UNIVERSITY OF KWAZULU-NATAL

A SYSTEMATIC STUDY OF THE GENUS *RHOICISSUS* Planch. (VITACEAE) IN KWAZULU-NATAL

Sinethemba Faith Kunene

A SYSTEMATIC STUDY OF THE GENUS *RHOICISSUS* Planch. (VITACEAE) IN KWAZULU-NATAL

by

SINETHEMBA FAITH KUNENE

Submitted in fulfilment of the academic requirements for the degree of Master of Science

In the

School of Life Sciences
College of Agriculture, Engineering and Science

University of KwaZulu-Natal, Durban

DECEMEBER 2015

PREFACE

The experimental work described in this thesis was carried out in the School of Life Sciences, University of KwaZulu-Natal, Durban from January 2013 to December 2015, under the supervision of Prof Ashley Nicholas, Dr Yougasphree Naidoo and Mr. Richard Boon.

The study represents original work by the author and has not been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text

NOTE

The proposed new names and new combinations are not to be considered scientifically available for use as they have not yet been validly or effectively published under the Melbourne Code of International Nomenclature for Algae, Fungi and Plants

DECLARATION BY SUPERVISORS

We hereby declare that we acted as Supervisors for this MSc student:

Students Full Name: SINETHEMBA FAITH KUNENE

Student Number: 208 500 435

Thesis Title: A SYSTEMATIC STUDY OF THE GENUS *RHOICISSUS Planch*. (VITACEAE) IN KWAZULU-NATAL

Regular consultation took place between the student and ourselves throughout the investigation. We advised the student to the best of our ability and approved the final documentation for submission to the College of Agriculture, Engineering and Science Higher Degrees Office for examination by the University appointed Examiners.

As the candidate's supervisors we have approved this thesis/dissertation for submission

SUPERVISOR: ----------
PROFESSOR YOUGASPHREE NAIDOO

CO-SUPERVISOR: ----------
PROFESSOR ASHLEY NICHOLAS

CO-SUPERVISOR: ----------
MR RICHARD BOON

Plagiarism Declaration

I ……Student no……

1. Know that plagiarism is wrong. Plagiarism is to use another's work and to pretend that it is one's own.

2. Will use a recognised convention for citation and referencing. Each significant contribution to, and quotation in, my report/ project from the work, or works, of other people has been acknowledged through citation and reference.

3. This report / project is the original work completed by myself, It has not been in use in any submissions to the university or collage.

4. I have not allowed anyone to copy my work with the intention of passing it off as his or her own work.

_____ _____

Signature of student: Date

Abstract

The family Vitaceae, sometimes referred to as the grape family, comprises about 700 to 800 species and 13 to 14 genera, which includes *Rhoicissus* Planch. *Rhoicissus* contains 12 species all of which are described as climbing shrubs with tendrils that are without adhesive discs. This study was aimed at updating the taxonomy of the genus *Rhoicissus* in KwaZulu-Natal such that the names and number of species contained within the genus reflect the current findings. This dissertation looks primarily at the taxonomy of the leaves of the *Rhocissus* species of KwaZulu-Natal. The reason for this is that this work is meant to help conservationists, environmental managers, rangers, amateur botanists and others who will usually only encounters these species in their vegetative state. It is at this audience that this dissertation is aimed.
Rhoicissus tridentata was found to be a complex that is made up of three subspecies: *R. tridentata* subsp. *cuneifolia*; *R. tridentata* subsp. *diplonervia* and *R. tridentata* subsp. *tridentata*. Phenetic results, scatter plots and polygonal graphs did not all support the division of *R. digitata* into three subspecies. Morphological results, however, did show the slight differences between the subspecies of *R. digitata* which are *R. digitata* subsp. *digitata*; *R. digitata* subsp. *oravivens* and *R. digitata* subsp. *emarginata*. The other species of *Rhoicissus* (*R. revoilii*; *R. rhomboidea*; *R. sessilifolia* and *R. tomentosa*) were all found to be distinct species.

Dedication

This thesis is dedicated to my late grandmother who was always supportive of me. She was the true pillar of my strength. It is also in part dedicated to my family, who also has been supportive of my dreams.

Acknowledgements

I would like to thank and acknowledge Professor A. Nicholas for his continuous insight in regards to this study. For his patience, understanding and great knowledge when it came to the completion of this project. Dr. Y. Naidoo is thanked for her continuous and supportive role in bringing this project to fruition. Also thanks to Richard Boon for giving his time and knowledge at the beginning of this study. This made the identification and the grouping of the species in this study possible. Thanks to Dr. Elizabeth Retief for her dedication to the genus (*Rhoicissus*). Her dedication to this genus made the research of this study easier. I would also like to say thank you to Nhlanhla E. Khathi for his technical and practical guidance which enabled the documentation of specimens that would serve as evidence for field work. All this contributed immensely towards the completion of this study. Also, thanks to all my friends who helped me with all the field work that was conducted for this study.

TABLE OF CONTENTS

Chapter 1

Introduction

Introduction

The family Vitaceae, sometimes referred to as the grape family, comprises of 700 to 800 species in 13 to 14 genera including *Rhoicissus* Planch. (Rossetto *et al*., 2007). These are spread throughout the tropical and temperate regions of both hemispheres (Boon, 2010), distributed from Africa to Asia as well as in the Pacific islands (Rossetto *et al*., 2007; Siebert *et al*., 2001). The majority of these genera are said to be predominantly distributed in the tropical and subtropical regions (Rossetto *et al*., 2007). Studies show that the Vitaceae is most closely related to the monogeneric Leeaceae. This is based on the two families sharing the synapomorphies of the presence of raphides as well as pearl glands (Wen *et al*., 2007). Of the 14 genera worldwide, southern Africa harbours five of the genera and has a total of 53 known species (Boon, 2010). According to Siebert *et al*. (2001), Vitaceae is among the most prolific families with regard to endemism in Sekhukhuneland (South Africa), along with Araceae and Euphorbiaceae.

