-1} of the species showed that seedling > sapling > matured tree in Arba Minch natural forest. Based on the criteria of Dhaulkhandi et al. (2008) and Tiwari et al. (2010) the species is categorized under the species with good regeneration. According to Chauhan et al.*,(* 2008) the calculation of the ratio among the mature tree, sapling and seedling can provide information regarding the distribution of mature tree, sapling and seedling and the regeneration status of the species. In line with Chauhan et al*.,* (2008) the ration of seedling to sapling, seedling to mature tree and sapling to mature tree of the species was conducted and the result was 71: 64, 22: 17 and 7: 6 respectively. These reveal that the distribution of seedling density is greater than both sapling and mature tree (i.e. density of seedling > density of sapling > density of mature tree) of the species. According to Dhaulkhadi et al*.,* (2008), a given species had good regeneration if seedling is greater than sapling and mature tree/adult (seedling density > sapling density > mature tree/adults); fair regeneration if seedling > or ≤ sapling ≤ mature tree; poor regeneration if seedling < sapling ≥ or ≤ mature tree; and no regeneration if species are represented only by adult/mature trees. From the three conditions, the species fulfills the first condition and in general, it had good regeneration status. Depending upon the general pattern of frequency distribution, the regeneration of the species within the study area shows the presence of small density of mature species and gradually increases towards the highest density value of sapling and seedling and they formed inverted J-shaped distribution pattern (Figure 4). According to the study of Tesfaye et al*.,*(2010) and Markos and Simon, 2015), plant species with such distribution pattern had good regeneration and recruitment potential.

c) *Population Structure of the species*

Analysis of population structures for each individual tree and shrub species could provide more realistic and specific information for conservation measures. Based on the assessment of diameter class distributions, the population structure patterns of the species recorded from Arba Minch Natural forest was given in Figure 5. The species exhibited reverse J-shaped distribution. Inverted J-shaped pattern shows high distribution of individuals of a species in the lower diameter classes and a gradual decrease towards the higher classes. In other words, it shows good reproduction and recruitment potential of the species. Population structure of the species indicated the absence of individuals in DBH class 80.1 - 100. This and field observation during data collection clearly confirmed the occurrence of high disturbance in matured tree by cutting of trees for charcoal production, firewood, house construction, and timber.

IV. Conclusion

Vepris dainellii is the most locally useful endemic plant that needs attention for future research. Current over harvesting of the species influenced the population structure, population and regeneration status of this species. The large number of seedling and sapling and small number of mature population of the species is an indication of good regeneration and recruitment potential. If the unsustainable harvesting by local people continues, the capacity of the species to maintain its wild population will be significantly reduced. Therefore, management and conservation strategies are essential to be put in place to save the species.

V. Further Research

Further research is undergoing to determine the conservation status of the species in Arba Minch natural forest, Nech Sar National Park.

VI. Acknowledgements

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Table 1: DBH class and the density of the species in the forest

DBH classes (cm)	Number of species	Density/ha	Percentage
< 20	130	40.63	63.73
20.1-40	53	16.56	25.98
40.1-60	14	4.38	6.86
60.1-80	7	2.19	3.43

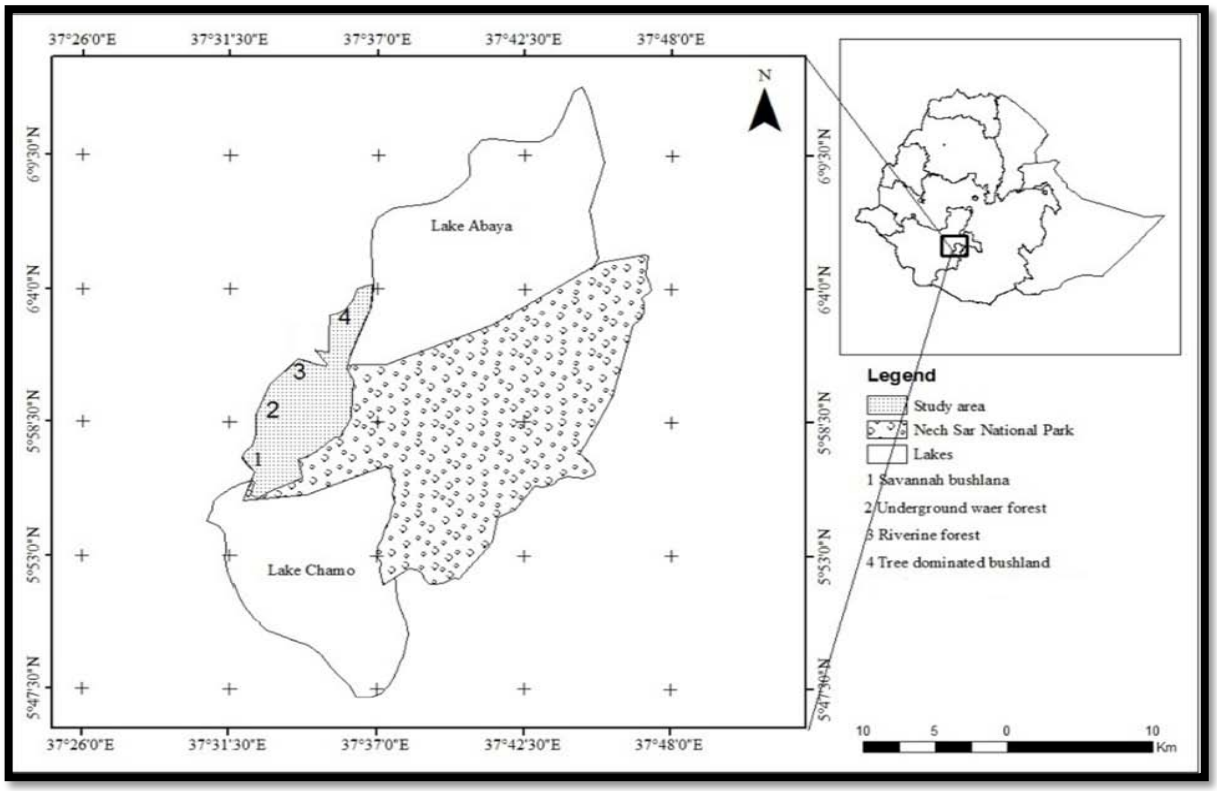

Figure 1: Map of the study area