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Research Article

Population Structure, Regeneration Status, and Threats to *Dobera glabra* (Forssk.) Poir. in Chifra District, Afar Regional State, Ethiopia

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Dobera glabra is a much branched multipurpose evergreen shrub or tree, which is distributed in *Acacia* savanna, *Acacia* open woodland with grassy clearings, and *Acacia nubica* scrub. This study investigates the population structure, regeneration status, cultural importance, and major threats to *D. glabra* and provides input for policy and decision-makers to develop conservation strategies that improve the population of the species. A sample plot of 30 × 20 meters and 10× 10 meters were systematically laid along transect lines for the mature *D. glabra* population and seedling and saplings of the species, respectively. The historical distribution and principal threats to *D. glabra* were collected through semistructured interviews and focused group discussion with the purposively selected informants. Moreover, direct field observation of threats such as cutting and debarking was recorded. The density of *D. glabra* was found to be 18.33 stem ha^{-1}. The mean DBH was 43.55 cm (SE ± 1.58), showing a bell-shaped pattern implying the mid-DBH class is the dominant class. The mean height and crown diameter was 5.5 m (SE ± 0.19) and 8.60 m (SE ± 0.31), respectively. Furthermore, the regeneration status of the *D. glabra* was found to be extremely poor. The major threats to the species were identified as drought, lightning, grazing, cutting, and windfall. The population structure of the species revealed a bell-shaped pattern. The extremely poor natural regeneration status of the species shows the need to implement a reactive conservation approach.

1. Introduction

Dobera glabra (Forssk.) Poir. (Salvadoraceae) is a much branched evergreen shrub or tree, which is distributed in *Acacia* savanna, *Acacia* open woodland with grassy clearings, and *Acacia nubica* scrub, often on rocky hillsides, 400–1250 m above sea level. It is a drought-tolerant evergreen woody species found in different parts of Ethiopia and the arid horn.

Dobera glabra is a multipurpose plant, which serves as browse for animals, edible fruits and seeds, shade, firewood, timber, and medicine for humans in pastoral and agropastoral communities of Ethiopia [1–6]. In southern Ethiopia, particularly, the Maale and Ari ethnic communities, *D. glabra* is recognized as the most important edible fruit in periods of drought and food shortage [4, 7]. A nutritional analysis of this species indicated its high nutritional value, for instance, magnesium, calcium, and crude protein [8].

The importance of *D. glabra* is not confined to the aforementioned values. Rather, it is also medicinal for humans and animals. Tsegaye et al. (2007) reported *D. glabra* treats swelling on the legs and hands, stomach problems, Tumawo`a (infectious disease), bone breakage of animals, and camel eye disease (Abeb) of animals. Furthermore, it heals head wounds, anthrax, blackleg, bloating, and skin infection [4].

Due to anthropogenic disturbances, however, the plant is threatened. In Aba'ala district, Afar regional state, for unknown reasons, the regeneration status of the species is reported as poor in Northern Afar [1]. Furthermore, the population of *D. glabra* in Northern Afar revealed a

declining trend due to insufficient rainfall, cutting, browsing, and land use transformation [2]. Nevertheless, apart from Northern Afar, particularly Aba'ala and Erebti, the population structure, regeneration status, and major threats to the species are yet unknown. Being similar in climate and vegetation type, these problems might be existing in Chifra rangelands. Hence, this project is proposed to investigate the population structure, regeneration status, socioeconomic-cultural importance, and major threats to *D. glabra* and provide input for policy and decision-makers to develop conservation strategies that improve the population of the species.

The objectives of this study were to describe the population structure of *D. glabra*, assess the regeneration status of *D. glabra*, identify the principal threats to *D. glabra*, document the socioeconomic-cultural importance of *D. glabra*, and analyze the spatial structure of *D. glabra* in Chifra district.

2. Materials and Methods

2.1. Study Area Description. Chifra district is one of the 32 administrative districts, zone 1, in Afar regional state, near the escarpment of Ethiopian highlands. It is bordered by Dubti district in the east, Worebabo district of South Wollo zone in the west, Ewa and Awra district in the north, and Mille and Bati district in the south. It is located 160 km far from Semera, capital of the region (Figure 1).