This family contains a group of genera which are perennial woody climbers with leaf-opposed tendrils which are sometimes modified to form inflorescences (Rossetto *et al*., 2001). Tendrils of this family, like the leaves, are always lateral organs of the stem and are usually the ones bearing flowers (Shah and Dave, 1970). These tendrils then undergo modification to form inflorescences (Rossetto *et al*., 2001). They then usually branch during this process so as to hold multiple inflorescences at a time (Rossetto *et al*., 2001).

Although, with more than ten genera, this family is not genetically varied as only three major clades were supported within the family (Wen *et al*., 2007).

- The first of the three clades contains *Ampelopsis* Michx, *Rhoicissus* Planch., the South American *Cissus strista* complex, *Parthenocissus* Planch., *Yua* C.L. Li, *Vitis* L., *Ampeloissus* Planch., as well as *Pterisanthers* Blume (Wen *et al*., 2007)
- The second clade consists of the core of the genus *Cissus* L.
- The third clade contains *Cayratia* Jussieu, *Tetrastigma* (Miquel) Planchon and *Cyphostemma* (Planchon) Alston.

Cissus is the largest of the 14 genera with approximately 350 species, distributed in the tropics worldwide (Ingrouille *et al.*, 2002). *Vitis* with about 70-80 species, is by far the most economically important genus in this family due to the inclusion of the species *Vitis vinifera* L.; the grape which is commercially valuable (Ingrouille *et al.*, 2002). *V*itis *vinifera* is used to make wine and according to Gerrath and Posluszny (2007) is important economically worldwide and socially to western society (Ingrouille *et al*., 2002). It is also used as a table fruit and when dried produces raisins (red grapes) and sultanas (white grapes).

Although a relatively small genus, *Rhoicissus* adds to the ecological importance of the grape family (Gerrath and Posluszny, 2007). *Rhoicissus* is native to eastern Africa, extending from the Arab regions in the northeast to as far south as South Africa (Gerrath *et al*., 2004). Traditionally it has been considered to contain 12 species all of which are described as climbing shrubs with tendrils that are without adhesive discs (Gerrath *et al*., 2004). The flowers in this genus usually lack tendrils and are crowded into shortly pedunculate cymes (Gerrath *et al*., 2004).

Species within the genus are often used in traditional herbal remedies. These species are used all over southern Africa especially as the expense of Western medicines and medical care makes the trade of traditional medicinal plants essential in this region (Hutchings and van Staden, 1994). Numerous surveys carried out in South Africa revealed that most of these remedies are used extensively to treat both human and animal diseases (Naidoo *et al*., 2006). Crude extracts from the leaves of *Rhoicissus digitata* (L.*f.*) Gilg & M. Brandt, roots of *Rhoicissus rhomboidea* (E. Mey. Ex Harv.) Planch. and *Rhoicissus tridentata* (L.*f.*) Wild & R.B. Drumm., as well as the leaves and stem of *Rhoicissus tomentosa* (Lam.) Wild & R.B. Drumm. have been shown to have significant inhibitory activity against cyclooxygenase, an inflammation inducing enzyme (Lin *et al*., 1999). Even though 29 crude extracts from different species were tested for the inhibitory activity of cyclooxygenase, only extracts from *R. rhomboidea* and *R. digitata* exhibited the greatest inhibitory activity (Lin *et al*., 1999). Extracts of *Rhoicissus tridentata* subsp. *cuneifolia* (Eckl. & Zeyh.) Urton on the other hand had the highest anti-proliferation percentage (96.27%) against HepG2 cancer cells (Opoku *et al*., 2000). Other species of *Rhoicissus* (*R. rhomboidea*, *R. digitata* as well as *R. tridentata*) were also found to have the ability of inhibiting the proliferation of these cancer cells when the crude extracts generated from their dried material were assayed (Opoku *et al*., 2000).

Extracts of *R. tridentata* have been found to have several compounds which are known for their health benefits, some of which support traditional healer's claims that extracts generated from this species promotes good health during pregnancy (Brookes and Katsoulis, 2006). Also, herbal concoctions generated from *R. tridentata* are fed to children in cases where their mothers are away from home for a long time (Lin *et al.*, 1999). Leaves and root tubers of the species of *Rhoicissus* are eaten by game animals; bush pigs and porcupines (Pooley, 1994). Birds and humans only eat the fruits of these species (Pooley, 1994).

Rhoicissus needs to be systematically studied because it has many valuable medicinal and ecological benefits that make this genus important. Knowing the correct name of each species would make the utilisation of their properties, both medicinal and ecological, more efficient and successful. Urgency in systematically analysing this genus should also be applied due to the potential cancer combating properties some species within the genus contain. This is particularly important as new and yet unnamed species of *Rhoicissus* has been proposed by Boon (2010). These unnamed species need to be confirmed and if valid need to be named and described before they can be properly investigated for medicinal properties on a scientific basis. The application of names for these new species are also required if we are to establish their conservation status.

This study thus aims to update the taxonomy of the genus *Rhoicissus* in southern Africa such that the names and number of species contained within the genus reflect current knowledge i.e. features and characteristics of the genus.

Chapter 2

Literature Review

2.1 Species of *Rhoicissus* in KwaZulu-Natal

2.1.1 *Rhoicissus digitata* (L.*f*) Gilg &M. Brandt

Taxonomically, *Rhoicissus digitata* (L.*f*) Gilg and Brandt (1911) (Wild and Drummond, 1963) has been described under six synonyms: *Rhus cirrhiflora* Gilg & Brandt; *Cissus thunbergii* Eckl. and Zeyh.; *Rhoicissus thunbergii* Planch.; *Rhoicissus cirrhiflora* (L.*f*) Gilg and Brandt as well as *Rhus cirrhiflorum* together with *Cissus cirrhiflora* (Wild and Drummond, 1963). The basionym is Rhus digitata L.*f*.

