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Bark and wood structure of *Prunus africana* (Rosaceae), an important African medicinal plant

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ABSTRACT

Detailed morphological and anatomical descriptions and photographs of the bark and wood of *Prunus africana* are provided for future use in taxonomic, phylogenetic, forensic and pharmacognostic studies. The bark is used in African traditional medicine and has become an important raw material for commercial extracts to treat benign prostate hyperplasia. Anatomical characters of diagnostic importance include parenchyma cells in the non-conducting part of the phloem with a reddish-brown content, abundance of druse crystals, scanty fibre-like sclereids and fibres (both of them solitary or arranged in groups of two to 15), and shape and position of rays in the dilated secondary phloem. The large number of sieve areas (four to 23) in the compound sieve plates appears to be a unique character—all other species have three to 10 sieve plates. The long sieve tube members (230–600 μm) differ from those of other *Prunus* species (typically 80–375 μm). *P. africana* is compared with other species of *Prunus*, and shares with them wood with distinct growth rings, vessels that are solitary or in radial multiples and clusters, perforation plates that are simple, the walls of vessel elements with helical thickenings, diffuse axial parenchyma and ray cells having a reddish-brown content or druse crystals. The loss of distinctive borders in the pits, as found also in *P. davidiana* and *P. persica*, was also observed in *P. africana*. *P. africana* shares with a small group of other species the scanty amount of fibre-like sclereids and fibres in the bark.

1. Introduction

According to the latest classification system of Rosaceae (Potter et al., 2007), *Prunus* L. (200 species) is placed in the monotypic tribe Amygdaleae, and includes many well-known fruit trees such as cherries, peaches, plums, apricots and almonds (Wen et al., 2008; Shi et al., 2013). *Prunus* species are mostly distributed in the northern hemisphere with only one, *Prunus africana* (Hook.f.) Kalkman, occurring in the southern hemisphere. *Pygeum africanum* Hook.f. is an old synonym for *P. africana* and the species has numerous vernacular names such as African cherry and red stinkwood. The tree is restricted to highland forest, generally above 1500–2000 m in altitude, and distributed in the southern, central, eastern and western parts of Africa, including 20 countries (Kadu et al., 2011; Cunningham et al., 2014). Populations of *P. africana* are relatively small and scattered in southern Africa but were larger in East and West Africa, particularly Cameroon, before commercial bark harvesting began. In southern Africa, *P. africana* occurs only in Afromontane forest, which forms the major part of the forest biome, the latter covering only about 0.3% of the total land area of South Africa (Mucina and Rutherford, 2006).

The deeply fissured and greyish-brown to blackish bark with its distinctive reddish inner bark (Brendler et al., 2010) is widely used in African traditional medicine and is commonly sold on local markets (Grace et al., 2002; Von Ahlefeldt et al., 2003; Cunningham et al., 2014). The leaves and bark are widely used in African traditional medicine to treat chest, stomach and intercostal pain, as well as fever, gonorrhoea, inflammation, urinary tract ailments, kidney problems, impotence, malaria, insanity and to stimulate appetite (Watt and Breyer-Brandwijk, 1962; Kokwaro, 1976; Burkill, 1997; Neuwinger, 2000; WHO, 2002; Van Wyk et al., 2009; Brendler et al., 2010). In western medicine, the plant has been heavily exploited as a source of raw material for making preparations to effectively treat benign prostatic hypertrophy. Clinical trials were reviewed by Andro and Riffaud (1995); Bombardelli and Morazzoni (1997) and Ishani et al. (2000).

In terms of wild harvested bark volume, *P. africana* ranks among the top most exploited species in the world, with 3200 to 4900 tons exported annually to European countries (France, Italy, Belgium and Spain) (Cunningham et al., 2002, 2014). Most bark entering the international market is wild harvested (Cunningham, 2014). Therefore, this species is endangered and was listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) in 1995. The major trading countries to the external market are Cameroon, Kenya, Madagascar and Equatorial Guinea (the island of Bioko); a smaller amount is exported by the Democratic Republic of Congo and Burundi

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(Cunningham, 2014). In other African countries, *P. africana* bark is harvested mainly for traditional medicines and sales on the local market. However, the problem of conservation of the species in these countries is also important as bark harvesting is unsustainable.

The timber is hard, tough, heavy, strong and finely structured with the sapwood white to pale pink and the heartwood pale red darkening to dark red (Palmer and Pitman, 1972; Burkill, 1997). It has an unpleasant smell when cut, hence the common name red stinkwood. The timber is easily worked and suitable for a wide range of uses, including carpentry, furniture, construction, implement handles, floors and firewood (Palmer and Pitman, 1972; Burkill, 1997; Van Wyk et al., 2008).

Information on the anatomy of the wood and bark of *P. africana* is scanty. Although published anatomical results of *P. africana* are available for the wood (Kromhout, 1975; InsideWood, 2004–onwards) and the bark (Lotova and Timonin, 2005), the data is incomplete and lacks critical details. Anatomical data for several other species of *Prunus* is available but scattered and incomplete. These species were previously included in the genera *Amygdalus* L., *Armeniaca* Scop., *Cerasus* Mill., *Lauro-cerasus* Duhamel, *Maddenia* Hook.f. & Thomson, *Padus* Mill. and *Pygeum* Gaertn. (Potter et al., 2007) and some useful anatomical descriptions can be found in the old literature under these synonyms.

