POPULATION STATUS OF *PTEROCARPUS TINCTORIUS*: A MEDICINAL PLANT SPECIES IN URUMWA FOREST RESERVE, TANZANIA

Augustino, S.[1*] and J.B. Hall[2]

[1]*Department of Wood Utilization Sokoine University of Agriculture, P.O.Box 3014, Morogoro, Tanzania.*
[2]*School of the Environment and Natural Resources, Bangor University, Gwynedd LL57 2UW, United Kingdom.*
E-mail: snyefwe@suanet.ac.tz

ABSTRACT

The paper examine the population status in terms of size-class structure and density by size class for *Pterocarpus tinctorius* a priority medicinal plant tree used by local communities around the miombo woodland of Urumwa Forest Reserve, Tanzania. Plotless inventory techniques using multiple-nearest-tree sampling strategy was employed during data collection. Results revealed that, the species population structure was represented by high frequencies of large trees (> 25 cm dbh) with few small trees represented in size classes < 20 cm. The species had lower mean distance (42 m) between conspecific neighbours in the north of the reserve. *P. tinctorius* was found to be well-stocked with large individuals of ≥ 25 cm dbh but poorly stocked in terms of trees ≤ 15 cm per hectare. The species apparently seem to meet the immediate medicinal plant material needs of the local people in short-term, but strategies need to be developed for ensuring long-term supply. It is strongly recommended that an intensive ecological survey of the species and other potential medicinal plants in Urumwa be implemented in future to provide a greater insight to its dynamics in the miombo and assist in forest management and conservation and in turn sustain the primary health care system of dependent communities.

Keywords: Population status- Medicinal plants-Miombo-Urumwa-Tanzania

INTRODUCTION

Traditional medicinal plant practices in Africa are widespread and deep rooted, with most medicines from plants coming from wild populations especially those of forests and allied ecosystems (Chikamai and Tchatat, 2004). Almost any type of resource harvesting conducted in a tropical forest has an impact on its ecological functions. It has long been suspected (*e.g.* Cunningham, 1993) that intensive harvesting, especially of commercial species in high demand, threatens the wild populations since it is generally vital parts such as roots and bark that are gathered. According to Sheldon *et al*. (1997), the over-exploitation of medicinal plants is economically driven. Harvesters, in need of income, access a free and seemingly abundant resource. Distributors reap enormous profits by packaging and selling large volumes of medicinal plants. Harvest of wild plants on such a massive scale is unsustainable.

Often there is a contradiction in forest resource use and their maintenance. For example, harvesting bark for medicinal purposes or wood for carving or harvesting of wild fruits sometimes involves destructive harvesting practices that impact on the plant populations being harvested (Peters, 1996; Obiri and Lawes, 2000). In these circumstances highly sought plant species may fail to sustain harvesting pressure and eventually undergo losses in population numbers (Cunningham, 1988). Characterization of diameter size class distribution of harvested woody species is a useful tool for monitoring forest stands in which harvesting is taking place (Geldenhuys, 1993a). Size class distribution profiles can also be used to project population trends of species being harvested (Shackleton, 1993) and also facilitate inferences regarding the stability the harvested populations.

The pattern of distribution of a species provides some indication of its sensitivity to harvesting. Widespread species with a continuous distribution are likely to be less sensitive to harvesting or other threats than species with widespread, if fragmented distributions (Rosser and Haywood, 2002). Implementation of sustainable use practices with wild populations of medicinal plants as for other non-timber forest products, however, must take into account distribution, abundance and (ideally) the dynamics of target species (Russell-Smith *et al*., 2006).

It has been estimated that more than 80% of rural dwellers in miombo woodlands of Tanzania (Oduol *et al.,* 2004) depend on indigenous medicinal plants, but there are concerns that deforestation and increasing human and livestock populations are threatening this resource. In many places the structure of miombo vegetation has been substantially modified through shifting agriculture, harvesting for firewood and charcoal, frequent fires and (in drier areas) heavy grazing by livestock (Fors, 2002).

