

The decline of the Vulnerable yeheb *Cordeauxia edulis*, an economically important dryland shrub of Ethiopia

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Abstract *Cordeauxia edulis* (Leguminosae: Caesalpinioideae), commonly called yeheb, is a small tree/shrub species endemic to Ethiopia and Somalia. The tree produces nuts that are consumed as a staple food by pastoralists and are sold in local markets. Recent reports indicate that *C. edulis* has vanished from many locations where it was noted by earlier travellers and, as a result, it is currently categorized as Vulnerable on the IUCN Red List. To assess the current status of the species we studied it around 10 villages in Boh district in the Somali Regional State of Ethiopia, where the only known remnant stands of *C. edulis* in Ethiopia are found. The results show that these populations of *C. edulis* are declining and natural regeneration is negligible. We recommend that yeheb should be categorized as Endangered on the IUCN Red List, based on criteria A1d, because we estimate that there has been at least a 70% reduction in population size from overexploitation. The major constraints to natural regeneration and imbalance in the population structure are over-harvesting of immature nuts, excessive browsing of shoots and leaves by livestock and excessive cutting of wood for fuel and construction. We recommend that conservation measures for the species focus on sustainable harvesting of mature nuts, raising awareness among local people, preservation and monitoring of remnant populations and introduction of the species in ecologically suitable sites.

Keywords Caesalpinioideae, *Cordeauxia edulis*, Ethiopia, nuts, population density, regeneration, size class distribution

Introduction

A clump of a shrub species always consists of stems of different ages and sizes as old stems are replaced with newly sprouted stems. In drylands this allows multi-stemmed shrub species to maintain themselves for a

long time where individual stems cannot survive for a long period or establishment of new shrubs by seedlings is difficult because of the harsh climate and edaphic conditions, and grazing pressure. Thus, assessment of the size class distribution of stems within clumps can be used to determine whether or not the population of a shrub species is in decline. An even distribution of size classes indicates that the species is in a condition of stable self-maintenance. A greater number of stems of clumps in higher size classes compared to lower size classes reflects a decline in self-maintenance ability. If such a trend continues a population could go extinct locally (Fujiki & Kikuzawa, 2006).

Assessment of regeneration status from the population dynamics of seedlings is a further means by which the status of the population of a plant species can be determined. A population structure characterized by the presence of a sufficient number of seedlings indicates satisfactory regeneration or a stable population whereas an inadequate number of seedlings indicates poor regeneration or a declining population (Swaine et al., 1990).

Cordeauxia edulis Hemsley, locally called yeheb, is a small evergreen multi-stemmed tree or shrub (Ali, 1988, cited in Liew, 2003) of the legume subfamily Caesalpinioideae, endemic to eastern Ethiopia and central Somalia. It is drought hardy and a source of food for both animals and humans (NAS, 1979). The tree produces nuts that are collected and consumed as a staple food by pastoralists and sold in local markets to provide household income. Because of high demand and competition, the fruits of *C. edulis* are usually collected prematurely (Kazmi, 1979). Yeheb foliage is a preferred browse for camels and goats, which are the dominant livestock in the region, and is heavily browsed throughout the year (Yusuf, 2010). The wood of yeheb is also a preferred building material because it is termite resistant (Yusuf, 2010). *C. edulis* is the only species in the genus (Bally, 1966) and is dominant or co-dominant in the deciduous *Acacia-Commiphora* bushland vegetation of the Somali–Masai floristic zone (White, 1983). Since the 1930s it has declined over most of its original range and has disappeared from many locations where it was noted by earlier travellers (Bally, 1966).