The total area of the district is 1519.32 square kilometers—the total population of the district is 91080, of whom 50861 are men and 40219 women [6,9]. Eventhough it was projected to be 107067 by 2014–17 [10], the national census was not performed as per the schedule. It is almost 14 years since the last census, which makes the population data untimely.

2.2. Climate and Vegetation Types. The vegetation type of the study area is *Acacia-Commiphora* deciduous bushland and thicket. Some of the woody species found in the study area include *Acacia abyssinica* Hochst., *Acacia mellifera* (Vahl) Benth., *Acacia drepanolobium* Harms ex Sjostedt., *Balanites aegyptiaca* (L.) Del., *Dobera glabra* (Forssk.) Poir., and *Ziziphus spina-christi* L.

The climate of the study is arid to semiarid. According to the climate data (1981–2010) analyzed online (https://climate.mapresso.com/?lat=31.95&lon=35.93), the mean annual temperature and mean annual rainfall are 26.2°C and 548 mm, respectively (Figure 2) [11].

2.3. Data Collection. A reconnaissance survey was made to select the appropriate sites. Sample plots of 30 × 20 meters (600 m^2) and 10 × 10 meters (100 m^2) were systematically laid along transect lines for mature *D. glabra* (Figure 3) population and seedlings and saplings of the species, respectively. Data were collected from 50 sample plots. Sample plots were laid at rangelands that have relatively abundant population of the species. The data were collected from March to May 2021.

The plant attributes such as diameter at breast height (DBH) at 1.3 m for tree individuals and diameter at stump height (DSH) at 0.5 m for shrub individuals, height, and crown diameter (mean of two cross-sectional lengths, i.e., the narrowest and widest diameters of the crown) were recorded. Environmental variables such as GPS coordinates, elevation, and slope were also recorded in each plot. The historical distribution and principal threats to *D. glabra* were collected through semistructured interviews and focused group discussion with the purposively selected informants (Figure 4). Thirty informants who lived in the area for at least three decades were selected. Furthermore, the researchers obtained additional information from the district administrators about the informants' knowledge on the target species. The researchers believed these are fundamental, and the sample size is sufficient. Nine key informants (3 agropastoralists, 3 elders, and 3 natural resource extension workers) were selected for the focused group discussion. Moreover, direct field observation of threats such as cutting and debarking was recorded. The socioeconomic-cultural importance of the species was documented through semistructured interviews and focused group discussions with the purposively selected informants.

2.4. Data Analysis. The density of mature individuals, seedlings, and saplings were calculated as the number of stems/seedlings per hectare as in the following equation.

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area sampled (ha)}}. \quad (1)$$

Furthermore, the population structure of the species was generated according to the DBH size class distribution. The DBH class distribution were categorized into eight DBH classes (1 < 10, 2 = 11–20, 3 = 21–30, 4 = 31–40, 5 = 41–50, 6 = 51–60, 7 = 61–70, and 8 > 71) and were presented by generating bar graphs. The DBH classes were used to determine the age structure of the species. To determine the height (1 meter interval) and crown diameter classes distribution (1 < 3, 2 = 3.1–6, 3 = 6.1–9, 4 = 9.1–12, and 5 = >12.1), bar graphs were also generated. The Shapiro–Wilk test was used to assess data normal distribution. The regeneration status of *D. glabra* was determined by comparing the mature individuals with seedlings and saplings following Gebrehiwot and Hundera [12]. The data about the disturbances and socioeconomic-cultural importance were analyzed by descriptive statistics using an R programming language [13].

3. Results

3.1. Density of Dobera glabra. Tree density is the number of stems of a particular area. The study revealed that the density of *D. glabra* was found to be 18.33 stem ha^{-1}. The minimum and maximum number of individuals per plot recorded were one and nine, respectively. This elucidates the density of the species in the study is low.