Rhoicissus digitata, is among the species in *Rhoicissus* that has looping lateral veins. The species name, *digitata*, was given to this species because of the arrangement of its leaflets around the base of the petiole, which resembles that of an open hand (Pooley, 1994; Boon, 2010). *Rhoicissus digitata* has compound leaves of 3 and 5 leaflets (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Retief *et al*., 2001; Boon, 2010). These different forms of compound leaves can occur on separate plants and sometimes on one plant there are more trifoliate than pentafoliate leaves. According to Boon (2010), the trifoliate leaves are often found on old growth while the pentafoliate leaves are mostly found on young growth of individual *R. digitata* plants. Terminating leaves of this species are oblanceolate to obovate in shape (Wild and Drummond, 1963; Retief *et al*., 2001; Boon, 2010) with some being emarginated. The leaflets are also smooth with entire margins, dark green on the adaxial surface and covered with fine russet hairs on the abaxial surface (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Retief *et al*., 2001; Boon, 2010).

This species can grow and reach 15m in length and is usually a woody climber or a scrambling vine in the riverine fringing vegetation, forest, forest margins, grasslands as well as valley bushveld (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Retief *et al*., 2001; Boon, 2010). Besides South Africa this species can be found in Swaziland and Mozambique (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Boon, 2010). In South Africa this species commonly occurs on the coastal dunes of both KwaZulu-Natal and the Eastern Cape (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). It also occurs in the Western Cape, Mpumalanga as well as the northern parts of South Africa (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

This species is commonly known as *Bobbejaandruif* and *vyfvingerdruif* in Afrikaans (A); baboon grape or the five-finger grape in English (E); *isaqoni* and *isaQoni esincinci* in iSiXhosa (X) and as *isisnwazi*, *umthwazi*, *umnangwana*, and *umphambane* in isiZulu (Z) (Pooley, 1994; Boon, 2010).

2.1.2 ***Rhoicissus revoilii* Planch.**

Rhoicissus sessilifolia was often mistakenly identified as *R. revoilii* and historically this species has been described with three synonyms. These are *Rhoicissus erythrodes* (Fresen) Planch. var. *ferruginea sensu* Eyles; *Rhoicissus schlechteri* Gilg & M. Brandt and *Rhoicissus sansibarensis* Gilg before it reverted to the oldest name: *R. revoilii* by Planchon (1887) (Wild and Drummond, 1963). In the past, it was believed that *R. schlechteri* was a form of *R. revoilii* which represented *R. revoilii* in the northern parts of South Africa, parts of Mozambique (which include Maputo) and parts of Zimbabwe (Wild and Drummond, 1963). *Rhoicissus revoilii* on the other hand is mostly represented or found in areas north of Zimbabwe (Wild and Drummond, 1963).

Rhoicissus revoilii is either a shrub, robust woody climber, a small tree or a creeper in mid to high altitude forests; forest margins; bushveld; riverine shrubs or woodlands (Wild and Drummond, 1963; Retief and Herman, 1997; Retief, *et al*., 2001; Boon, 2010). At higher altitudes it is often found in *Brachystegia* woodlands especially those found occurring on rocky hills (Wild and Drummond, 1963). *Rhoicissus revoilii* has trifoliate leaves with entire margins, looping lateral veins, domatia on lateral vein axils of the abaxial surface as well as being dark to dark green in colour (Wild and Drummond, 1963; Retief and Herman, 1997; Retief *et al.*, 2001; Boon, 2010). The lateral leaflets of this species are asymmetrical and it also produces edible fruits (Boon, 2010).

Rhoicissus revoilii is widely distributed not only, within the bounds of South Africa (KwaZulu-Natal and possibly the Eastern Cape Province) but Africa as a whole (Boon, 2010). This species can even be found in areas such as the Comoros, Saudi Arabia, Mozambique, Zimbabwe, Ghana, Congo as well as East Africa (Wild and Drummond, 1963; Boon, 2010).

Rhoicissus revoilii is commonly known as *bosdruif* (A); forest grape (E); *umbovu* in si Swati (S); *isaqoni* and *ingximba* (X) and *isinwasi* (Z).

2.1.3 ***Rhoicissus rhomboidea* (E. Mey. ex Harv.) Planch.**

The leaves of this species are so unique and well defined in the genus (*Rhoicissus*) in that they are always made up of rhomboid leaflets (assymetrical rhomboid for lateral leaflets) and almost always with six dentitions along the margin (Wild and Drummond, 1963; Pooley, 1994; Retief and Herman, 1997; Boon, 2010). Like most species in the genus, this species has trifoliate leaves and russet hairs on both surfaces of the leaflets (Wild and Drummond, 1963; Pooley, 1994; Retief and Herman, 1997; Boon, 2010). In texture, the leaves are leathery, glossy, dark green on the adaxial surface and without hair when fully grown (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

Rhoicissus rhomboidea is a canopy climber that can grow and reach a length of 20m (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). In terms of habitat, this species is found in forests, forest margins and thickets of areas such as KwaZulu-Natal, Eastern Cape as well as the north-west regions of South Africa (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). Other areas where it is found besides South Africa include Swaziland, Mozambique and Zimbabwe (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

In more common terms this species is usually referred to as *blinkblaarbosdruif* (A); *umbovu* (S); *umnxele*, *aqondi*, *umthwazi* (X); *isinwazi* (Z) and the glossy forest grape (E) (Pooley, 1994; Boon, 2010). The fruits of *R. rhomboidea* are eaten by both people and birds while its stem is used to make ropes (Pooley, 1994; Boon, 2010).