The species is threatened by several factors, including drought, grazing and over-harvesting of nuts (Bally, 1966; NAS, 1979; Walter & Gillett, 1998). Although it is categorized as Vulnerable on the IUCN Red List its status has not been assessed since 1998, and requires updating

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(WCMC, 1998). Because of its high nutritional value and economic importance attempts to grow the species have been made in Kenya, Tanzania and Israel (Nerd et al., 1994), Sudan, Yemen, India, Australia and the USA (Veitmeyer, 1985; FAO, 1988). The seeds appear to germinate well (up to 80% germination) but establishing the seedlings in the field has been less successful. Thus, the species is still confined to its natural range in Somalia and Ethiopia. As there are no published reports of field assessments of the status of the species a study of the population structure and regeneration status of yeheb was therefore undertaken during 2007–2008 in Boh District of the Somali region of Ethiopia.

Study area

Boh district, in the Somali Regional State, is the only place where yeheb now occurs in Ethiopia. Over 85% of the human population of Boh is pastoralist and dependent upon livestock. The area is arid, with a total annual rainfall of 150–250 mm that falls in two rainy seasons of varying reliability; the two pronounced dry seasons are each of at least 5 months duration. The south-west monsoon brings the main rains in March/April to May/June; the north-east monsoon brings rain in October–November. The area is frost free with a mean annual temperature of 28 °C. Altitude is 300–1,000 m. The mean monthly wind speed is 2–3 km h⁻¹ except during the south-west monsoon, when it is 4–5 km h⁻¹. Mean annual potential evapotranspiration is 1,700–2,600 mm (Drechsel & Zech, 1988; Yusuf, 2010).

Methods

Members of the agropastoral extension staff of the Somali Regional State and knowledgeable villagers and clan leaders were contacted to make enquiries about the occurrence of yeheb in the region. All responses confirmed that the species is only found in Boh district, the region where Captain Cordeaux obtained botanical specimens in July 1907 (Bally, 1966). Following this confirmation we made a preliminary reconnaissance to identify the locations of the stands of yeheb. Of the 72 villages in the district yeheb was found only in 10 (a village is the smallest administrative unit after district and includes the settled area and the surrounding environment), in an area from approximately 46.6°E 7.0°N to 47.2°E 7.4°N. We conducted this study in all 10 of these villages. The distance between neighbouring village settlements was at least 8 km. We therefore regard the stands of yeheb in each village as separate populations.

Quadrats were used as sampling units for the assessment of the populations of yeheb. In each population 10 quadrats, each of 10 × 10 m size, were surveyed at 100-m intervals along a transect of 1 km (the total area surveyed was therefore 1 ha). The purpose was to enable comparable samples to be obtained from areas of consistent size, shape,

number and direction in all 10 populations. The transect line started from the edge of the village settlement in a direction best representing all target areas, including areas close to the settlement and those further away. According to Brink (2006) and Ali (1988, cited in Liew, 2003) proximity to a village is one of the factors that influences the density of yeheb.

In the early stages of growth yeheb is reported to be single-stemmed whereas mature plants are multi-stemmed, with most of the stems arising from the base of the plant near the ground (Ali, 1988, cited in Liew, 2003). Each separate clump of stems thus constitutes an individual adult plant. Therefore, within each quadrat all clumps of yeheb with ≥ 2 stems per clump, and single-stemmed individuals, were counted. The number of stems in each clump was recorded along with the basal diameter of each. Other species of trees and shrubs growing with yeheb in each quadrat were identified and the number of individuals of each species counted.

Frequencies and densities by basal diameter classes were computed and skewness coefficients calculated to examine the size distribution. An analysis of variance was used to examine variation between populations and Tukey's test was used to make pairwise comparison between means to test the hypothesis that there are no differences in density and size class between populations.

Results

A total of 67 clumps of yeheb were enumerated in the 10 populations, giving a mean density of 67 clumps ha⁻¹ (range 30–110; Table 1). The ANOVA indicated there was no significant difference in the density of clumps between populations. A total of 1,059 stems were enumerated in the 10 populations. The mean number of stems per clump was 16 ± SE 1.62. The ANOVA indicated that the mean stem basal diameter (Table 1) differed significantly between populations. The majority of stems were of intermediate basal diameter; the skewness coefficient of the distribution was -0.43. One single-stemmed plant was found in one quadrat in each of four of the 10 populations (Maned, Gambare, Mirafadle and Dudun) and none in the other six populations.