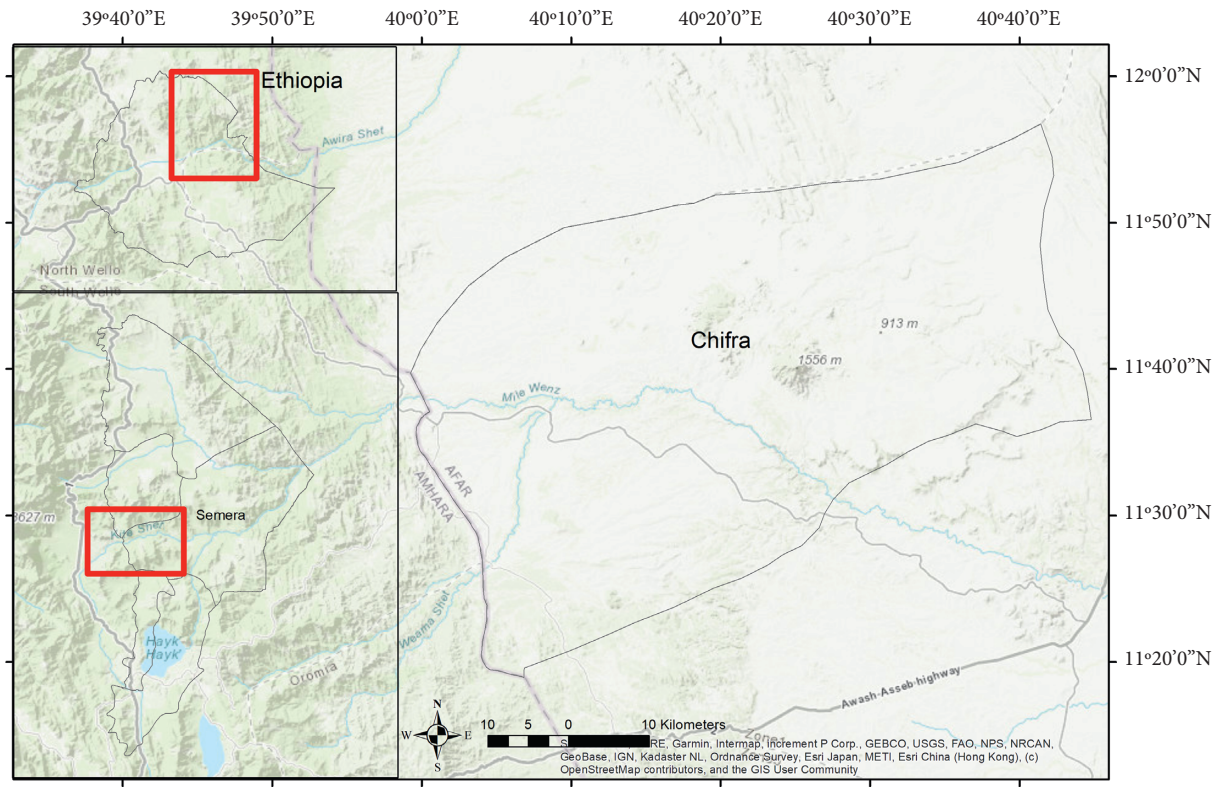

Figure 1: Map of the study area.

