

# The importance of ecological, biological and medicinal properties of *Diplorhynchus condylocarpon* (Müll. Arg.) Pichon (Apocynaceae) in Tropical Africa

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(Received 19 November, 2020; Accepted 12 April, 2021)

## ABSTRACT

*Diplorhynchus condylocarpon* (Müll. Arg.) Pichon is a shrub or small tree which occurs naturally in Angola, Botswana, the Democratic Republic of Congo (DRC), Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe. This study aims to provide some information about the ecological, biological and medicinal properties of *D. condylocarpon* in tropical Africa. This review examines the existing literature on the ecological, biological and medicinal properties of *D. condylocarpon*. This study revealed that the aerial part, bark, fruit, latex, leaf, root, root bark and stem bark infusions and/or decoctions of *D. condylocarpon* are mainly used as anthelmintic and galactagogue, and traditional medicines for headache, abdominal pains, snake bites, respiratory problems, blackwater fever, fever, malaria, sexually transmitted infections and gastro-intestinal problems. Ethnopharmacological research revealed that the species is characterized by alkaloids, antibacterial, antiplasmodial and antiprotozoan activities. The data from this study should contribute to improved management and conservation of *D. condylocarpon* in tropical Africa, considering concerns about anthropogenic pressure on plant biodiversity.

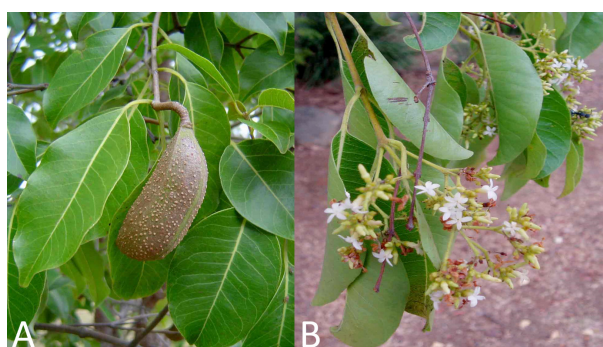
**Key words :** Apocynaceae, *Diplorhynchus condylocarpon*, Indigenous pharmacopeia, Traditional medicine

## Introduction

The genus *Diplorhynchus* Welw. ex Ficalho and Hiern is a monotypic genus of the Apocynaceae family with one recognized species, *D. condylocarpon* (Müll. Arg.) Pichon (Leeuwenberg *et al.*, 1985). The genus name *Diplorhynchus* based on two Greek words “*Diplo*” and “*rhynchos*” which mean “double” and “beak”, respectively (Palmer and Pitman, 1972). The species name *condylocarpon* is based on two Greek words “*kondylos*” and “*knuckle*” which mean “a projection” and “fruit”, respectively, in reference to the beak-like shape of fruits which are associated with the species (Palmer and Pitman, 1972). Synonyms of *D. condylocarpon* include *Aspidosperma condylocarpon* Muell. Arg., *D. angolensis* Büttner, *D.*

*angustifolia* Stapf, *D. condylocarpon* spp. *angolensis* (Büttner) Duvign., *D. condylocarpon* ssp. *mossambicensis* (Benth. ex Oliv.) Duvign., *D. condylocarpon* ssp. *mossambicensis* var. *mossambicensis* f. *angustifolius* (Stapf) Duvign., *D. condylocarpon* ssp. *mossambicensis* var. *psilopus* (Welw.) Duvign., *D. condylocarpon* ssp. *mossambicensis* var. *psilopus* f. *microphylla* Duvign., *D. mossambicensis* Benth. ex Oliv., *D. poggei* Schum., *D. psilopus* Welw. ex Fic. & Hiern, *D. welwitschii* Rolfe and *Neurolobium cymosum* Baill. (Plaizier, 1980; Leeuwenberg *et al.*, 1985). The English common names of *D. condylocarpon* include “horn-pod tree”, “Rhodesian rubber tree”, “Transvaal rubber tree” and “wild rubber” (Palgrave, 2002). *Diplorhynchus condylocarpon* (Figure 1) is a multi-stemmed, slender and deciduous

shrub or small tree growing to a height of 12 metres (Palgrave, 2002). The bark is grey-brown to black in colour, thick, corky and fissured in small square sections. The leaves of *D. condylocarpon* are simple, opposite, more or less drooping, elliptic in shape and shiny yellowish green in colour above, paler below with entire and waxy margins. The flowers of the species occur in terminal sprays, white to cream in colour and faintly scented. *Diplorhynchus condylocarpon* produces two hard, woody, dark reddish brown fruits or follicles with pointed tips speckled with small whitish dots or lenticels when mature.