A total of 16 other tree and shrub species were found growing with yeheb in the 100 quadrats (Table 2). *Acacia tortilis* and *Boswellia neglecta* were the most common associated species. In eight of the 10 populations yeheb was the most abundant species in the area (Table 1). The exceptions were the Damerjog and Foye ade populations, in which the mean basal stem diameter of yeheb is the lowest.

Discussion

The mean density (67 clumps ha⁻¹) of *C. edulis* in Boh district is considerably lower than the 162 clumps ha⁻¹ in

TABLE 1 Number of clumps, mean basal stem diameter and number of individual stems of yeheb *Cordeauxia edulis* and number of individuals of other tree and shrub species per transect (in 10 quadrats of 10 × 10 m) in the 10 known populations around 10 villages in Boh district in the Somali Regional State, Ethiopia, ordered by number of clumps per transect.

Village	No. of clumps per transect ¹	Mean basal stem diameter ± SE (cm) ²	No. of stems	No. of individuals of other species per transect
Maned	11	3.03 ± 0.05 ^a	187	3
Gambare	10	2.99 ± 0.10 ^{ad}	170	3
Godirwayis	8	2.66 ± 0.09 ^{ab}	129	4
Dudun	7	2.88 ± 0.12 ^{ad}	112	3
Mirafadle	7	2.84 ± 0.10 ^{ad}	111	4
Afardod	6	2.87 ± 0.16 ^{ad}	97	5
Dabhablan	6	2.25 ± 0.10 ^{bce}	96	5
Dalhamur	6	2.56 ± 0.13 ^{bd}	89	4
Foye ade	3	1.57 ± 0.06 ^{ce}	35	6
Damerjog	3	1.55 ± 0.08 ^c	33	7
Total	67		1,059	44

¹ANOVA indicated no significant differences between populations ($P > 0.05$)

²Different letters indicate significant difference between populations at $P < 0.001$, with Tukey's test

poor sites (where soils are shallow and rainfall is < 150 mm) and 319 clumps ha⁻¹ in good sites (where soil is deep and rainfall is > 200 mm) reported by Ali (1988, cited in Liew, 2003) in Somalia and Ethiopia, and up to 320 clumps ha⁻¹, depending on growing conditions and distances from villages and water points, reported in Somalia by earlier authors and compiled by Brink (2006). In the villages of

Damerjog and Foye ade in our study there were only 30 clumps ha⁻¹. As these two populations are close to the border with neighbouring Somalia the low density may be attributed to overexploitation both by the local people and by people crossing the border from Somalia.

The distribution of basal diameters also appears to indicate that yeheb is declining and the scarcity of young stems potentially indicates poor regeneration. The relative scarcity of larger stems could be because of harvesting of the wood for house construction (Yusuf, 2010). However, there are no published data on the basal stem diameter of yeheb to compare with our findings.

The negligible natural regeneration could be because of the excessive harvesting of the nuts for food and sale (Kazmi, 1979; Nerd et al., 1994; Yusuf, 2010) and consumption by wild animals, especially squirrels (*Xerus* sp.; authors, pers. obs). The continued weakening of plants through excessive browsing and cutting, reducing the production of viable seeds, may also be limiting regeneration. In addition, it may be difficult for seedlings to establish in this arid area and this may be exacerbated by excessive grazing pressure. Bally (1966) also noted the absence of seedlings and young plants of yeheb both in Somalia and Ethiopia, suggesting that regeneration has been inhibited for many years.