2.1.4 ***Rhoicissus schlechteri* Gilg & M. Brandt.**

Based on its morphology and ecology, in this thesis, *R. schlechteri* Gilg & M. Brand is treated as a distinct species separate from *R. revolii*. Unlike *R. revoilii*, *R. schlechteri* can be found climbing low altitude sand and coastal forests as well as bushvelds all of which have

been often found to occur in sandy areas (Boon, 2010). *Rhoicissus schlechteri* can also grow and reach lengths of 5m (Boon, 2010). Not only was this species misidentified as *R. revoilii* in the past (but sometimes in the present too), it is also often misclassified as *R. digitata*, another *Rhoicissus* species with looping lateral veins (Boon, 2010). Around St. Lucia as well as coastal Maputaland, *R. schlechteri* apparently grades into *R. digitata* (Boon, 2010). The trifoliate leaves of *R. schlechteri* have a lanceolate terminating leaflet and relatively sickle-shaped lateral leaflets with an asymmetrical base (Boon, 2010). Intermediate plants between *R. schlechteri* and *R. digitata* are however being mapped with *R. schlechteri* even though they have much broader, obovate leaflets with rounded apices (Boon, 2010). The overall narrow leaflets of *R. schlechteri* have a pale, to mid green, to slightly blue-green colour according to Boon (2010). On the abaxial surface, they are usually grey and have grey-brown hairs which are normally seen on young leaves (Boon, 2010). Commonly this species is referred to as *laevelddruif* in Afrikaans and as the lowveld grape in English (Boon, 2010).

2.1.5 ***Rhoicissus sessilifolia*** **Retief**

Rhoicissus rhomboidea has in the past, been mistaken for *R. sessilifolia* (Retief, 1980). The first record of *R. sessilifolia* in the National Herbarium is that of a specimen collected by Guy and Ward (62) at the Umlalazi Nature Reserve (Retief, 1980). Material of this species had been collected for 20 years, however, they were either identified as *R. rhomboidea* or *R. revoilii* or placed among the unnamed species (Retief, 1980). This occurred before the species was correctly identified and described by Retief (1980). *Rhoicissus sessilifolia* differs from the other species in the genus by being the only species with sessile trifoliate compound leaves that do not have hair on them (Retief, 1980; Boon, 2010). Also, the lateral and terminating leaflets have different shapes and sizes. The terminating leaflets have a lamina that is obovate to elliptic in shape while the lateral ones have a lamina that is ovate in shape (Retief, 1980). The number of dentition along the margin also differs between the lateral and terminating leaflets. Terminating leaflets are usually without dentitions along the margin but can sometimes have up to six dentitions, while the lateral leaflets usually have 1-3 dentitions along the margin (Retief, 1980; Boon, 2010). The branching stem of this species has very large lenticels that make the stem appear extensively corky and warty (Retief, 1980; Boon

2010). *Rhoicissus sessilifolia* is a climber in the dune and coastal forests of KwaZulu-Natal (Retief, 1980; Boon, 2010). This species occurs in a restricted area of the coastal dune forests of KwaZulu-Natal making it endemic to this area (Retief, 1980). This species can be found distributed from Mtunzini and Kosi Bay, and possibly extending into southern Mozambique.

It is commonly known as *kusbosdruif* (A) and the coastal grape (E) (Retief, 1980; Boon, 2010).

2.1.6 ***Rhoicissus tomentosa*** **(Lam.) Wild & R.B. Drumm.**

The leaves of this of species are unique in the genus as these leaves are the only ones with lobes along the margin, simple in form and 3-nerved at the base (Wild and Drummond, 1963; Pooley, 1994; Retief and Herman, 1997; Boon, 2010). Some leaves of the same species can be extremely lobed to the extent that they appear 3-partite, i.e. one leaf having three lobes, with one for each nerve (Wild and Drummond, 1963). The leaves are also dark green on the adaxial surface, covered with rusty velvet hairs on the abaxial surface. Lobes can sometimes be kidney-shaped (reniform) (Wild and Drummond, 1963; Pooley, 1994; Retief and Herman, 1997; Retief, 2000; Boon, 2010). The rusty velvety hairs are also found covering young stems and tendrils, but are later lost on stems as they mature and are replaced by raised dots known as lenticels (Pooley, 1994; Boon, 2010). Unlike the young stems, the main stem of this species has a rough bark, and is broad and woody (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). In terms of habit, *R. tomentosa* can either be a scrambling shrub or a canopy climber that can reach up to 20m in length (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Boon, 2010). This high climbing liana is found in forests (fringing forests or in gaps in closed forests) as well as on riverine bushes (Pooley, 1994; Retief and Jaarsveld, 1997; Boon, 2010). Specifically in South Africa it can be found from the Western Cape to Mpumalanga Province including KwaZulu-Natal and the Eastern Cape (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Boon, 2010).

Ecologically this species is significant as its swollen tubers are eaten by porcupines, baboons and bush pigs, while its leaves are browsed by game animals such as black rhino (Pooley, 1994; Boon, 2010). The swollen tubers have red outer flesh (Pooley, 1994; Boon, 2010). The

fruits of *R. tomentosa* are eaten by birds, mammals and people, and grown as an attractive vigorous climber as a result it makes a good screen patio cover (Pooley, 1994; Boon, 2010). Compared to the other species of the genus, *R. tomentosa* is the most common woody climber in coastal and dune forests of KwaZulu-Natal. *Rhoicissus tomentosa* is almost always present in forests suitable for the species of *Rhoicissus*, either alone; with another or multiple other species of *Rhoicissus*. The other species found distributed among the individuals of *R. tomentosa* in these forests depends on the geographical location of the forest.