For Tanzania with most medicinal plants being collected from the wild without any control or regulations, the population status of most exploited species remains poorly understood. With trees, population status is expressed in terms of diameter at breast height (dbh) classes, using these as substitutes for age classes. Density and size-class structure data are the most fundamental pieces of information needed for the management of forest resources (Peters, 1994). Information on the distribution and abundance of tree species is also of primary importance in the planning and implementation of conservation strategies (Newton *et al*., 2003). The diameter distribution of species for a particular forest type or a forest in general may indicate whether the species is expanding, stable or declining in terms of population (Geldenhuys, 1993b). Population structure analysis also provides evidence of any impact of harvesting (Dalle and Potvin, 2004). For most medicinal plants exploited from the miombo woodlands of Tanzania like *Pterocarpus tinctorius*, population status information appears to be completely lacking. The species is used by local communities in traditional medicine and it's availability in the wild is still questionable if the demand increases due to its multiple use including durable timber.

Often changes in tree population structure takes place before changes in species composition making population structure a useful indicator of use impact on woody species populations (Lorimer, 1980; Walker *et al*., 1986). By definition tree population structure is the expression of the frequency distribution of variously sized trees in a given forest stand (Geldenhuys, 1993a; Peters, 1996). Diameter at breast height is the most commonly used size variable in the analysis of that structure although some other studies have used height (e.g. Brown and Bredenkamp, 2004). The study though lacks detailed ecological aspects, sought to describe the size distributions of *P. tinctorius* to meet the local medicinal plant stakeholders demand as well as formulating the basis for future planning and development of medicinal plants conservation strategies in the Urumwa Forest Reserve. Two aspects were specifically assessed, that is to determine the size-class structure of *P. tinctorius* and determine density by size class of the species within Urumwa Forest Reserve, Tanzania.

MATERIALS AND METHODS

The study area

Urumwa Forest Reserve is found in Tabora-Uyui District, Tabora Region (4-7^o S, 31-34^o E). The region forms part of the vast central plateau of the mid-western part of Tanzania

(Figure 1a), an area of generally low relief most of which lies between 1,100 m and 1,300 m elevation (Acres *et al*., 1984) , where about 61% of the vegetation covers of Tabora region is dry Zambezian miombo woodland (White, 1983). The choice of the study area was based on the richness of its miombo woodlands. The reserve and its surrounding villages (5° 08’ - 5 ° 14’ S, 32 ° 44’ - 32° 50’E) are about 15 km south of Tabora municipality (Figure 1b) and cover an area of about 13,000 ha. The reserve is bordered by 12 villages collectively with an estimated population of about 22,500 (Mbwambo, 2000). A large proportion (approximately 80%) of Tabora’s urban population relies on the reserve for medicinal products.

The climate of the area is warm with temperatures reaching a peak in September and October, just before the onset of the rainy season. Monthly means of daily maximum temperature vary from 28°C (January) to 32°C (October), while the corresponding minima range from 13°C (June/July) to 19°C (October). Urumwa Forest Reserve is situated in the high rainfall zone of Tabora Region (Mbwambo, 2000) and receives relatively high rainfall (1000–1100 mm year^{-1}) falling mainly from November to April but with wide year-to-year variation (Mbwambo and Mwiga, 1999; Mbwambo, 2000).

The two seasonal rivers (*i.e.* Walla and Kasisi) in Urumwa Forest Reserve, which feed into the Malagarasi swamp to the west, form an important seasonal catchment area, for the provision of water for humans, livestock and wild animals immediately after the rainy season (Mbwambo, 2000). The natural vegetation cover within Urumwa Forest Reserve is drier Zambezian miombo woodland (White, 1983) with the canopy layer dominated by *Brachystegia* and *Jubernaldia* in the hills and the *Acacia/Combretum* communities in the valleys. The reserve has regenerated since people were evacuated in the early 1950’s when it was gazetted (Mbwambo, 2000).

Most of communities who reside around Urumwa are subsistence farmers and pastoralists. However, pitsawing, charcoal production and beekeeping are undertaken regularly (Mbwambo, 2000) and various non-timber forest products such as wild fruits and medicinal plants are collected and sold.