The tree and shrub species found growing with *C. edulis* are indigenous species, in agreement with reports that *C. edulis* grows in rangelands dominated by deciduous species, mainly *Acacia* and *Commiphora* (Bally, 1966; White, 1983). We found that the density of other tree species is low in areas where *C. edulis* is relatively abundant, confirming the report by Bally (1966) that *C. edulis* is locally dominant and, apart from a few scattered trees of *Acacia tortilis*, *C. edulis* is the tallest of the woody plants with which it grows in association. However, we found that other tree

TABLE 2 Other tree/shrub species found growing with yeheb in Boh district (% frequency was calculated by taking the number of individuals of a species found in a plot and dividing it by the total number of individuals of all the species in the plot).

Species	Family	Somali name	Growth form	% frequency
<i>Acacia tortilis</i>	Leguminosae	Qudhac	Tree	13.64
<i>Boswellia neglecta</i>	Burseraceae	Murchen	Tree	13.64
<i>Commiphora erytherae</i>	Burseraceae	Hagar	Tree	9.09
<i>Commiphora candidula</i>	Burseraceae	Rahanreeb	Tree	9.09
<i>Terminalia orbicularis</i>	Combretaceae	Bisiq	Shrub	9.09
<i>Euphorbia cuneata</i>	Euphorbiaceae	Dhirindhir	Tree	9.09
<i>Commiphora</i> spp.	Burseraceae	Qadhoon	Tree/Shrub	6.82
<i>Acacia horrida</i>	Leguminosae	Sarmaan	Tree	6.82
<i>Commiphora horrida</i>	Burseraceae	Qadhoon madow	Tree	4.55
<i>Boswellia microphylla</i>	Burseraceae	Jewdheer	Tree	4.55
<i>Indigofera ruspoli</i>	Papilionaceae	Jillab	Tree	2.27
<i>Fagonia lahovari</i>	Zygophyllaceae	Baskalax	Tree	2.27
<i>Cordia africana</i>	Boraginaceae	Madheedh	Tree	2.27
<i>Cassia obovata</i>	Leguminosae	Jallelo	Shrub	2.27
<i>Balanites scillin</i>	Zygophyllaceae	Shillin	Tree	2.27
<i>Sesamothamnus rivae</i>	Pedaliaceae	Salaamako	Tree/Shrub	2.27

and shrub species appear to be becoming dominant in areas where *C. edulis* is being overexploited, such as in the villages of Damerjog and Foye ade.

In conclusion, in the Somali region of Ethiopia *C. edulis* appears to be declining, principally because of heavy grazing pressure, over-harvesting of nuts for food and sale, and excessive cutting for fuelwood and wood for construction (Booth & Wickens, 1988; FAO, 1988). This is in agreement with earlier reports (Bally, 1966; Hemming, 1966). As suggested by Bally (1966), unless steps are taken to protect the areas from overgrazing, to limit over-harvesting of nuts and to set aside some of the plants for seeding purposes, *C. edulis* will eventually become locally extinct in the Boh district, and thus in Ethiopia.

Yeheb is currently categorized as Vulnerable on the IUCN Red List based on criteria A2cd (i.e. projected or suspected population reduction of at least 20% within the next 10 years or three generations). Based on our research in the Somali regional State of Ethiopia we recommend that the species be recategorized as Endangered, based on criteria A1ad (an observed population reduction of at least 50% over the last 10 years based on direct observation and actual level of exploitation). A comparison of our findings with earlier studies indicates that there has been at least a 70% reduction in population size because of overexploitation. According to Bally (1966) and Soderberg (2010) the species is more widespread in Ethiopia than in Somalia and therefore its disappearance from many places in Ethiopia and the reduction of the population in Boh, the only location where the species now occurs in the country, indicate the general decline of the species.

Based on our findings, we make five recommendations for the conservation of *C. edulis*: (1) active protection is required, including monitoring, (2) supplementary regeneration by planting nursery-grown seedlings could help to reverse the species' decline, (3) ex situ conservation in a seed bank is required as an insurance policy and as a source of seed for future reintroduction or reinforcement, (4) introduction of the species to other, ecologically suitable sites would help to minimize the risk of local extinction, and (5) discussions are required with the local communities, for whom yeheb is economically valuable, regarding the need for sustainable use of the species. The Somali Region Pastoral and Agropastoral Research Institute have received the reports and recommendations of our research.

