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ORIGINAL ARTICLE

Growth dynamics of *Dracaena cinnabari* under controlled conditions as the most effective way to protect endangered species

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Abstract *Dracaena cinnabari* Balf. fil. is an endangered endemic species growing on the Yemeni island of Soqotra. *Dracaena* woodlands are considered as one of the oldest forest communities on Earth. Uncontrolled grazing unfortunately caused a lack of naturally occurring regeneration. Our two-year research was focused on the growth dynamics of *Dracaena* seedlings from two separate populations. One hundred of germinated seeds from two different altitudes from the island were sown and planted under the same conditions. Average increment and difference between the growth dynamics of plants from the two localities were investigated. The observed data on this plant species revealed very interesting, hitherto unknown results. (1) The seedlings germinated within a time period from four to ten weeks. Germination rate was 90% on the Firmihin highland plateau and 78% on the Scand Mountain. (2) Average plant length from both localities was almost the same (24.9 cm) at the end of measurement. Differences in values between the two populations proved as non-significant. (3) A significant difference was found in the number of leaves and in the sum of lengths of all leaves on one plant. While the seedlings from Firmihin featured a wide spreading above-ground part with a large number of leaves, the plants from Scand invested more energy into faster leaves elongation rate. (4) Growth dynamics reflected seasonal changes. Increments were slower or ceased during the period of vegetative rest from autumn to spring. (5) Average mortality rate was 13%. Most of the plants died during the period of vegetative rest. Further study on germination and regeneration under artificial conditions seems like the only way to prevent species extinction.

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1. Introduction

The genus *Dracaena* comprises between 60 and 100 species (Adolt and Pavliš, 2004). It belongs in the family of *Asparagaceae* or *Dracaenaceae* (Brown and Mies, 2012). *Dracaena* species are exceptional among monocotyledonous plants because of their ability of the secondary growth of stems, branches and roots (Habrová et al., 2009). Most of *Dracaena* species grow as shrubs or geophytes. There are only seven species featuring arborescent growth and the xeromorphic *Dracaena cinnabari* belongs to them (Bekele, 2007).

D. cinnabari is a large, single-trunked tree with height up to 10 m and smooth grey bark. Branches with sausage-shaped sections form an umbrella-shaped crown. The crown shape is adapted to arid climates and is affected by the availability of atmospheric moisture. Tough leaves are densely tufted, dark green and elongated, up to 60 cm long and up to 4 cm wide. The leaves are scleromorphic as a specialised feature to prevent excessive loss of water (Brown and Mies, 2012). Small creamy flowers grow in large terminal panicles. Globose fruits have about 1 cm in diameter and contain from 1 to 3 spherical and brownish-red seeds, which are very hard. Their stage of ripening goes from black to red (Miller and Morris, 2004). The seeds are spread by birds. Since ancient times, the plant has been used for harvesting blood-red medicinal resin and as fuel wood. Moreover, flowers, fruits and leaves have been used as a source of dry season feed for livestock.

D. cinnabari (Dragon's Blood Tree) is an endemic species and the most iconic plant of the Soqotra Island. It is a highly conspicuous element in the landscape of Soqotra, specifically at altitudes between ca. 300 and 1480 m (Brown and Mies, 2012). Soqotra is an isolated island lying in the Indian Ocean between the Horn of Africa and the Arabian Peninsula. It belongs to the Republic of Yemen. Separated from the continent during the Tertiary period, the island's floral endemism rate makes it one of the most biodiverse islands in the world (Grant, 2005). Today, it hosts more than 950 plant species, including some 825 terrestrial plants (430 genera, 114 families) and about 130 algae and seagrasses (Miller and Morris, 2004; Cheung and DeVantier, 2006; Brown and Mies, 2012). Of the total number of flowering plants and ferns, 37% are endemic, when compared with other archipelagos. In 2003, upon the international recognition of these outstanding attributes, the island became a UNESCO Man and Biosphere Reserve. In 2005, the islands were nominated for World Heritage listing (Cheung and DeVantier, 2006; Scholte et al., 2011). According to Cheung and DeVantier (2006), during the long period of isolation, evolution of the island's flora and fauna has proceeded in various adaptations to cope with the arid, wind-swept environment. The umbrella-shaped shrubs and trees have adopted eco-morphological strategy. The unique vegetation formation adapted to semi-arid environment is an evergreen woodland dominated by the Dragon's Blood Tree (*D. cinnabari*) (Miller et al., 2006). The *Dracaena* woodland covers 3658 ha, i. e. 1.1% of the island (Král and Pavliš, 2006). The general distribution of *Dracaena* on Soqotra reflects the size of areas that are affected by the monsoon mists (Brown and Mies, 2012).