**Fig. 1.** *Diplorhynchus condylocarpon*. A: branch showing a fruit and B: branch showing flowers (photos: B Wursten and M Hyde)

*Diplorhynchus condylocarpon* has been recorded south of the equator in Angola, Botswana, the Democratic Republic of Congo (DRC), Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe (Figure 2). The species has been recorded in dry sandy loamy and rocky soils of savannas, bushveld, open woodlands, wooded grassland and of open forests often on rocky outcrops and stony hillsides at an altitude ranging from sea level to 1700 m above sea level (Plaizier, 1980). *Diplorhynchus condylocarpon* is an important medicinal plant in tropical Africa (Vasisht and Kumar, 2004; de Ruijter, 2008) and the bark of the species is sold in informal herbal medicine markets in Malawi and exported to Botswana, Zambia and Zimbabwe (Meke *et al.*, 2017). Similarly, the fruits of *D. condylocarpon* are sold in informal herbal medicine markets in South Africa (Cunningham, 1993). The bark fibre of *D. condylocarpon* is used in Mozambique and Zimbabwe for weaving clothes or blankets and other handcrafts (Ellert, 1984; Bruschi *et al.*, 2014; Van Wyk and Gericke, 2018). All parts of *D. condylocarpon* contain milky sap or latex which is

sticky and used as birdlime and glue, also applied to the hides of drums to improve their quality and tone in Angola, DRC, Malawi, South Africa and Zambia (Morris, 1996; Fowler, 2002; Van Wyk and Van Wyk, 2013; Latham and Mbuta, 2014; Lautenschläger *et al.*, 2018). The leaves of *D. condylocarpon* are browsed by game and livestock (Van Wyk and Van Wyk, 2013; Schmidt *et al.*, 2017). The edible caterpillars (*Bunaeaalcinoe*) feed on the leaves of *D. condylocarpon* (Latham and Mbuta, 2014). *Diplorhynchus condylocarpon* is fire-resistant and withstands repeated burning (Palgrave, 2002). Poles of *D. condylocarpon* are used as fence posts and have been known to take root (Maroyi 2012; Schmidt *et al.*, 2017). It is therefore, within this context that the current study was undertaken aimed at documenting the ecological, biological and medicinal properties of *D. condylocarpon* in tropical Africa.

## Materials and Methods

Results of the current study are based on literature search on the ecological, biological and medicinal properties of *D. condylocarpon* throughout its distributional range using information from internet databases. The databases used included Scopus, Google Scholar, PubMed and Science Direct. Other sources of information used included pre-electronic sources such as journal articles, theses, books, book chapters and other scientific articles obtained from the University library.

## Results and Discussion

### Medicinal uses of *Diplorhynchus condylocarpon*

Medicinal uses of *D. condylocarpon* have been recorded in Angola, Botswana, DRC, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe (Table 1), representing 90.0% of the countries where the species is indigenous. The aerial part, bark, fruit, latex, leaf, root, root bark and stem bark infusions and/or decoctions of *D. condylocarpon* are mainly used as anthelmintic and galactagogue, and traditional medicines for headache, abdominal pains, snake bites, respiratory problems, blackwater fever, fever, malaria, sexually transmitted infections and gastro-intestinal problems (Table 1, Figure 2). Other medicinal applications of *D. condylocarpon* in at least two countries and supported by at least two literature sources include the use of aerial part,



Fig. 2. Geographical distribution of *Diplorhynchus condylocarpon* in tropical Africa

bark, fruit, latex, leaf, root, root bark and stem bark infusions and/or decoctions as colic in Angola and Tanzania (Hedberg *et al.*, 1982; Novotna *et al.*, 2020), and traditional medicine for blennorrhoea and sore eyes in DRC and Tanzania (Chhabra and Uiso, 1991; de Ruijter, 2008; Kokwaro, 2009; Amuri *et al.*, 2018), diabetes mellitus in DRC and Tanzania (Moshi and Mbwambo, 2002; de Ruijter, 2008; Amuri *et al.*, 2018), infertility in Tanzania and Zimbabwe (Gelfand *et al.*, 1985; Chhabra *et al.*, 1987; de Ruijter, 2008), sores and wounds in Malawi and Tanzania (Palmer and Pitman, 1972; Ruffo, 1991; de Ruijter, 2008; Latham and Mbuta, 2014) and vertigo in

