IECF 2024 Conference

The 4th International Conference on Forests

23–25 September 2024 | Online

MDPI

Distribution and population structure of the coffee wild relative *Coffea racemosa* in southern and central Mozambique

Lopes Mavuque[1,2], Ivete Maquia[2,3], Isabel Marques[3], Ana Isabel Ribeiro-Barros[3,4]

1. Lúrio University, Faculty of Agricultural Sciences, Campus de Unango, EN733 km42 Unango, 3003 Niassa, Mozambique. mavuque@gmail.com
2. Biotechnology Center, Eduardo Mondlane University, Km 1.5, P.O. Box 3453, Maputo, Mozambique. ivetemaquia@gmail.com
3. Forest Research Center (CEF) & Associate Laboratory TERRA, School of Agriculture (ISA), Universidade de Lisboa (UL), Tapada da Ajuda, 1349-017 Lisbon, Portugal. isabelmarques@isa.ulisboa.pt (IM); aribeiro@isa.ulisboa.pt (AR)
4. Unidade de Geobiociências, Geoengenharias e Geotecnologias (GeoBioTec), Faculdade de Ciências e Tecnologia (FCT), Universidade NOVA de Lisboa (UNL), Monte de Caparica, 2829-516 Caparica, Portugal.

INTRODUCTION & AIM

Coffee (*Coffea* L.) is one of the most consumed beverages in the world, with over 250 farmers involved in its production (ICO, 2019). There are 130 known coffee species (Davis et al., 2021), but the global coffee trade relies on two species: Arabica (*Coffea arabica* L.) and Robusta (*Coffea canephora* Pierre ex A. Froehner). Currently, the global coffee sector faces several threats, such as the duration and severity of droughts and temperatures, and the spread of pathogens (Davis et al., 2012; 2019). As a result, there is a growing demand for raw materials to develop new elite coffee varieties (Davis et al., 2007; Guyot et al., 2020; Davis et al., 2021). This can be provided by wild coffee species, the wild relatives of cultivated coffee (CWRs). However, a recent study applying the IUCN Red List criteria to all wild coffee species found that at least 60% are threatened with extinction, 45% are not conserved in any germplasm collection, and 28% are not found in any protected area (Davis et al., 2019).

In Mozambique, several wild species occur in their natural habitats. Besides the cultivation of *C. arabica*, a wild coffee species endemic to Mozambique, *C. racemosa* Lour., offers new opportunities for farming communities in Mozambique. This species is extremely drought-resistant, can thrive in sandy soils, and is naturally resistant to most coffee pests (Hallé and Faria, 1973). It also has a low caffeine level, making it a high-potential market alternative for coffee consumers sensitive to caffeine (Sureshkumar et al., 2010; Davis et al., 2021). However, the current distribution of this species in Mozambique and the factors that may threaten its sustainable use are unknown.

In this study, we examine the demographic structure of wild populations of *C. racemosa* occurring in different forest fragments in Mozambique. Specifically, we address the following questions: (1) How are the wild populations structured in Mozambique? (2) Do they vary between forest fragments and conserved forests? (3) Is regeneration occurring? (4) Is habitat fragmentation affecting the demographic structure of the populations? Answering these questions will provide the first insights into the conservation and management of *C. racemosa* in Mozambique.

METHOD

Study Species

Coffea racemosa is a diploid species with 2n=2x=22 chromosomes (Silva, 1956). Bridson (2003) considered *C. racemosa* (Inhambane coffee) to be endemic to central and southern Mozambique, northern South Africa (KwaZulu Natal), and eastern Zimbabwe, occurring in coastal and riverine forests, deciduous woodland, and bushland at elevations of 0-500 m. It is currently reported to be used in KwaZulu Natal (South Africa) and eastern Zimbabwe (O'Sullivan et al., 2017). The species is tolerant to high temperatures, drought, and resistant to various coffee pests, especially the coffee leaf miner (*Perileucoptera coffeella*) and some nematodes (Meloidogyne) (Krug, 1965; Hallé and Faria, 1973; Guerreiro Filho, 1992). Several studies suggest that *C. racemosa* has been cultivated on several Mozambican farms since at least the beginning of the 20th century (Guerreiro Filho, 1992).

