ABSTRACT

Plant ecological studies at the population level on carefully selected single species provide key insights into their structural and functional ecology, but may also be extrapolated to enhance ecologists' understanding of other similar taxa, which ultimately contributes to the conservation and management of the group as a whole. Long-lived, slow-growing plants such as succulents and cycads, which are popular among plant collectors and often threatened as a consequence, are prime candidates for research owing to the considerable benefits to their conservation and management. *Aloe plicatilis* is a unique and charismatic arborescent succulent monocot that is endemic to the Cape Floristic Region, South Africa. It is restricted to mountainous areas in the Cape Winelands in the south-western Cape, and is the only tree aloe that occurs in the Cape fynbos. *Aloe plicatilis* is a prized species in the horticultural trade in succulent plants, and a recent spike in exports of the species from South Africa, including consignments of reportedly wild-collected plants, has raised concerns about its persistence in the wild.

Potential threats to *A. plicatilis* combined with a dearth of knowledge on the species' ecology prompted a broad-scale ecological study on the species, and an assessment of how potential threats may be affecting its survival in the wild. The primary aim of this study was to investigate three key elements of the ecology of *A. plicatilis*, viz. (1) demographic trends across the species' distribution, (2) the reproductive ecology of the species, and (3) its fire ecology. The study was first contextualized by compiling a comprehensive review of the ecology of African aloes. The objectives specific to *A. plicatilis* then involved determining the species' habitat profile, its geographical distribution, number of populations, and estimations of the sizes thereof. Further objectives entailed an assessment of the population size structure and density of a large proportion of *A. plicatilis* populations across the species' distribution, studies of its pollination and seed ecology, and an investigation of the species' fire survival and the impacts of fire on population structure. The study concludes with a synthesis that highlights and extrapolates the findings of the research and the implications these have for other *Aloe* species and similar long-lived, slow-growing plant taxa. Threats to the persistence of *A. plicatilis* in the wild are discussed, and recommendations are made for management, population monitoring and directions for future research.

Several of the knowledge gaps in aloe ecology highlighted in the review were investigated for *A. plicatilis* in this study, notably seed ecology, resprouting and fire ecology. The demographic study on *A. plicatilis* uncovered 14 previously undocumented populations, bringing the total currently known to 30. Fifty percent of the 19 populations surveyed for size structure, density and spatial extent exhibited bell-shaped size class distributions (SCD), which are hypothesized to indicate an adult-persistence population survival strategy, typical of many long-lived, slow-growing plant taxa. This trend was reflected in the apparent lack of persistent seed banks in *A. plicatilis*, which suggests minimal 'drib-drab' recruitment over time as opposed to mass episodic recruitment. There appears to be a positive relationship between *A. plicatilis* population size and reproductive success. Quantification of natural fruit and seed set at three *A. plicatilis* populations revealed that large, dense populations exhibit higher seed production/plant relative to smaller and sparser ones, suggesting an Allee effect. Pollinators of the species (insects and specialist avian nectarivores) are probably attracted in greater numbers to large, dense populations where prolific food rewards and short inter-plant distances facilitate efficient floral visitation, and hence effective pollination.

Recruitment in *A. plicatilis* appears to depend on the alignment of numerous biotic and abiotic factors such as slope, aspect, temperature, quantity and timing of rainfall, fire occurrence, and the availability of suitable rocky microsites. These sites are of particular importance as they serve as fire refugia and provide nurse objects (nurse plants and/or nurse rocks), which create cool, shady conditions, where organic matter and moisture may accumulate, all of which appear to be essential to germination and establishment in *A. plicatilis*. As with most plant species, the large majority of *A. plicatilis* seeds are dispersed close to parent plants (estimated 1.3 – 15.3m for 0.8 and 4.0m in height respectively). However, the occurrence of *A. plicatilis* on Paarl Mountain and the Paardeberg, which are completely isolated from other mountain ranges where the species occurs, suggests the possibility of long-distance dispersal by strong, persistent and gusty summer winds that blow during the peak seed dispersal season.

Size structure analyses and detailed field observations suggest that *A. plicatilis* displays the 'bonsai effect', whereby plants growing in very rocky sites with restrictive rooting space and/or sites where they are exposed to persistent strong winds, are maintained as stunted individuals termed 'suppressed juveniles' or 'reproductive dwarfs'. However, rocky sites also act as fire refugia and provide nurse rocks, both of which are necessary for recruitment and persistence. Hence, there appears to be a trade-off between plant size and fire survival probability: individuals in very rocky sites are well-protected from fire, but often remain stunted and unreproductive, while plants in less rocky sites with more rooting space can attain larger sizes but are more vulnerable to fire damage. *Aloe plicatilis* is unique in that it is the only *Aloe* species that possesses thick, corky bark, which affords it additional fire protection. Its stems, leaves and bark also contain large water reserves, which may act as a fire retardant. Fire survival is heavily reliant on the prevention of hydraulic failure by the thick insulating bark and the protection of apical meristems, which facilitates onward apical growth, since *A. plicatilis* is incapable of epicormic or basal resprouting post-fire. Despite the species' fire survival adaptations, *A. plicatilis* population size structure may be dramatically altered by fires, especially at sites where they have been excluded for periods longer than appropriate for the vegetation type.

The very recent name change from *Aloe plicatilis* to *Kumara plicatilis* has important conservation implications for the species. Recognition of the species' uniqueness by ascribing it to a monotypic genus may result in greater conservation efforts to preserve its sole genetic lineage; nonetheless, the inadvertent and unwanted consequence may be increased perceived rarity and desirability, and concomitant threats to the species' persistence in the wild. Illegal wild-harvesting of *A. plicatilis* does not appear to be posing a major threat to the species at present; however, monitoring of small and/or low-lying and easily-accessible populations is advised. The four smallest surveyed populations are also recommended for long-term monitoring due to poor or absent recent recruitment and vulnerability to climate change at the species' distribution edge. Appropriate management actions are recommended for twelve *A. plicatilis* populations that are under potential threat by invasive alien plant species encroachment.

The baseline data presented in this study serve as a foundation for future studies, which will build on current understanding of the ecology of *A. plicatilis*, other aloe species, and long-lived, slow-growing plant taxa in general. Opportunities for future research on *A. plicatilis*, (which also apply to other *Aloe* species) include: (1) a study on the long-term population dynamics of the species, which includes population modelling; (2) further studies on the species' pollination ecology, seed dispersal and recruitment patterns; (3) investigations into the physiological role that bark properties and plant tissue water content play in fire survival and (4) a predictive species distribution modelling study that models the current distribution of *A. plicatilis*, and how this might change under different climate change scenarios. Modelling Cape fynbos species distributions using climate change predictions is vital for adaptation and mitigation in the south-western Cape, where severe climate change impacts are forecast. Furthermore, deepened insight into the ecology of long-lived, slow-growing and potentially threatened plant species will contribute to predicting and understanding their responses to threats including climate change, which will ultimately lead to better management and conservation practises.