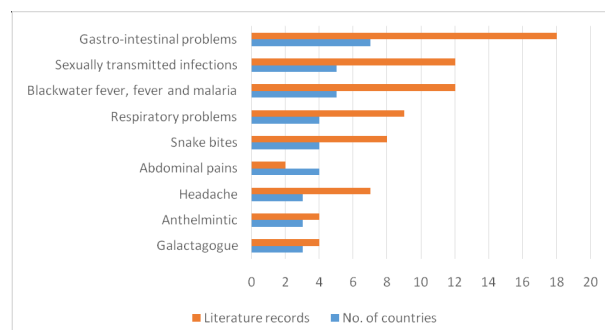


Fig. 2. Medicinal applications of *Diplorhynchus condylocarpon* derived from literature records

Angola and Mozambique (Bruschi *et al.*, 2011; Lautenschläger *et al.*, 2018). In Namibia, the roots of *D. condylocarpon* are mixed with those of *Annona stenophylla* Engl. and Diels, *Diospyroschamaethamnus* Mildbr., *Strychnospungens* Soler. and *Bobgunniamada gascariensis* (Desv.) J.H. Kirbr. and Wiersema as remedy for malaria and psychological problems (Von Koenen, 2001; Dushimemaria *et al.*, 2017; Maroyi, 2019).

### Nutritional, phytochemical and biological properties of *Diplorhynchus condylocarpon*

Researchers such as Becker and Lohrmann (1992) and Dierenfeld *et al.* (1995) investigated the nutritional properties of *D. condylocarpon* leaves and twigs (Table 2). A wide variety of nutrients associated with different parts of *D. condylocarpon* (Table 2) imply that the species could be a source of health promoting nutrients such as calcium, copper, crude fibre, iron, magnesium, phosphorus, potassium, proteins, sodium and zinc when utilized as fodder. Stauffacher (1961), Monseur *et al.* (1962) and Bisset (1980) identified alkaloids from the stem bark and root bark of *D. condylocarpon* (Table 2).

The aqueous extract of *D. condylocarpon* roots and stems are reported to have useful sympatholytic properties (Raymond-Hamet, 1969). Mulyangote (2016) evaluated the antibacterial activities of aqueous and dichloromethane and methanol (1:1) extracts of *D. condylocarpon* roots against *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis* and *Shigella sonnei* using the disk diffusion method. The extracts exhibited weak activities against the tested pathogens with the zone of inhibition ranging from 3.0 mm to 10.0 mm (Mulyangote, 2016). These findings could be used to corroborate traditional uses of *D. condylocarpon* extracts as traditional medicines against microbial infections.

Clarkson *et al.* (2004) evaluated the antiplasmodial activities of water, dichloromethane and dichloromethane : methanol (1:1) extracts of *D. condylocarpon* roots against *Plasmodium falciparum* strain D10 using the parasite lactate dehydrogenase (pLDH) assay. The dichloromethane : methanol (1:1) extract exhibited weak activities with half maximal inhibitory concentration ( $IC_{50}$ ) value of 24.0  $\mu$ g/ml (Clarkson *et al.*, 2004). Mokoka (2013) evaluated the antiplasmodial activities of dichloromethane: methanol (1:1) whole plant part extracts of *D. condylocarpon* against *Plasmodium falciparum* KI strain using G-3H-hypoxanthine incor-