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References

- ALI, H.M. (1988) *Cordeauxia edulis: production and forage quality in central Somalia*. MSc thesis. Faculty of Agriculture, Somali National University, Somalia.
- BALLY, P.R.O. (1966) Miscellaneous notes on the flora of Tropical East Africa. Enquiry into the occurrence of the yeheb nut (*Cordeauxia edulis* Hemsl.) in the Horn of Africa. *Candollea*, 21, 3–11.
- BOOTH, F.E.M. & WICKENS, G.E. (1988) Non-timber uses of selected arid zone trees and shrubs in Africa. *FAO Conservation Guide*, 19, 52–58.
- BRINK, M. (2006) *Cordeauxia edulis Hemsl Record from Protobase*. PROTA (PLANT RESOURCES OF TROPICAL AFRICA), Wageningen, The Netherlands. <http://database.prota.org/> [accessed 5 December 2010].
- DRECHSEL, P. & ZECH, W. (1988) Site conditions and nutrient status of *Cordeauxia edulis* (Caesalpinaceae) in its natural habitat in Central Somalia. *Economic Botany*, 42, 242–249.
- FAO (1988) *Non-Timber Uses of Selected Arid Zone Trees and Shrubs in Africa*. Food and Agriculture Organization of the UN, Rome, Italy.
- FUJIKI, D. & KIKUZAWA, K. (2006) Stem turnover strategy of multiple-stemmed woody plants. *Ecological Research*, 21, 380–386.
- HEMMING, C.F. (1966) The vegetation of the northern region of the Somali republic. *The Linnean: Newsletter and Proceedings of the Linnean Society of London*, 177, 173–250.
- KAZMI, S.M.A. (1979) Yicib (*Cordeauxia edulis* Hemsl.) an important indigenous plant of Somalia which has many uses. *Somali Range Bulletin*, 7, 4–5.
- LIEW, J. (2003) *Desiccation tolerance of yeheb (Cordeauxia edulis Hemsl.) seeds*. MSc thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.
- NAS (1979) *Tropical Legumes: Resources for the Future*. National Academy of Sciences, Washington, DC, USA.
- NERD, A., ARONSON, J.A. & MIZRAHI, Y. (1994) Introduction and domestication of rare and wild fruit and nut trees for desert areas. *West Australian Nut & Tree Crops Association*, 18, 42–53.
- SÖDERBERG, V. (2010) *The importance of yeheb (Cordeauxia edulis) for Somali livestock production and its effects on body tissues when fed to Swedish domestic goats*. MSc thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.
- SWAINE, M.D., LIEBERMAN, D. & HALL, J.B. (1990) Structure and dynamics of a tropical dry forest in Ghana. *Vegetatio*, 88, 31–51.
- VIETMEYER, N. (1985) In praise of shrubs. *Review on Agriculture & Development*, 18, 28–32.
- WALTER, K.S. & GILLET, H.J. (1998) *1997 IUCN Red List of Threatened Plants*. Compiled by the World Conservation Monitoring Centre. IUCN, Gland, Switzerland.
- WCMC (WORLD CONSERVATION MONITORING CENTRE) (1998) *Cordeauxia edulis*. In *IUCN Red List of Threatened Species v. 2011.2*. <http://www.iucnredlist.org> [accessed 17 February 2012].
- WHITE, F. (1983) *The Vegetation of Africa, A Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa*. UNESCO, Paris, France.
- YUSUF, M. (2010) *Cordeauxia edulis (yeheb): resource status, utilisation and management in Ethiopia*. PhD thesis. University of Bangor, Bangor, UK.

Biographical sketches

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