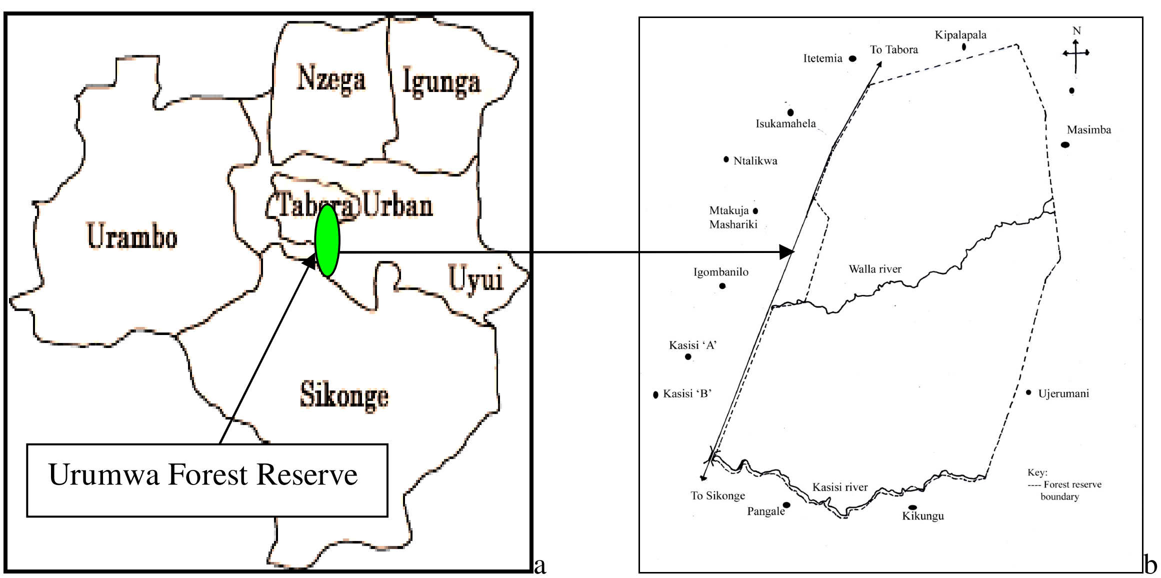

Figure 1 Location of Urumwa Forest reserve in Tabora region, Tanzania

Inventory approach

Some references to dryland tree stocking are made in the literature (*e.g*. Schultz and Company, 1973). Low values apply for most species, particularly if attention is restricted to large (≥10 cm dbh) individuals. This makes conventional small-plot work inefficient and a species-centered approach favourable. Except where exports of quality timber species such as *Pterocarpus angolensis* are concerned, there is lack of past attention to small individuals because high minimum sizes have usually been set (Schultz and Company, 1973, use 15 cm dbh).

Prior to the survey, Urumwa Forest Reserve was stratified into two compartments, north and south using the Walla River as a boundary between the strata. In each stratum, samples of 100 individuals for the species were assessed. A distance of at least 1.5 km separating the centres of different samples of the species in each stratum was maintained to prevent any sample overlapping. In total four samples were established; two samples in the northern stratum and two in the southern stratum. To minimize edge effects during measurement, each sample was established starting with an individual large enough for inclusion (often ≥10 cm dbh) at least 500 m from the nearest point on the forest reserve boundary and at least 500 m from the Walla River. This also ensured exclusion of riverine habitat and areas that had suffered serious encroachment.

A diameter threshold of 3 cm was adopted as the minimum size for inclusion in the population samples. This ensured that all individuals of sizes routinely exploited were included and also that juveniles were represented, although there is no knowledge of the typical age of an individual 3 cm diameter at breast height (dbh) in the study area.

The sample populations were established following the process used in other multiple-nearest-tree sampling (Boaler, 1966; Hall, 1991). To begin sampling, one *Pterocarpus* tree (≥10 cm dbh), identified in an area by a local plant identifier was used as a starting point. Moving away from the starting tree, the 99 nearest other individuals' ≥ 3 cm dbh of the target species were then progressively added to the sample. As the sample was expanded by adding more individuals, it was kept as compact as possible. The process was concluded when the sample size reached 100 individuals. Tree positions in each sample were numbered serially. Using coloured masking tape, each tree was tagged with an identification number to avoid repetition in recording and measuring and its position was mapped using a Geographical Positioning System (GPS) facility.