**Table 1.** Medicinal uses of *Diplorhynchus condylocarpon*

Medicinal uses	Parts used	Country	Reference
Abdominal pain	Root decoction taken orally	Malawi, Mozambique, Tanzania and Zimbabwe	Gelfand <i>et al.</i> , 1985; Chhabra <i>et al.</i> , 1987
Abortifacient	Root infusion taken orally	Tanzania	Chhabra <i>et al.</i> , 1987; Moshi and Mbwambo, 2002
Anorexia	Root infusion taken orally	Zimbabwe	Gelfand <i>et al.</i> , 1985
Anthelmintic	Root decoction taken orally	Angola, Malawi and Tanzania	Morris, 1996; Bester, 2006; Lautenschläger <i>et al.</i> , 2018
Aphrodisiac	Root decoction taken orally	Tanzania	Luoga <i>et al.</i> , 2000; Moshi and Mbwambo, 2002
Bilharzia	Leaf and root decoction taken orally	Tanzania	Watt and Breyer-Brandwijk, 1962; Shangali <i>et al.</i> , 2008; Kacholi, 2014
Blackwater fever, fever and malaria	Leaf, root, root bark and stem bark decoction taken orally	Angola, Namibia, Tanzania, Zambia and Zimbabwe	Von Koenen, 2001; Fowler, 2006; Ngarivhume <i>et al.</i> , 2015
Malaria and psychological problems	Roots mixed with those of <i>Annona stenophylla</i> Engl. & Diels, <i>Diospyroschamaethamnus</i> Mildbr., <i>Strychnospungens</i> Soler. and <i>Bobgunniamadagascariensis</i> (Desv.) J.H. Kirbr. & Wiersema	Namibia	Von Koenen, 2001; Dushimemaria <i>et al.</i> , 2017; Maroyi, 2019
Blennorrhoea and sore eyes	Root and root bark decoction applied topically	DRC and Tanzania	Chhabra and Uiso, 1991; de Ruijter, 2008; Kokwaro, 2009; Amuri <i>et al.</i> , 2018
Colic	Fruit and root decoction taken orally	Angola and Tanzania	Hedberg <i>et al.</i> , 1982; Novotna <i>et al.</i> , 2020
Diabetes mellitus	Root decoction taken orally	DRC and Tanzania	Moshi and Mbwambo, 2002; de Ruijter, 2008; Amuri <i>et al.</i> , 2018;
Epilepsy	Leaf infusion taken orally	Angola	Lautenschläger <i>et al.</i> , 2018
Facilitate child birth	Roots	Tanzania	de Ruijter, 2008; Kokwaro, 2009
Galactagogue	Bark, leaf and root decoction taken orally	Malawi, Namibia and Tanzania	Ruffo, 1991; Morris, 1996; Leffers, 2003
Gastro-intestinal problems (diarrhoea, dysentery, indigestion and stomach complaints)	Bark, leaf and root decoction taken orally	Angola, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe	Storrs, 1979; Chinemana <i>et al.</i> , 1985; Chinsemu <i>et al.</i> , 2015; Mulyangote, 2016; Lautenschläger <i>et al.</i> , 2018
Headache	Leaf and root decoction taken orally	Malawi, Tanzania and Zambia	Watt and Breyer-Brandwijk, 1962; Fowler, 2002; Morris, 1996
Heart complaints	Root infusion taken orally	Malawi	Chhabra <i>et al.</i> , 1987;
Hernia	Root decoction taken orally	Tanzania	Luoga <i>et al.</i> , 2000
Hydrocele and testicle inflammation	Root and root bark decoction taken orally	Tanzania	Hedberg <i>et al.</i> , 1982; de Ruijter, 2008; Kokwaro, 2009

**Table 1.** *Continued ...*

Medicinal uses	Parts used	Country	Reference
Infertility	Root decoction taken orally	Tanzania and Zimbabwe	Gelfand <i>et al.</i> , 1985; Chhabra <i>et al.</i> , 1987; de Ruijter, 2008
Leprosy	Root infusion taken orally	Tanzania	Chhabra <i>et al.</i> , 1987; Chhabra and Uiso, 1991
Menstrual problems	Root infusion taken orally	Malawi	Morris, 1996
Mosquito repellent	Latex	Angola	Lautenschläger <i>et al.</i> , 2018
Rectal prolapse	Stem bark infusion taken orally	Tanzania	Hedberg <i>et al.</i> , 1982; de Ruijter, 2008
Respiratory problems (cough, measles, pneumonia and tuberculosis)	Fruit and root decoction taken orally	Malawi, Tanzania, Zambia and Zimbabwe	Gelfand <i>et al.</i> , 1985; Chhabra <i>et al.</i> , 1987; Morris, 1996; Fowler, 2002
Sexually transmitted infections (gonorrhoea, syphilis and venereal diseases)	Leaf and root decoction taken orally	Botswana, Malawi, Tanzania, Zambia and Zimbabwe	Hedberg and Staugård, 1989; Chhabra and Uiso, 1991; Mavi, 1996; Ndubani and Höjer, 1999
Snakebites	Aerial part, latex and root decoction applied topically	Angola, DRC, Tanzania and Zambia	Storrs, 1979; Bester, 2006; Latham and Mbuta, 2014; Lautenschläger <i>et al.</i> , 2018
Sores and wounds	Bark, leaf and root decoction applied topically	Malawi and Tanzania	Ruffo, 1991; de Ruijter, 2008
Vertigo	Latex, leaf and root decoction taken orally	Angola and Mozambique	Bruschi <i>et al.</i> , 2011; Lautenschläger <i>et al.</i> , 2018
Vomiting	Latex and root infusion taken orally	Mozambique	Bruschi <i>et al.</i> , 2011
Womb disinfection	Root infusion taken orally	Angola	Novotna <i>et al.</i> , 2020
Ethnoveterinary medicine (ectoparasites)	Root decoction applied topically	Zimbabwe	Mwale <i>et al.</i> , 2006