*R*hoicissus *tomentosa* (Lam.) Wild & Drummond is generally known as the common wild grape in English; *umbovu* in isiSwati; *isaqoni* and *uchithibhunga* in isiXhosa; *umthwazi* and *isinwazi* in isiZulu and *gewone bosdruif* in Afrikaans (Boon, 2010).

2.1.7 ***Rhoicissus tridentata*** **(L.f) Wild & Drummond**

Rhoicissus tridentata, like *R. tomentosa*, also tolerates an extensive range of climatic conditions which include annual rainfall ranging from 380-1 500 mm (Wild and Drummond, 1963). The wide tolerance of both climatic conditions and altitude by this species might explain its varied distribution in a variety of habitats including habitats such as grasslands. This species can be found distributed in dune forests, forest margins and grassy hillsides, thickets as well as in woodlands (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). *Rhoicissus tridentata* can be seen in all these habitats particularly here in South African provinces such as KwaZulu-Natal; Eastern Cape; Western Cape; Free State; Northern Cape as well as the North West Province (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). In these habitats, this species flowers are visited by sunbirds and its fruits are eaten by both birds and people (Pooley, 1994; Boon, 2010). This species can be found distributed as far north as Arabia and is also found all across central Africa to Ethiopia (Wild and Drummond, 1963). In upland northern Nigeria, *R. tridentata* grows as a trailer in the rocky areas of savannas (Wild and Drummond, 1963). This species can also be found in Angola, Mozambique; Lesotho; Swaziland and South Africa (Wild and Drummond, 1963).

Medicinally this species is extensively used by healers in the traditional medicine trade. Concoctions generated from its plant material can be found in most vending stores around Johannesburg (Katsoulis *et al*., 2002). Reports of *R. tridentata* (L.*f*) Wild and Drumm. subsp. *cuneifolia* (Eckl. and Zehr.) N.R. Urton (1963) is that it is used as a herbal oxytocics by nearly 80% of the South African Zulu and Xhosa populations, and it is among the six most frequently used species in such herbal remedies (Brookes and Katsoulis, 2006). In general, *R. tridentata* and its subspecies are used to treat various ailments, and these include kidney and bladder complications, stomach ailments, colds, infertility as well as to facilitate childbirth (Boon, 2010). *Rhoicissus tridentata* subsp. *cuneifolia* was also found to have higher antineoplastic activity against the HepG2 cell line, which are cancer cells, than the other nine traditional Zulu medicinal plants species in which the crude extract were also prepared from and their antineoplastic activity tested against these cells (Opoku *et al*., 2000). All these findings have crucial implications for cancer treatment in the future. While it is the roots and tubers that are mainly used by traditional healers to prepare concoctions, which are then used by their patients, to treat various ailments, the structure of the leaves of *R. tridentata* as a whole remain the most interesting taxonomic aspect about this species.

Firstly, the leaves of *R. tridentata* are trifoliate with a wedge-shaped terminating leaflet and a few to multiple dentations along the margin (Pooley, 1994; Boon, 2010). The size of the leaflets as well as the number and depth of toothing along the leaflet margin is highly variable (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). *R*hoicissus *tridentata* subsp. *tridentata* has extremely small leaves and has entire or 3-4 dentations on the margin of each leaflet (Wild and Drummond, 1963; Urton *et al*., 1986; Pooley, 1994; Boon, 2010). According to Urton *et al*. (1986), the reduction in leaf size, depth and degree of dentition as well as the increased density of indumentum observed in this subspecies are all ecological adaptations as it usually occupies the most arid regions. *Rhoicissus tridenatata* subsp. *tridentata* chiefly grows in sandy soils of permanent coastal dune bushes (Urton *et al*., 1986). It even extends inland to the southern Eastern Cape and into the Karoo, where it forms part of the dry Valley Bushveld vegetation (Urton *et al*., 1986). The leaves of *R. tridentata* subsp. *cuneifolia* on the other hand are often large, with 10-12 dentations along the margin of the terminating leaflets (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). This subspecies also has a wider distribution range than *R. tridentata* subsp. *tridentata* as it

extends from the Eastern Cape right through to the northern limits of South Africa (Urton *et al*., 1986). This might explain why *R. tridentata* subsp. *cuneifolia* is the most common form in South Africa (Wild and Drummond, 1963). In these areas it is found scrambling freely over the vegetation along forest margins or in high bushes (Urton *et al*., 1986). Generally, the leaf size and the density of indumentum decrease from the north to the south throughout the distribution range and as a result, the southern forms are usually without hair i.e. glabrescent (Urton *et al*., 1986). A wide variation in this character can be seen as the species of *R. tridentata* have been reported to have tolarence of a wide range of altitudes ranging from 0 to 2000m (Wild and Drummond, 1963; Boon, 2010).

Also, the general trend is that *R. tridentata* subsp. *tridentata* represents the southern group while *R. tridentata* subsp. *cuneifolia* represents the northern group (Urton *et al*., 1986). The two groups are, however, sympatric and where this occurs (e.g. Grahamstown), the greatest diversity of form is observed, and intermediates of the two subspecies are encountered which, indicates hybridisation (Urton *et al*., 1986). The high level of hybridisation shown by the *Rhoicissus tridentata* complex might explain why there has been six different names given to *R. tridentata* before the nomenclature was corrected and stabalised by Wild and Drummond (1963). *Rhoicissus tridentata* has the following synonymy: *Cissus cuneifolia* Eckl. & Zeyh; *Vitis erythrodes* Fresen; *Rhoicissus cuneifolia* (Eckl. & Zeyh.) Planch.; *Rhoicissus erythrodes* (Fresen) Planch. as well as *Rhoicissus cirrhiflora* (L.*f*.) Gilg & M. Brandt.