Population Structure of *Coffea racemosa* in Mozambique

In 2018, several field missions were conducted to locate all *C. racemosa* plants in Mozambique. A total of 13 populations were found (Figure 1). For each individual tree, we measured the height and diameter at breast height (DBH), and the basal diameter (5 cm above the ground) for seedlings and trees. All plants found were georeferenced and categorized as: seedlings (h < 50 cm), small trees (h ≥ 50 cm and DBH < 5 cm), medium trees (5 cm ≤ DBH ≤ 15 cm), and large trees (DBH ≥ 15 cm). We also recorded which individuals were flowering, how many flowers each produced, and the number of flowers developing into fruits. We selected three types of habitats, including forest fragments of 5 ha and 20 ha distant from continuous forests (Table 1).

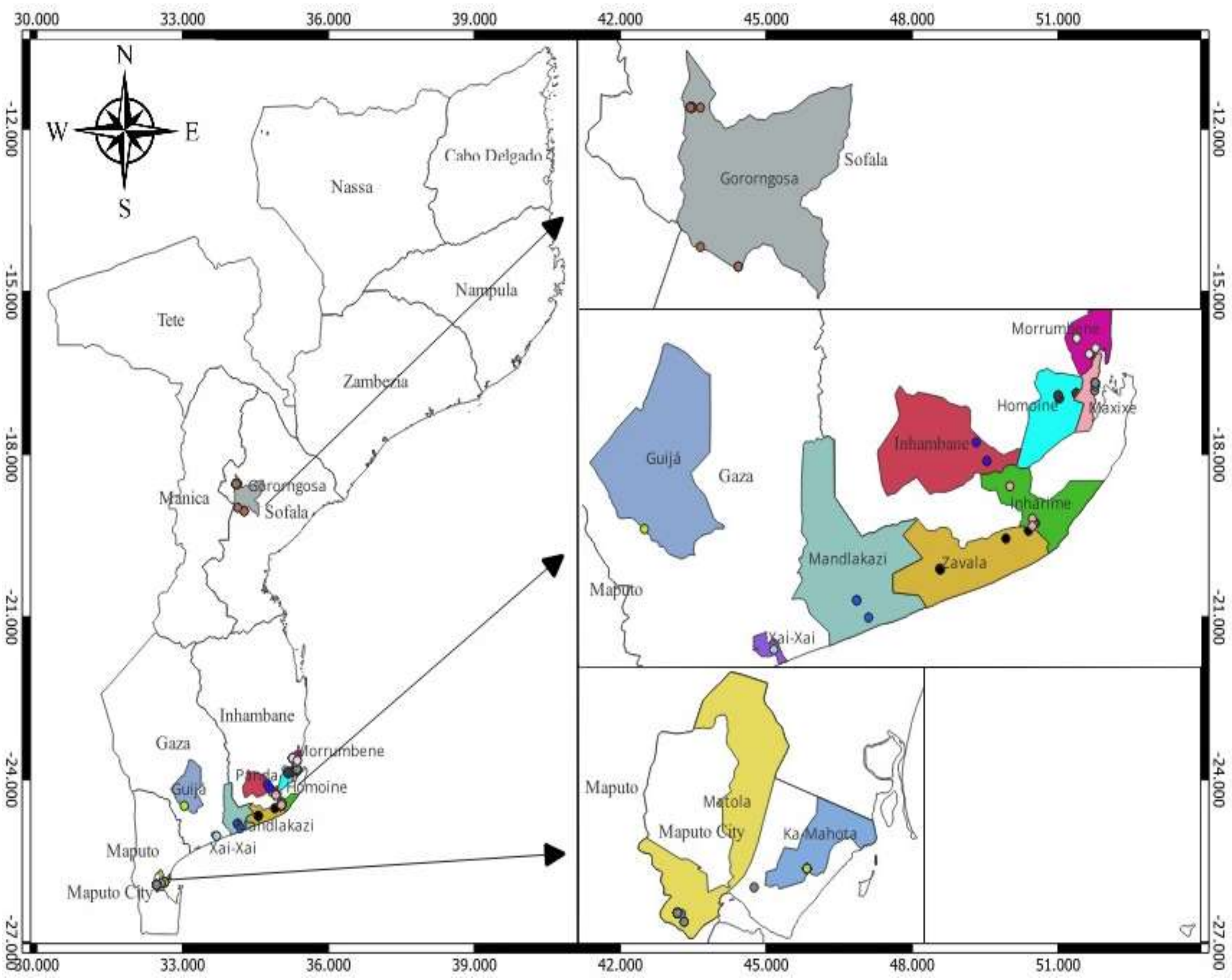

Figure 1. Map of *Coffea racemosa* distribution in Mozambique

RESULTS & DISCUSSION

Current status of populations

A total of 2251 trees were found in all populations studied (Table 1). However, population density of *Coffea racemosa* varied significantly between the different fragments and continuous forest, ranging from 3 to 1000 individuals ($F_{1,12}$= 5.12, P=0.04; Table 1).