The diameter at breast height (dbh) of every individual *Pterocarpus* tree ≥3 cm dbh, (based on the thickest stem if more than one was present), in each sampled population was measured to the nearest centimetre using a calliper and recorded in a specially prepared form. Tree total height for the largest stems (*i.e.* ≥20 cm dbh) was measured using a clinometer. The nearest neighbour distance from one tree to another was recorded using the GPS odometer in each sampled population. For close distances (*e.g.* 3 m – 10 m) where the odometer signal sometimes failed to record the distances, the alternative option of using measuring tape was taken.

Data analysis

GPS positions were used to prepare maps of each sample. From the maps, summaries of nearest neighbour distances were determined for core trees (trees in the sample excluding those nearer the boundary than to another tree within the sample). From the maps, nearest neighbour distances (assembled from individual distances to nearest meter) were determined (Okullo, 2004) for core trees (trees in the sample excluding those nearer the boundary than another tree within the sample).

For expressing parameters recorded on a per hectare basis, the sampled area for the species populations was estimated. First, the sample was mapped and then trees at the sample margin were taken to be the angles of a convex polygon. The area of the polygon (ha) was estimated using dot grid method.

MINITAB 13 and Microsoft Excel computer software tools in form of frequency, mean and standard deviation for tree diameter at breast height, nearest neighbour distances (proximity of core trees) and species density were used in data analysis. The overall population density estimate was made from: 100/population area (ha). The per hectare tree densities of the species were calculated for all trees ≥3 cm dbh and, after rounding the nearest whole centimetre for the different size classes by dividing the number in each size class by the total area (ha) within which the 100 sampled individuals were assessed.

RESULTS

Population structure by size-class

Tree diameter frequency of four hundred *Pterocarpus tinctorius* trees: 100 trees in each of the two samples in the north and 100 in each of the two samples in the south of Urumwa Forest Reserve were assessed in eight diameter classes (Table 1) to depict the population structure. Overall, in all sampled populations at Urumwa, the species population structure is represented by high frequencies of large trees (size class > 25 cm dbh) with few small trees represented in size classes < 20 cm. There is a total lack of trees ≤ 15 cm dbh for Population II – South of the Walla River (Table 1).

Table 1 Diameter frequency of *Pterocarpus* tree by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Frequency per sampled populations				
	NW I – Pop 1	NW II – Pop 2	SW I – Pop 3	SW II – Pop 4	Total populations
3 – 5	3	13	5	-	21
6 – 10	7	1	12	-	20
11 – 15	8	5	13	-	26
16 – 20	7	2	3	6	18
21 – 25	21	8	10	14	53
26 – 30	22	20	21	28	91
31 – 35	16	16	14	27	73
> 35	16	35	22	25	98
All trees	**100**	**100**	**100**	**100**	**400**

Note: Pop = population, NW = North Walla, SW = South Walla

Nearest neighbour distances

A total of 335 core trees of *P. tinctorius* from the four sampled populations in the north and the south of Urumwa Forest Reserve were assessed to check how close on average, an individual tree was to its neighbour. Most individuals ≥ 3 cm dbh of *P. tinctorius* trees were > 20 cm from the nearest conspecific neighbour (Table 2, Figures 2a, 2b, 2c.) indicating generally sparse distributions. *Pterocarpus tinctorius* in Population 2 (North Walla II) had lower mean distance (42 m) between conspecific neighbours than the other populations.