The Soqotra's flagship species *D. cinnabari* suffers from the lack of regeneration due to intensified goat grazing (Miller and Morris, 2004). Therefore, the seedlings and young trees grow mainly on rock ledges and other sites that are inaccessible to goats. There are only mature and overmature trees in the accessible terrain. Plant density is not homogenous. The *Dracaena* woodland on Firmihin is considered as one of the oldest forest communities on Earth (Miller and Morris, 2004). However, further development of this community is not optimistic. Prediction of tree density development was made for Firmihin, the locality with the highest density of *Dracaena* trees (Hubálková, 2011). It showed that the *Dracaena* tree density would decrease by 36% until 2110, if the actual grazing intensity remains unchanged. A similar situation occurs with the Frankincense tree *Boswellia papyrifera* growing in Eritrea and in the Horn of Africa. Its populations are declining due to human pressure and environmental degradation, the trees are found mainly in hilly areas on steep slopes as an adaption to harsh growing conditions (Ogbazghi et al. 2006). To assess the perspectives of woodland restoration, Negussie et al. (2008) examined *Boswellia* seedling densities in grazed woodland and a grazing exclosure in the lower Geba river catchment in northern Ethiopia. According to the results of their experiment, the number of *Boswellia* seedlings varied throughout the year, showing higher values in the rainy season. There were more seedlings in the exclosure than in grazed woodland. The authors also mention dry season as a serious cause of seedling mortality which limits the potential of native woodland recovery. Ogbazghi et al. (2006) devoted to the role of environment and land use factors determining the distribution limits of *B. papyrifera* in Eritrea. Their field survey was conducted in 113 village areas. Species occurrence was related to rainfall, air temperature, length of growing period, physical and chemical soil factors, topography and land-use types. The results show decreasing distribution as a result of several interrelated human factors such as the conversion of woodlands into agricultural fields and increasing livestock pressure.

The vulnerable Dragon's Blood Tree has been therefore one of the main concerns for conservation efforts and research activities on Soqotra in recent years (Attore et al., 2007; Habrová et al., 2009). Several detailed studies have been conducted to assess the potential impacts of various environmental factors on the plant development (Brown and Mies, 2012; Van Damme and Banfield, 2011; Scholte et al., 2011). However, there is little information about phenology and growth of *D. cinnabari*. There are few current studies related to the growth dynamics of *D. cinnabari* (Adolt et al., 2012; Attore et al., 2007; Habrová et al. 2009). Germination of *Dracaena* seeds under greenhouse conditions appears to be unproblematic (Brown and Mies, 2012). Adolt and Pavliš (2004) in Brown and Mies (2012) reported that germination rates as high as 77% could be achieved under greenhouse conditions, and that the mortality of seedlings amounted to only 10%. Beyhl (1996) mentioned comparably low rates of 35% germinability, which would appear to be adequate to maintain populations. In his thesis, Adolt (2001) carried out a germination experiment using 50 seeds of *D. cinnabari* from the Diksam area and 100 seeds of *Dracaena draco* from Tenerife. The experiment was conducted in the greenhouse of Mendel University in Brno, Czech Republic, at an average temperature of 22 °C. The germination was boosted by variously diluted solutions of hydrogen peroxide. The germination rate of *D. draco* was significantly higher (34%) than that of *D. cinnabari* (5%). One percent hydrogen peroxide solution increased the germination of Dragon's Blood Tree to 22%. Petroncini et al.

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