Table 1. Studied populations of *Coffea racemosa* in Mozambique.

ID	Province	Population	Habitat	Latitude	Longitude	Number of trees
GJ	Gaza	Guija	< 5 há	-24.49875	33.01081	10 ᵃ
MZ	Gaza	Manjacanze	> 5 há	-24.49964	33.02190	100 ᶜ
XA	Gaza	Xai-xai	< 5 há	-25.05598	33.68798	3 ᵃ
IR	Inhambane	Inharrime	20 há	-24.30259	34.90360	100 ᶜ
PD	Inhambane	Panda	> 5 há	-23.88346	35.15154	500 ᵈ
ZV	Inhambane	Zavala	20 ha	-24.50669	34.99922	100 ᶜ
HO	Inhambane	Homoine	20 ha	-23.87354	35.24530	100 ᶜ
MX	Inhambane	Maxixe	> 5 ha	-23.82476	35.34279	100 ᶜ
MR	Inhambane	Morrumbene	> 5 ha	-23.66450	35.34482	200 ᶜ
MP	Maputo	Matola	> 5 ha	-25.92764	32.54849	10 ᵃ
MC	Maputo	Ka-Mahota	< 5 ha	-25.90665	32.614341	28 ᵇ
SF	Sofala	Gorongosa	Continouos forest	-18.56340	34.08540	1000 ᵉ

The highest proportion of flowering was recorded in continuous forests, with up to 70%, and no flowering occurred in the 5-hectare forest fragments. The differences in fruit set and seed set among the different-sized forest fragments and continuous forests were also not significant.