Table 2 Proximity (m) of nearest conspecific neighbour for target species at Urumwa Forest Reserve, Tabora Region, Tanzania

Population	N	≤ 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	25 - 28	≥ 29
1. NW I (58 m)	86	3	3	5	4	5	11	3	52
2. NW II (42 m)	81	5	6	5	8	4	5	6	42
3. SW I (44 m)	85	12	8	5	9	6	4	9	32
4. SW II (49 m)	83	5	5	11	4	7	2	8	41

Note: NW = North Walla; SW = South Walla

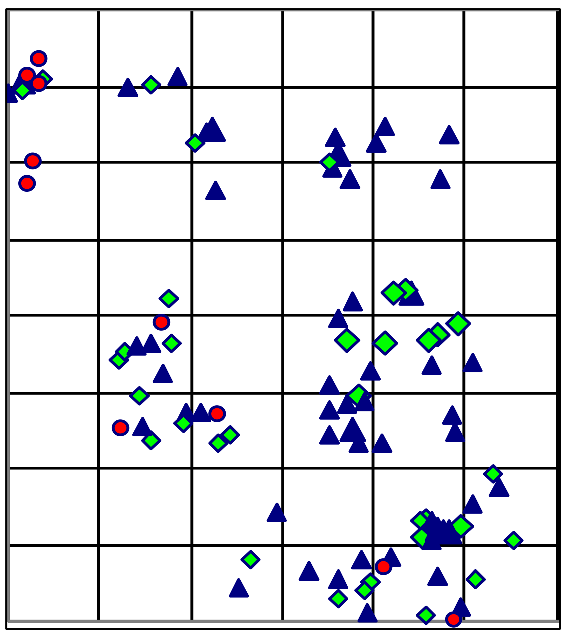

Figure 2a Distribution of *Pterocarpus tinctorius* in a sampled area of North Walla I at Urumwa Forest Reserve, Tabora Region, Tanzania (Each cell = 100m x 100m = 1ha). Keys: Red dots = dbh size 3 – 10 cm; diamond-shaped green = dbh size 11 – 25 cm; blue triangles = dbh size > 25 cm.

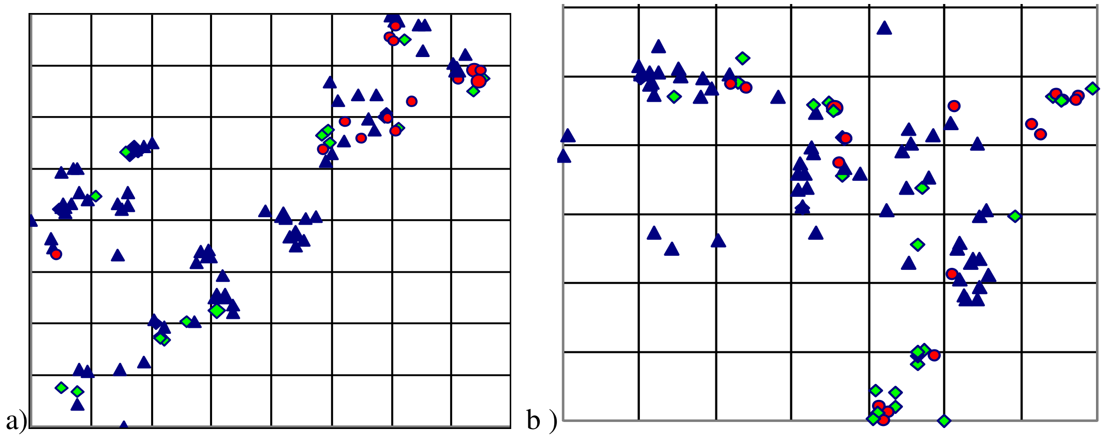

Figure 2b Distribution of *Pterocarpus tinctorius* in a sampled area of North Walla II (a) and south Walla I (b) at Urumwa Forest Reserve, Tabora Region, Tanzania (Each cell = 100m x 100m = 1ha).