2.1.8 General Observations

Based on the specimens used for analysing the complex relations of *Rhoicissus* species, it became clear that the northern areas of KwaZulu-Natal (i.e. the Zululand area), might have ideal conditions for both the existence and growth of most of the species within this genus.

Almost all the species within *Rhoicissus* have been collected from this area, although some species were collected in greater numbers in this area than others. Such is *R. sessilifolia*, with all the specimens (18 in total) collected from Zululand as well as its surrounding areas. Another is *R. tomentosa*, where a total of 8 out of the 12 specimens analysed were collected

from Zululand. *Rhoicissus tridentata* has shown an interesting observation, from the collection records as well as upon observationin the coastal forests explored during the course of this study. *Rhoicissus tridentata* has shown, in KwaZulu-Natal, a pattern of primarily being distributed along the Zululand area as well as its surrounding areas. Further, the shape of the leaflets of this species differ from different parts of KwaZulu-Natal in that specimens collected from the Drakensberg area differ from those collected around Mtubatuba.

Chapter 3

The Leaves of the Species of *Rhoicissus*

Generally leaves are important in plants as they help to keep the plants alive through photosynthesis. For the species of *Rhoicissus*, the leaves are especially important because they are used in identifying and classifying these species. The flowers of the species of *Rhoicissus* are microscopically small to be used for identification purposes unlike those of most species in other genera. Usually flowers are used for the identification and classification of most plants, however, leaf characters are used to identify and classify the species of *Rhoicissus*. Besides being too small and uniform, the fact that petals and sepals fall off early often results in the use of flowers to identify specimens, being difficult (Pers. comm. Richard Boon). Also, the flowers are reportedly similar between the species of *Rhoicissus* and can hardly be used for separating the different species of this genus. More luck may be had with fruit if it is present.

The use of leaves for these purposes is not difficult because they are highly diagnostic i.e. extremely definitive as well as unique. Although some species in this genus share a few characteristics on the actual leaves, they are, however, still found to be uniquely different for each species. Different forms of leaves are observed in these species.

3.1 Types of leaves

Primarily there are two types of leaves, simple as well as compound leaves. Simple leaves (Figure 1) have only one blade that is not divided into leaflets. In this type of leaf form, the midrib is not divided to form a rachis. *Rhoicissus tomentosa* is the only species which has simple leaves. The rest of the species have compound leaves, most of which are trifoliate. Compound leaves (Figure 2) are those that have their single leaf blades divided into several leaflets. This type of leaf has the midrib as the main stalk that supports and connects the leaflets to the petiole. The leaflets can either be two or more, extremely tiny or larger in size. The majority of *Rhoicissus* species have three leaflets i.e. trifoliate leaflets. These species are *R. digitata* (L.*f.*) Gilg & Brandt subsp. *digitata*; *R. digitata* subsp. *nov.* a; *R. digitata* subsp. *nov.* b; *R. revoilii*; *R. rhomboidea*; *R. schlechteri*; *R. sessilifolia*; *R. tridentata* subsp.*nov*. c; *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*. *Rhoicissus digitata* subsp. *digitata* can sometimes have five leaflets in which case the leaves are referred to as being pentafoliate. In addition, the

leaflets originate from the single point like the fingers around the palm of a hand, which is why it is said to be digitate.

Figure 1: An example of simple leaves observed on the species of *Rhoicissus tomentosa*. Note the leaves opposite the inflorescences are very compact and not tendril-like (x 0.73).

Figure 2: An example of a compound leaf from *R. tridentata* subsp. *cuneifolia*. Note the large leaf opposite, to the more or less globose fruit (x 0.93).

3.1.1 Terminating and lateral leaflets

When the leaves are compound, they become divided into lateral and terminating leaflets. This classification of the leaflets is based on their position on the actual leaves. Lateral leaflets are positioned on either sides of the terminating leaflet (Figure 3 a), while terminating leaflets are found at the end of the actual leaves (Figure 3b). All the species of *Rhoicissus* mentioned above, with compound leaves, have both these leaflet types.

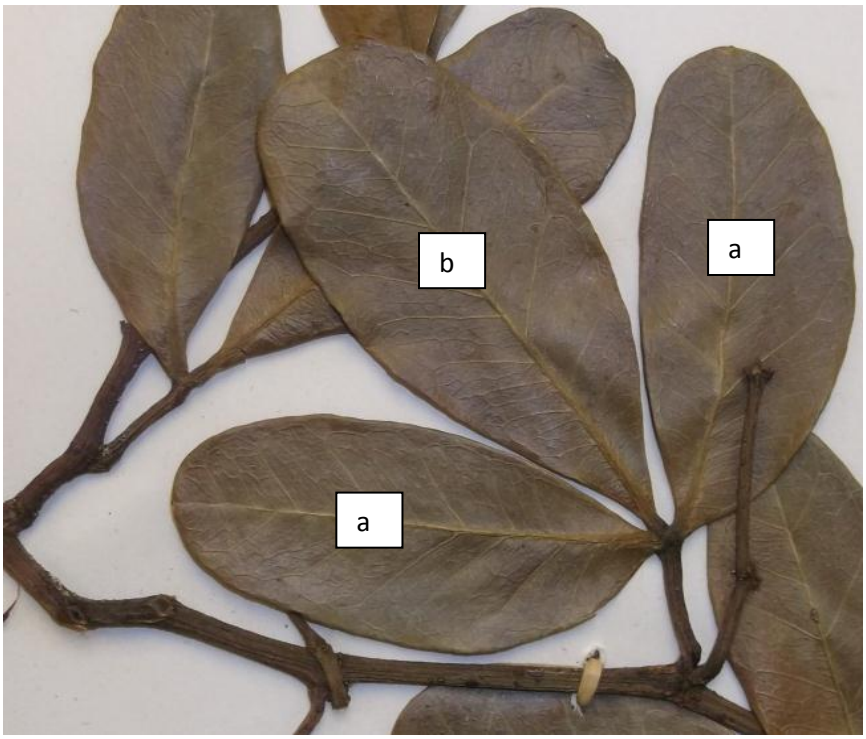

Figure 3: An example of lateral (a) and terminating (b) leaflets in *R. digitata* subsp. *digitata* (x 1.35).

