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Distribution, quantitative morphological variation and preliminary molecular analysis of different growth forms of wild rooibos (*Aspalathus linearis*) in the northern Cederberg and on the Bokkeveld Plateau

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Abstract

Aspalathus linearis (Fabaceae) is endemic to the Cape Floristic Region in the Western Cape and Northern Cape Provinces of South Africa. The reddish leaves and stems, primarily of one cultivar, are used to make a commercially important tea which is marketed locally and internationally as 'rooibos' or 'redbush' tea. In historical times rooibos was collected in the wild. In the twentieth century cultivation of a single cultivar increasingly replaced wild harvest to meet growing demand. Recently, tea from wild forms of the species, which vary significantly in growth form and reproductive strategy, has been marketed by small-scale farmers in Wupperthal and on the Suid Bokkeveld plateau in the northern part of the species' distribution. Little information on the wild forms of this species has been published, although a rich body of knowledge exists amongst local harvesters and other land-users. In this study, we focus on the northern part of the species' distribution area where wild rooibos is harvested for commercial sale to niche organic and fair-trade markets. We adopt a transdisciplinary approach to (1) document the different growth forms, (2) develop a bioclimatic model of the potential distribution of the species, (3) quantify the morphological variation that exists between growth forms relative to the established cultivar and (4) use molecular techniques to provide a preliminary insight into the infraspecific diversity of different wild *A. linearis* growth forms. Our results show that local land users in the region identify four main growth forms of wild *A. linearis*. These are an 'erect form' and a 'prostrate form' in the Wuppertal area, a 'shrub form' in the Suid Bokkeveld, and a 'tree form' that has been observed at specific sites at Wupperthal, Biedouw and the Suid Bokkeveld. The PCA analysis of seven morphological traits identified three growth forms, which support the land user descriptions except in the case of the 'tree' and 'erect' forms which co-occurred in coordinate space. Both shrub and prostrate forms are wider than they are taller and possess more stems closer to the ground than erect forms. While the stems of both shrub and prostrate forms lie relatively flat on the ground, stem thickness is significantly greater in shrub forms. The tree type, the erect form and the cultivar studied possess the highest harvestable biomass. Prostrate forms and shrub forms resprout after fire while erect and tree forms regenerate from seed only. Haplotypic variation was assessed using DNA sequences from a single chloroplast region and revealed strong genetic differences between the different growth forms. Although preliminary, there is some evidence that sprouting and nonsprouting forms of the species are genetically isolated. This has important taxonomic implications for the species. Additional chloroplast regions and a nuclear region were also identified as variable and potentially useful markers for a multi-locus molecular approach to studying taxonomic and ecological questions within the species.

Keywords: *Aspalathus linearis*; Bioclimatic modelling; Local knowledge; Morphological variability; *trnL-F* spacer

1. Introduction

Aspalathus (Fabaceae, Tribe Crotalarieae) consists of 279 species (Dahlgren, 1988; Cupido, 2007) and is the second largest genus of vascular plants in the Cape Floristic Region

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(Goldblatt and Manning, 2002). The genus is endemic to South Africa and most of the species are concentrated in the Cape Floristic Region, with only six species extending to southern KwaZulu-Natal. *Aspalathus linearis* (Burm.f.) Dahlg. (known locally as 'rooibos' or 'red bush') occurs over a wide geographic range in the western and south eastern parts of the Western Cape Province and in limited areas in the south-western part of the Northern Cape Province (Dahlgren, 1968, 1988; Fig. 1). Prior to the twentieth century rooibos was exclusively collected in the wild. Increasing demand stimulated cultivation of rooibos, and the proportion of wild harvested rooibos steadily diminished. Currently a single cultivated form of the species forms the basis for a commercially important tea industry. In recent years wild rooibos has been harvested and processed as a separate product by small-scale rooibos producers in the Suid Bokkeveld and Wupperthal areas (Arendse and Oettlé, 2001; Malgas and Oettlé, 2007).

Wild populations of *A. linearis* vary considerably from one area to another. The species exists as a series of partially allopatric populations (Van der Bank et al., 1999) which differ in a number of respects, specifically growth form, fire-survival strategy, vegetative and reproductive morphology, isozyme patterns and flavonoid composition (Dahlgren, 1968; Van der Bank et al., 1995, 1999). Substantial variation is observed within the species and distinct geographical forms can be recognised at a population level. Dahlgren (1968, 1988) and Van Heerden et al. (2003), for example, distinguish five and seven main rooibos tea 'types' and describe their distribution and main characteristics, respectively. Local harvesters in the northern Cederberg and on the Suid Bokkeveld plateau also differentiate between wild rooibos tea 'types' and use descriptive Afrikaans names that reflect morphological traits and growth forms which are usually easily observed in the field. The northern Cederberg refers to the area from Clanwilliam north towards the Doring River. The Suid Bokkeveld lies further north between the Doring River (where it forms the border between the Western and Northern Cape Provinces) and the town of Nieuwoudtville (Fig. 1).