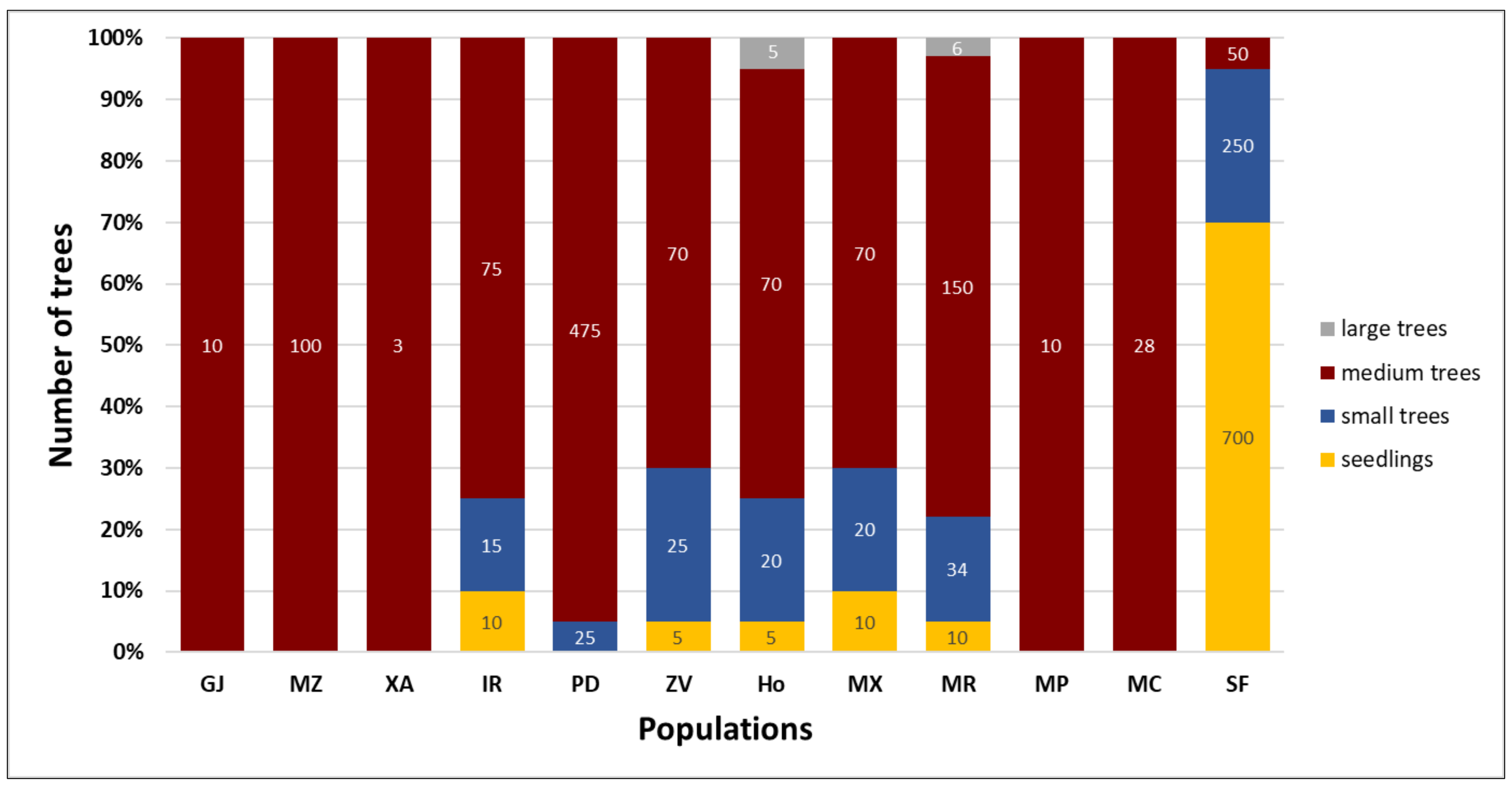

Figure 2. Size-class distributions of *Coffea racemosa* populations in Mozambique.

The population of *C. racemosa* presents a diverse demographic structure, including large, medium, and small trees (Figure 2), as well as seedlings. Seedlings were primarily found in conserved forests, especially in protected areas, indicating that these locations provide better conditions for the natural regeneration of the species (Silva et al., 2020).

In small urban fragments, no seedlings or large trees were observed, only isolated medium trees. This pattern may result from habitat fragmentation, reduced area available for plant growth, and the influence of human activities, such as urbanization (Ferreira and Santos, 2019). The absence of young trees and seedlings in these fragments suggests a compromised regeneration process, possibly due to the lack of viable seeds, degraded soil, or herbivory pressure (Oliveira et al., 2021). The lack of regeneration in small urban fragments indicates that these areas are not supporting the complete life cycle of *C. racemosa*, which could lead to a decline in population over time (Mendes and Costa, 2018).

For the effective conservation of *C. racemosa*, it is crucial to promote connectivity between habitat fragments, restore degraded areas, and protect conserved forests (Pereira and Almeida, 2020). The introduction of seedling planting programs and continuous population monitoring can help ensure the long-term survival of the species (Rodrigues et al., 2019). These actions, based on robust scientific data, are essential for maintaining the biodiversity and ecological resilience of Mozambican forests (Silva et al., 2020).

CONCLUSION

Our study reveals a stratified demographic structure in *C. racemosa* populations, including large, medium, and small trees, as well as seedlings, predominantly found in conserved forests, suggesting better conditions for natural regeneration. In contrast, in small urban patches, only medium trees were observed, indicating a compromised regeneration process due to habitat fragmentation and human activities.

FUTURE WORK / REFERENCES

Based on the results obtained, the next steps should include specific studies towards the regeneration of this species in urban fragments, investigating factors such as soil quality, seed availability, and herbivory pressure. It is essential to implement a continuous monitoring of *Coffea racemosa* populations to Observe changes in demographic structure and regeneration over time, as well as to assess the impact of habitat fragmentation and urbanization. The effectiveness of reforestation and seedling planting programs should be investigated to promote regeneration in degraded areas, while evaluating the effectiveness of protected areas in conserving the species. Additionally, promoting community education and awareness about biodiversity conservation is crucial to preserve *C. racemosa*.