3.2 Petiolate and sessile leaves

Leaves can be supported and connected to the rest of the plant by means of a petiole. When such an organ is present the leaf is said to be petiolate (Figure 4). When a leaf is directly connected to the stem and the rest of the plant without a petiole, it is then said to be sessile (Figure 5). Almost all the leaves of *Rhoicissus* species are petiolate. *Rhoicissus sessilifolia* is the only species with sessile leaves (Figure 5). The leaflets of *R. sessilifolia* do have petiolules. The leaves of *R. rhomboidea* have the longest petioles of all the species of *Rhoicissus*.

Figure 4: *Rhoicissus rhomboidea* with a petiolate leaf (x 0.98).

Figure 5: Sessile leaves of in *R. sessilifolia*. The terminal leaflets in this species have long petiolules (x 0.64).

3.3 Types of margins on the leaflets

The margins of the leaves of *Rhoicissus* are diverse in that both entire and dentate margins are observed on the leaves. Entire margins (Figure 6) are those which are without lobes and/ or teeth. Entire margins can be observed on *R. digitata* subsp. *digitata; R. digitata* subsp. *nov.* a; *R. digitata* subsp. *nov.* b; *R. revoilii* as well as *R. schlechteri*.

Rhoicissus tomentosa is the only species not only with simple leaves but also with lobes (Figure 7) around the margin. The remaining species: *R. rhomboidea*; *R. sessilifolia*; *R. tridentata* subsp. *nov*. c; *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*, have toothed margins (Figure 8). There are, however, differences between the margins of these species in that they are not the same. This type of margin (toothed margin) is even different between the species of the *R. tridentata* complex. *Rhoicissus tridentata* subsp. *nov.* c has the deepest dentitions in comparison to the species of the complex. The teeth on the leaflets of *R. tridentata* subsp. *tridentata* are the shallowest and sometimes absent. The leaves of *R. tridentata* subsp. *cuneifolia* have medium sized teeth. For *R. rhomboidea*, the teeth are usually six, but can be eight at times when the leaflets are large. The teeth when present are found at the end of the lateral veins that originates from the midrib.

Figure 6: The leaflet of *R. digitata* subsp. *digitata* with entire margins (x 1.08).

Figure 7: The simple leaf of *R. tomentosa* with lobes around the margin (x 1.01).

Figure 8: A leaf with toothed margins on its leaflets. In this figure though, the toothed margins are extensively deep in the leaflets of *R. tridentata* subsp. *nov*. c (x 0.85).

3.4 Leaf venation

There are two distinct groups when it comes to the leaf venation in the species of *Rhoicissus*. There are those species with looping lateral veins, and those without. Looping lateral veins are those which branch out from the midrib, do not reach the leaf margin but instead connect to one another about 1mm away from the margin (Figure 9). Those without them reach the leaf margin without being connected to one another, other than at the midrib (Figure 10). The leaves without the looping veins terminate with dentitions while those with looping veins have entire margins. Those species with looping veins are *R. digitata* subsp. *digitata*; *R. digitata* subsp. *nov.* a; *R. digitata* subsp. *nov.* b; *R. revoilii* as well as *R. schlechteri*. Those without looping veins include *R. rhomboidea*; *R. sessilifolia*; *R. tridentata* subsp. c; *R. tridentata* subsp. *cuneifolia* as well as *R. tridentata* subsp. *tridentata*. Of the species of *Rhoicissus* without looping lateral veins, *R. tomentosa* is the only species with lobes and not dentitions on the margin.

Figure 9: A leaflet with looping veins which belongs to *R. digitata* subsp. *digitata* (with trifoliate leaves) (x 1.88).

Figure 10: A leaflet of *R. tridentata* subsp. *cuneifolia* with veins that terminate in a tooth (x 1.61).

3.5 The shapes of the leaves of *Rhoicissus*

For all the species of *Rhoicissus* with compound leaves (except *R. digitata* subsp. *digitata* with pentamerous leaflets) the lateral and terminating leaflets have the same shape. The lateral leaflets, however, have an asymmetrical shape of the terminating leaflets, except those of *R. sessilifolia* which have a totally different shape to those of the terminating leaflets of the same species. As the result of the lateral leaflets being asymmetrical, the shapes of the leaves of *Rhoicissus* will be obtained from the terminating leaflets.

The subspecies of *R. digitata* have leaflets that are similarly shaped; the major difference can be seen on the apices of these leaflets. The leaflets of *R. digitata* subsp. *digitata* (those with trifoliate leaflets); *R. digitata* subsp. a and *R. digitata* subsp.*nov*. b all have an oblong-shape (Figure 11). Those individuals of *R. digitata* subsp. *digitata* which are pentafoliate as well as those of *R. revoilii* have elliptic-shaped leaves (Figure 12). The leaflets of *R. rhomboidea* are rhomboid (Figure 13). A lanceolate to falcate-shape can be seen in leaflets of *R. schlechteri* (Figure 12). The terminating leaflets of *R. sessilifolia* have an elliptic-shape (Figure 14a), while an orbicular-shape can be seen on (Figure 14b) the lateral leaflets of this species. The leaves of

R. tomentosa have a deltoid-shape (Figure 15). The leaflets of the species of the *R. tridentata* complex have an overall wedge-shape (Figure 16). The terminating leaflets of *R. tridentata* subsp. *nov*. c are have an averall obovate-shape, as do those of *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*.