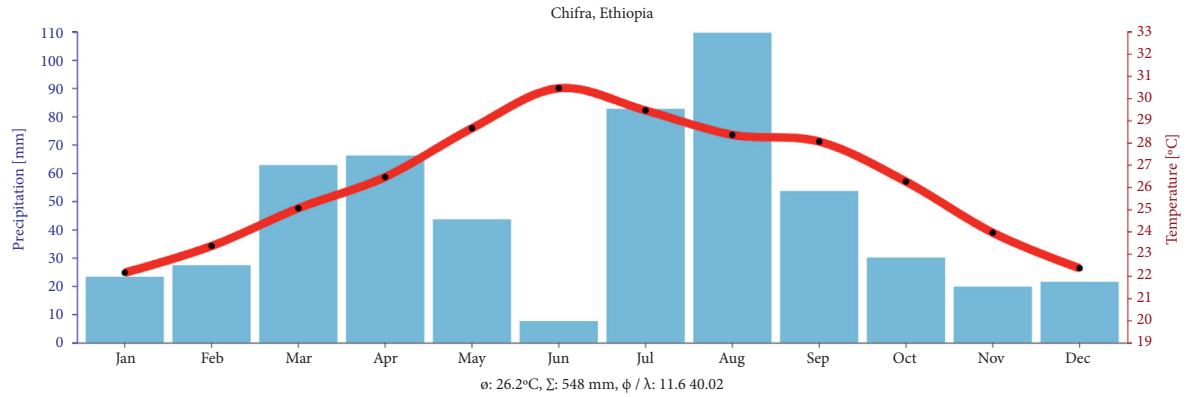

Figure 2: Climate diagram of the study area (blue bars, mean annual rainfall; red trend line, mean annual temperature) (1981–2010) [11]. The *x*-axis shows the mean annual temperature and rainfall.

3.2. DBH and Population Structure of Dobera glabra. The minimum and maximum DBH of the species ranged from 19 to 78 cm. Furthermore, the mean DBH was 43.55 cm (SE ± 1.58) (Figure 5). The population structure pattern of the species showed a bell-shaped pattern ($W = 0.972$; $P = 0.05$) implying the mid-DBH class is the dominant class, and the data were significantly drawn from a normally distributed population. On the other hand, few individuals represent the lower and upper DBH classes. Furthermore, the lower DBH class is between 19 and 30, which is also an indication that saplings and small trees of the species are extremely rare in the study area.

3.3. Height Class Distribution of D. glabra. The height class distribution of the species also ranged from two to nine meters. Whereas, the mean was 5.5 m (SE ± 0.19) (Figure 6). Eventhough the medium heightened individuals seem to be dominant, the overall height class distribution pattern is a little bit irregular ($W = 0.952$; $P > 0.05$). This implies the data were not significantly drawn from a normally distributed population.

3.4. Crown Diameter of Dobera glabra. The crown diameter of *D. glabra* is often round. The crown diameter ranged from 3 to 13.1 m. The mean crown diameter was 8.60 m (SE ±

Figure 3: Mature *Dobera glabra*

(a) (b)

Figure 4: Semistructured interview with informants

0.31) (Figure 7). The crown diameter revealed a bell-shaped pattern ($W = 0.980$; $P = 0.05$). This indicates the data were significantly drawn from a normally distributed population.

3.5. Regeneration Status. The regeneration status of the species was found to be extremely poor. Only five seedlings and no saplings were recorded in the study are. It is 1.5 stem ha^{-1}, which is extremely insignificant. Furthermore, when it is compared with the mature individuals, it is extremely low. According to the informants' responses, the main reasons for the extremely poor natural regeneration status were grazing and trampling by livestock and drought. As it can be seen from Figure 8, the seedlings recorded were inside thorny plants. The thorny plants serve as a fence for the emerging seedlings.

3.6. Cultural Importance. *D. glabra* has some cultural importance in the present study. The informants cited two main cultural values of the species. One, the Afar people perform their meetings under this tree to discuss social issues such as conflict resolutions. Furthermore, Dagu, a famous indigenous knowledge on sharing information, is also often performed under this tree. The other, the Afar people consider *D. glabra* as the symbol of long-life. Due to

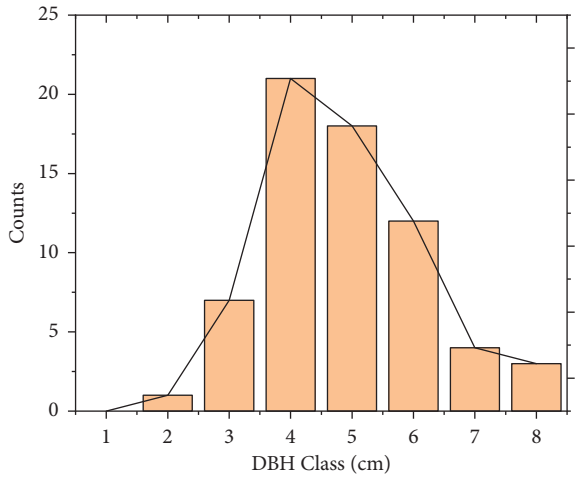

Figure 5: DBH classes distribution (1 < 10, 2 = 11–20, 3 = 21–30, 4 = 31–40, 5 = 41–50, 6 = 51–60, 7 = 61–70, and 8 > 71).