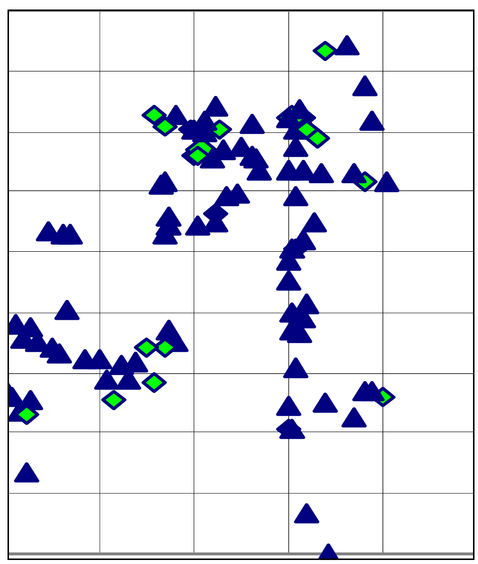

Figure 2c Distribution of *Pterocarpus tinctorius* in a sampled area of south Walla II at Urumwa Forest Reserve, Tabora Region, Tanzania. (Each cell = 100m x 100m = 1ha).

Population density by size-class

P. tinctorius stocking (all individuals ≥ 3 cm dbh) size class ranged from just one individual per hectare (Population 2 - North Walla II) to close to five individuals per hectare (Population 1 – North Walla I) (Table 3).

Table 3 Per hectare *Pterocarpus* tree density by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Sampled populations (Areas)				
	NW I - Pop 1 (21 ha)	NW II – Pop 2 (90 ha)	SW I - Pop 3 (70 ha)	SW II – Pop 4 (72 ha)	Total Population mean ± SD
3 – 5	0.14	0.14	0.07	-	0.09 ± 0.07
6 – 10	0.33	0.01	0.17	-	0.13 ± 0.16
11 – 15	0.38	0.05	0.18	-	0.15 ± 0.17
16 – 20	0.33	0.02	0.04	0.08	0.12 ± 0. 14
21 – 25	1.00	0.09	0.14	0.19	0.35 ± 0.43
26 – 30	1.05	0.22	0.30	0.39	0.49 ± 0.38
31 – 35	0.76	0.18	0.20	0.37	0.38 ± 0.27
> 35	0.76	0.39	0.31	0.35	0.45 ± 0.21
All trees	4.75	1.10	1.41	1.38	2.61 ± 1.73

Pop = population, NW = North Walla, SW = South Walla

Within all sampled populations in Urumwa Forest Reserve, however, *P. tinctorius* was well-stocked with large individuals (≥ 25 cm dbh) but poorly stocked in terms of trees ≤ 15 cm per hectare (Figure 3).

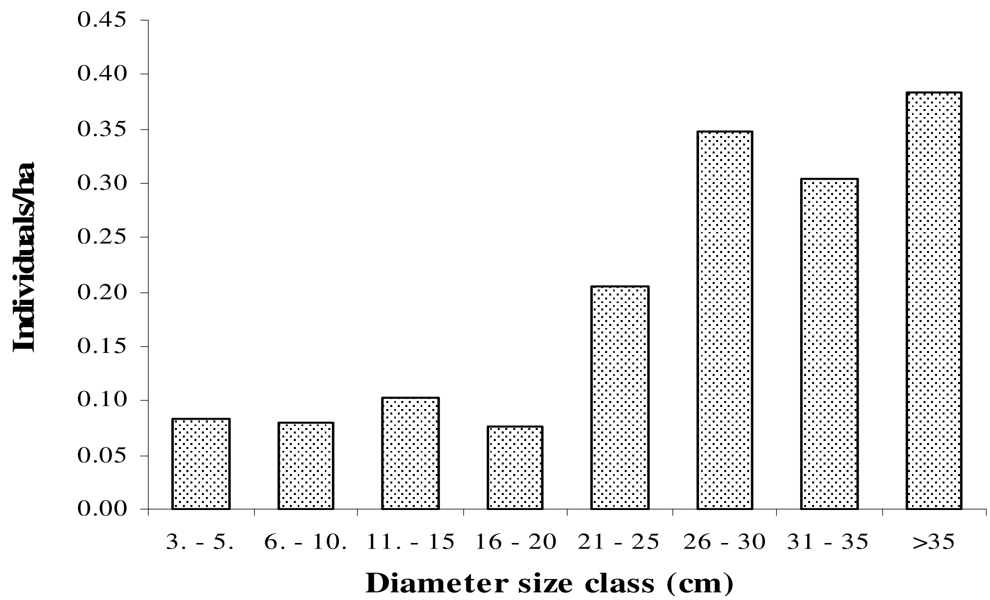

Figure 3 Individual per hectare, by size class, all samples combined for *Pterocarpus tinctorius* at Urumwa Forest Reserve, Tabora Region, Tanzania