poration assay with chloroquine ( $IC_{50} = 0.05 \mu M$ ) as a positive control. The extract exhibited weak activities with  $IC_{50}$  value of  $43.9 \mu g/ml$  (Mokoka, 2013). Mokoka (2013) also evaluated the antiprotozoal activities of dichloromethane: methanol (1:1) whole plant part extracts of *D. condylocarpon* against *Trypanosoma bruceirhodesiense*, *Trypanosomacruzi* and *Leishmaniadonovani* using *in vitro* assays with melarsoprol ( $IC_{50} = 0.03 \mu M$ ), benznidazole ( $IC_{50} = 0.5 \mu g/ml$ ) and miltfosine ( $IC_{50} = 0.2 \mu g/ml$ ) as reference drugs. The extract exhibited activities with  $IC_{50}$  values ranging from  $29.4 \mu g/ml$  to  $63.9 \mu g/ml$  against  $IC_{50}$  values ranging from  $0.004 \mu g/ml$  to  $0.4 \mu g/ml$  exhibited by the positive controls (Mokoka, 2013). This pharmacological evaluation is of importance in the traditional uses of *D. condylocarpon* and future research focusing on control and management of malaria and protozoan diseases in tropical Africa.

## Conclusion

The present review summarizes the ecological, biological and medicinal properties of *D. condylocarpon* in tropical Africa. Detailed studies focusing on phytochemical evaluations including toxicological, *in vivo* and clinical studies to corroborate the traditional medical applications of the species are recommended. Therefore, future research should focus on the molecular modes or mechanisms of action, pharmacokinetics and physiological pathways for specific extracts of the species including identification of the bioactive compounds of the species and their associated pharmacological activities.

## Conflict of interest

No conflict of interest is associated with this work.

**Table 2.** Nutritional and phytochemical composition of *Diplorhynchus condylocarpon*

Nutritional and phytochemical components	Value	Plant parts	Reference
14-hydroxy-(-)-akuammicine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Acid detergent bound protein (%)	1.5 – 1.7	Leaves and twigs	Dierenfeld <i>et al.</i> , 1995
Acid detergent fibre (%)	27.6 – 44.2	Leaves and twigs	Dierenfeld <i>et al.</i> , 1995; Becker and Lohrmann, 1992
Acid detergent lignin (g/100g)	17.0 – 19.2	Leaves	Becker and Lohrmann, 1992
Ash (%)	4.7 – 10.3	Leaves and twigs	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
á-tocopherols (ìg/g)	12.0 - 72.0	Leaves	Dierenfeld <i>et al.</i> , 1995
Calcium (g/100g)	1.1 – 1.5	Leaves	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Condylocarpine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Copper (ìg/g)	3.8	Leaves	Dierenfeld <i>et al.</i> , 1995
Crude protein (%)	6.5 – 11.0	Leaves and twigs	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Diplorrhincine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Diplorrhine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Iron (ìg/g)	45.0	Leaves	Dierenfeld <i>et al.</i> , 1995
Magnesium (g/100g)	0.3 – 0.5	Leaves	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Manganese (ìg/g)	60.8	Leaves	Dierenfeld <i>et al.</i> , 1995
Metabolizable energy (MJ/kg)	5.4 - 5.5	Leaves	Becker and Lohrmann, 1992
Mossambine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Neutral detergent fibre (%)	41.2 – 58.3	Leaves and twigs	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Nor-fluorocararine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Phosphorus (g/100g)	0.2	Leaves	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Potassium (g/100g)	0.5 - 1.2	Leaves	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Sodium (g/100g)	0.009 - 0.2	Leaves	Becker and Lohrmann, 1992; Dierenfeld <i>et al.</i> , 1995
Stemmadenine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Sulfuric acid lignin (%)	11.4 – 13.4	Leaves and twigs	Dierenfeld <i>et al.</i> , 1995
Tombozine	-	Root and stem bark	Stauffacher, 1961; Monseur <i>et al.</i> , 1962; Bisset, 1980
Water (%)	43.1 – 46.5	Leaves and twigs	Dierenfeld <i>et al.</i> , 1995
ã-tocopherols (ìg/g)	1.1 - 2.0	Leaves	Dierenfeld <i>et al.</i> , 1995
Zinc (ìg/g)	14.0	Leaves	Dierenfeld <i>et al.</i> , 1995

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