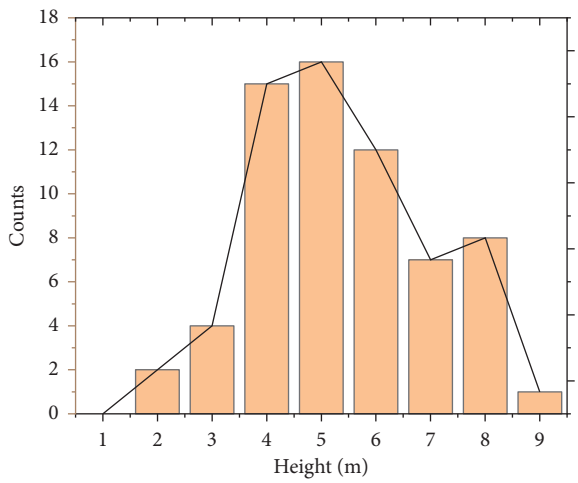

Figure 6: Height (m) class distribution.

this reason, elders bless the young by saying may your age extend like the age of Garsa. Furthermore, a newborn baby would be given milk by the young leaf of Garsa before breastfeeding. This is to wish long-life.

3.7. Major Threats. According to the data collected from the informants, the following major threats were identified. Drought, lightning, grazing, cutting, and windfall were the major threats to *D. glabra* (Table 1). Grazing mainly threatens the regeneration status of the species because the grazers graze and trample the germinants and seedlings before becoming mature individuals. On the contrary, lightning, windfall, and cutting threaten the mature trees. Drought, on the other hand, threatens the species at all stages.

4. Discussion

4.1. Density, Height, and Crown Cover. The density of *D. glabra* in the rangeland was low. Ecological studies on

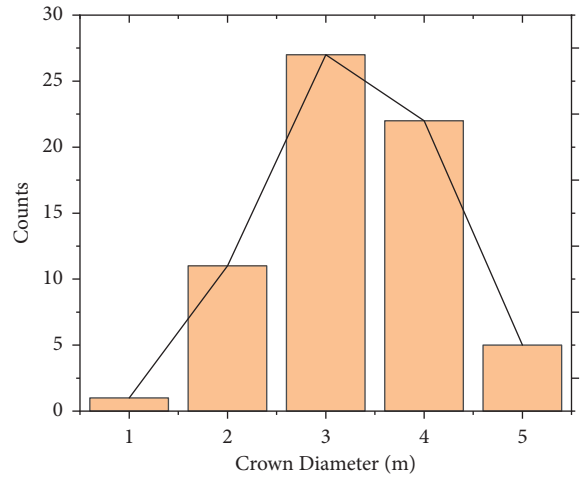

Figure 7: Crown cover diameter (m) class distribution (1 = <3, 2 = 3.1–6, 3 = 6.1–9, 4 = 9.1–12, and 5 = >12.1).

Figure 8: Seedling *D. glabra* emerging inside a thorny *Acacia* species.

Table 1: Major threats to *D. glabra*.

No.	Threat	*N*	Frequency	Percentage (%)
1	Drought	30	30	100
2	Grazing	30	24	80
3	Lightning	30	15	50
4	Cutting	30	11	36.7
5	Windfall	30	7	23.3

arid tree species are limited in Ethiopia. One study from Northern Afar, Aba'ala district, revealed that the density of *D. glabra* was 41 stems ha^{-1} [2]. Eventhough the present study was conducted in open rangeland, unlike the riverine study by these authors, it is by far lower than this study. However, it is higher than the report from Higelely dry forest and Fentale open woodland, Eastern Ethiopia [14, 15]. The low density in the present study could be due to the anthropogenic disturbances in the open rangeland [2]. However, the few sample plots laid along a seasonal river in the study area were not different from the open rangeland. Thus, whether it is riverine or open rangeland, the density of *D. glabra* was almost the same.