This study aims to present, for the first time, accurate and detailed descriptions and photographs of the wood and bark anatomy of *P. africana*. Comparative data is provided for future use in plant identification, quality control, forensic science, as well as taxonomic and phylogenetic studies.

2. Materials and methods

Samples of bark and wood were collected from a cultivated tree in the Walter Sisulu National Botanical Garden in Gauteng, South Africa (Voucher specimens KK82-14 in JRAU). For the bark investigation, we collected parts of stems of different stages of development from young tips of twigs down to mature bark at the bottom of the trunk. Some of the material was sectioned fresh and the rest was fixed in FAA (Johansen, 1940). Bark samples from the traditional (muthi) market in Johannesburg were used for comparison and for confirmation of the accuracy of the descriptions.

Transverse and longitudinal sections (both radial and tangential) of bark and wood were made with a freezing microtome (Ernst Leitz GMBH, Wetzlar, Germany). Sections from fresh unstained material were mounted in glycerol and immediately examined under a light microscope. Sections from fixed material were stained with a 1:1 alcian blue/safranin mixture (Jansen et al., 2004) and mounted in Euparal. Maceration of secondary phloem and wood was carried out in Jeffrey's solution for 24 h before mounting the macerated material in glycerol. Digital images were taken using an Olympus ColorView Soft Imaging System and measurements were made with the Olympus Analysis Imaging Solutions (OASIS) programme.

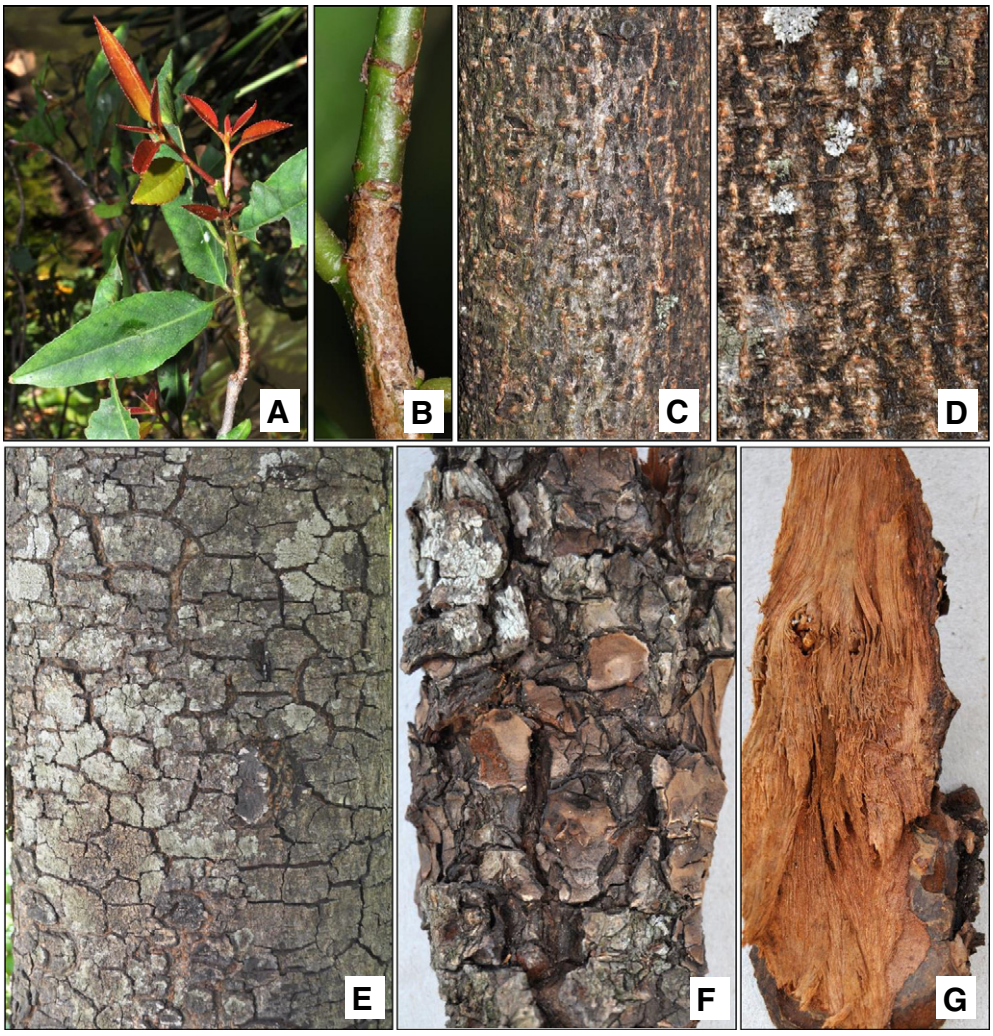

Fig. 1. Bark morphology of *Prunus africana* showing different stages of development. (A,B) Young branch; (B), first-formed periderm; (C,D) appearance of intermediate stems with lenticels and vertical cracking; (E,F) appearance of mature trunk with rectangular adherent scales; (F,G) commercial bark samples with (F) showing outer and (H) inner bark.