DISCUSSION

For the miombo woodlands of Urumwa Forest Reserve, the present study has indicated the population of *Pterocarpus tinctorius* being structurally characterized by larger trees (> 25 cm dbh) with poor representation of smaller trees (≤ 20 cm dbh), indicating a population at risk of elimination. Interpretation of the results from a survey on a single occasion must, however, be continuously. A single survey does not offer a useful view for the long-term prospects of a population. Nevertheless, in the case of *P. tinctorius*, which has many large individuals, it can be argued that, as long as seed sources survive and management can undertake appropriate interventions, the population can be sustained. A more difficult issue with this species is the potential genetic erosion or thinning of the large tree part of population, isolating individuals from cross-pollination.

The massive deforestation reported to have occurred in the miombo woodlands of central Tanzania particularly Tabora Region (Lawton, 1982) might have affected the population structures and distribution of the species in Urumwa Forest Reserve. Nevertheless, the observed population structure by size classes for the species at Urumwa, could still reflect other factors that have previously been reported to affect the structure and composition of dry woodland or miombo in south-central Africa, including disturbances such as fire (Kikula, 1986; Chidumayo, 1988) and anthropogenic factors including commercial charcoal production (Monela, *et al*., 1993) which is non-selective on what size of tree to fell, and cutting of building poles (Luoga *et al*., 2000). All these types of disturbances were noted inside Urumwa Forest Reserve and additionally, the impact of overgrazing by domestic livestock.

In terms of the density, the study has demonstrated a lower stocking of *P. tinctorius* inside Urumwa. At the same time, the species is overall sparsely distributed in the miombo woodlands of Urumwa Forest Reserve. On would need to travel long distance within the reserve to collect medicinal materials of the species, if large quantities were required. This highlights the need to pay attention to the species in future, if possible considering their cultivation in home gardens, taking advantage of the existing agroforestry techniques or domestication in community woodlots, reducing pressure on vulnerable (and probably declining) natural populations, and ensure availability of the resources nearer users especially women. It has been suggested that, domestication of indigenous plants in agroforestry systems (Teklehaimanot, 2004), could provide not only continuous tree cover and contribute to plant material supply, but also improve productivity and sustainability of farming system through maintained soil fertility, while reducing pressure from the wild sources.

CONCLUSION

In conclusion, *P. tinctorius* is a sparsely distributed species in Urumwa and poorly stocked though has many large individual trees. The species seem to meet the immediate medicinal plant material needs of the local people in short-term, but strategies (*e.g.* encourage coppicing of species, and cultivation in homegardens) need to be developed for ensuring long-term supply, and this could be extended to other potentially identified medicinal plants of high local significance. Luoga *et al.* (2004) for the Eastern miombo woodlands of Tanzania have recommended the use of coppice rotations as a management system for the woodlands. However, as well as cultivation of medicinal trees in homegardens, the "*Ngitili"* agrosilvopastoral system (Kamwenda, 2002) of *ex-situ* conservation could be applied in communal woodlots. Vegetative regenerating shoots often grow faster than newly established seedlings because they already have a well-established root system with stored reserves (Chidumayo, 1993; Grundy, 1995). It is recommended that an intensive ecological survey of the species and other potential medicinal plants in Urumwa be implemented in future to provide a greater insight to its dynamics in the miombo and assist in forest management and conservation.

ACKNOWLEDGEMENTS

We are grateful to the communities around Urumwa Forest Reserve in Tabora Region who generously shared their traditional knowledge regarding the species with us. Much thanks to the local plant identifiers at Urumwa: Mr. Athuman Juma and Mussa Kawili, for their tireless efforts to walk inside the reserve with the research team for the entire period of the survey. We are also indebted to the Commonwealth Scholarships Commission for funding the senior author's research activities.

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