Considering the species is arid and semiarid species, the mean crown diameter of the species is high. A study on the species in Ethiopia reported the mean crown diameter was four meters [2]. It is revealed that in the present study, the crown diameter is two times higher than the aforementioned study. This could be associated with the low density of the species in the present study, which avoids competition of resources. The mean height of *D. glabra* is also similar to the reports from tropical regions. For example, Tesemma [16] stated the height of the species could reach up to 8 m. Nevertheless, the mean height of the species reported in the present study is lower than the report from Higelely dry forest, Eastern Ethiopia [14]. On the other hand, it is higher than the mean heights in Yabelo, Karat, and Fentale districts open woodland and cultivated land.

4.2. Population Structure and Regeneration Status. The circumference class distribution of the tree species could describe population structure. Population structure of a particular species indicates its history of past distribution, anthropogenic, and environmental impacts [17, 18]. The population structure of *D. glabra* showed a bell-shaped pattern. Eventhough the pattern is showing bell-shaped, the lower DBH class, below 20, is almost unrepresented, while large DBH classes are dominant. Unlike the present study, Tsegaye et al. [2] reported an inverse-J shape population structure. However, individuals with small DBH, <10 cm, were not reported in this study too. Hence, the lower abundance of small DBH classes reveals that the species is inadequately regenerating naturally. As observed in the field, the plant bears sufficient seeds though this needs experimental confirmation about its viability. Nevertheless, *D. glabra* seed germination experiment in Werer, Afar, depicted that the seeds could germinate without any seed treatment methods though their growth is slower in comparison to others [19]. Furthermore, the scarce seedlings recorded in the field were also growing in cushions that cannot be reached by grazers. This implies that it is mainly the anthropogenic disturbances (e.g., livestock grazing) that led to the poor regeneration status of the species. The informants also confirmed that the driving factors for the natural regeneration status of the species are livestock grazing, trailing, and drought. Extremely poor natural regeneration status of *D. glabra* were reported both in Ethiopia and other tropical countries [2, 20–22].

4.3. Major Threats. Plants are threatened by several factors across all ecosystems. Arid and semiarid ecosystems are prone to various man-induced disturbances such as livestock grazing and recurrent drought. The impact of drought and livestock grazing on rangeland plants was reported in several studies [1–3, 20, 22]. Eventhough the plant is considered drought and osmotic stress-tolerant [23], the respondents unequivocally mentioned drought is the principal threat to the species.

Lightning was reported the third principal threat to the plant. This is interesting because lightning as a threat to a particular tree species was not reported in Ethiopia yet. Hence, it needs further investigation why lightning is a threat for *D. glabra*. The African continent is prone to lightning than other continents [24]. The importance of lighting for plants is often controversial. Eventhough its impact on tree death is considered negligible, lightning often strikes and kills hundreds of old and taller trees in tropical regions daily [25, 26]. Yanoviak et al. (2020) claimed that above 40% of the tree death with DBH above 60 cm was attributed to lightning. Quantitative study on the impact of lightning on *D. glabra* would contribute to the ecological knowledge of lightning in the tropics.

Tree cutting for firewood in alternative energy-lacking countries such as Ethiopia is a common practice. Utilization of *D. glabra* for firewood was reported [2, 16]. However, recently, cutting together with windfall were the least threats reported. This could be associated with the cultural importance of the plant. The community considers the plant as one of the most important and does not dare to cut it.

5. Conclusion and Recommendation

The present study investigated the population structure, natural regeneration status, principal threats, and socio-economic-cultural importance of *D. glabra* in Chifra district, Afar regional state. The population structure of the species revealed a bell-shaped pattern. This is attributed to the extremely poor natural regeneration status and absence of old individuals. Furthermore, the major threats to *D. glabra* reported were drought, grazing, lightning, cutting, and wind-throw. If a reactive conservation approach is not implemented, a large population of *D. glabra* could be lost.

The following recommendations are forwarded to improve the population of *D. glabra* over the coming decades.

(1) Establishing area exclosure from livestock grazing could improve the natural regeneration and recruitment of the plant. Herding on a seasonal basis could enhance the regeneration potential of the species and the rangeland at large.

(2) Field investigation of the seed germination efficiency both with seed treatment and without seed treatment could help seedling-producing stakeholders to choose the efficient one

(3) Mass *D. glabra* seedling production, distributing them to farmers, and regularly following up the growth of the seedlings are suggested

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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