Wild populations of *A. linearis* have also been noted to contain both sprouting and nonsprouting individuals (Schutte et al., 1995; Van der Bank et al., 1999). Fynbos is a fire driven system in which plant reproduction is largely centered around recurrent fires (Cowling, 1987). In general, sprouting and reseeding are mutually exclusive strategies (Vesk et al., 2004) used by plants in response to periodic natural disturbances that result in loss of above ground biomass, such as fire. Sprouters are able to regenerate from subterranean lignotubers after a fire, whereas nonsprouters are killed by fire and must re-establish through seeds.

Van der Bank et al. (1999) suggest that the different forms of *A. linearis* may be genetically fixed at the population level, while Van Heerden et al. (2003) mention an area near Citrusdal where four distinct forms co-occur, their distinctness apparently being maintained over multiple generations. A study of leaf chemistry (Van Heerden et al., 2003) provides further support for the

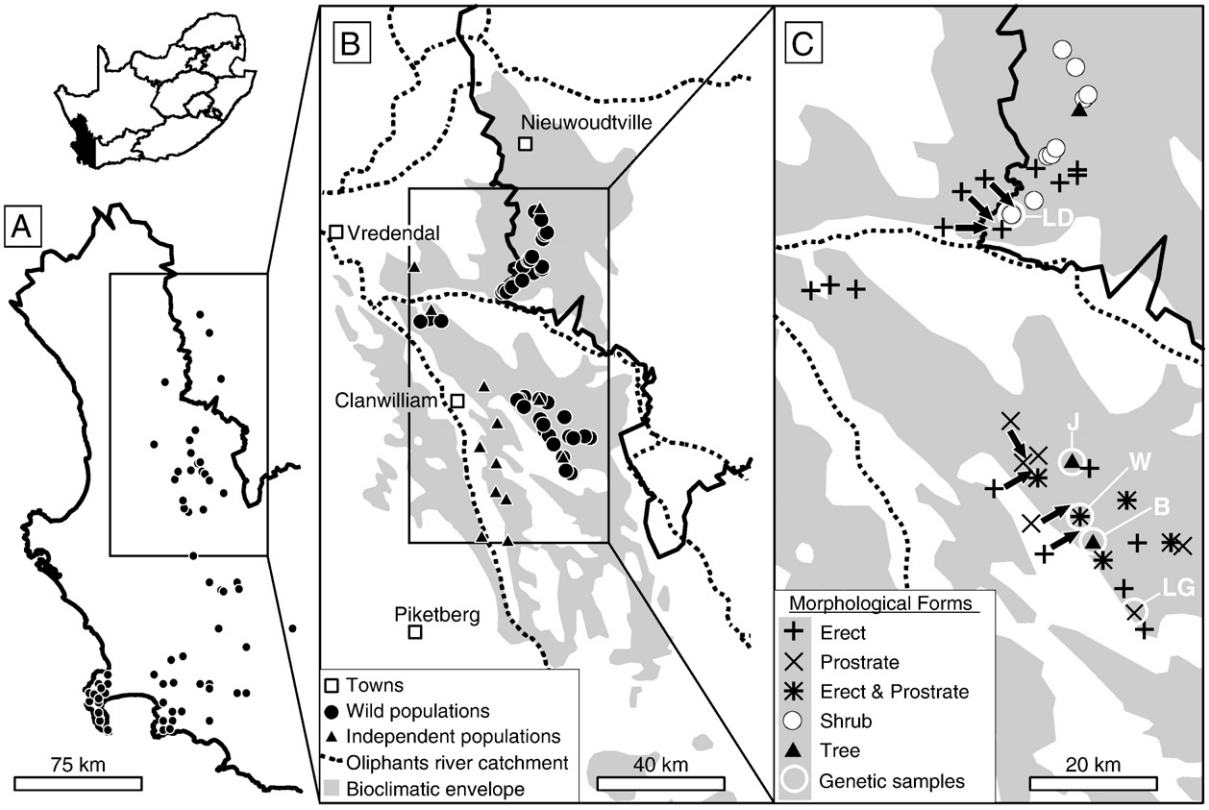

Fig. 1. (A) The distribution of *Aspalathus linearis* based on Dahlgren (1968, 1988). (B) The bioclimatic envelope for the northern part of the species range based on the distribution of 44 wild populations which were surveyed in this study. The distribution of several independent population locations obtained from the literature is also shown. (C) The distribution of different morphological forms of the species observed in wild populations with the populations selected for genetic analyses (LD – Landskloof; J – Jeugkamp; W – Witbank; B – Bo-Valletjie; LG – Langkloof).