Figure 11: The leaves with the leaflets that are oblong in shape. These leaflets belong to *R. digitata* subsp. *nov*. a, a new subspecies of *Rhoicissus* (x 1.33).

Figure 12: The leaves of *R. schlechteri* with a lanceolate terminating leaflet (x 0.82).

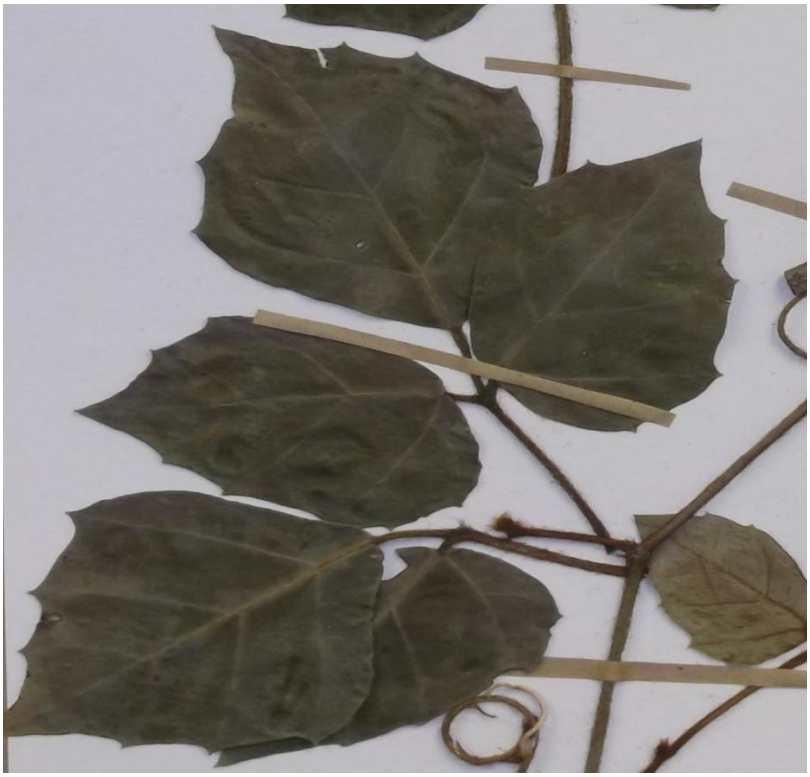

Figure 13: The leaves of *R. rhomboidea* with rhomboid terminating leaves (x 0.92).

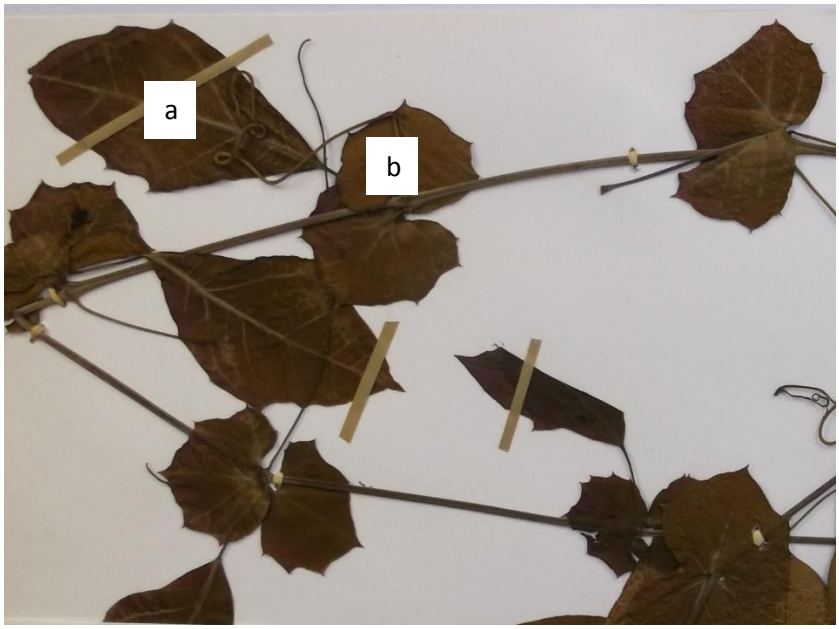

Figure 14: The leaves of *R. sessilifolia* with elliptic terminating leaflets (a) and orbicular lateral leaflets (b) (x 0.55).

Figure 15: The leaves of *R. tomentosa* with a deltoid-shape (x 0.73).

Figure 16: The wedge-shaped leaf found in species of the *R. tridentata* complex (*R. tridentata* subsp. *cuneifolia*) (x 1.14).

3.6 Types of apices on the terminating leaflets

The apices of the leaves and leaflets of the species of *Rhoicissus* are extremely diverse, as much as five types are observed. Firstly, the general type observed on the terminating leaflets of *R. digitata* subsp. *digitata* is rounded (for the species with trifoliate leaves), and tapering (for the species with pentafoliate leaves) (Figures 17 and 18, respectively). The type of apex observed on most of the terminating leaflets of *R. digitata* subsp. *nov*. a, is rounded (Figure 17). The apices on the leaflets of *R. digitata* subsp. *nov*. a are, however, wider than those observed on the leaflets of *R. digitata* subsp. *digitata* (the one with trifoliate leaflets). Most of the terminating leaflets observed on the leaves of *R. digitata* subsp. *nov*. b are emarginated (Figure 19). The apices on the terminating leaflets of both *R. revoilii* and *R. schlechteri* are tapering (Figure 18) with no teeth at the end. The apices on the leaflets of *R. sessilifolia* are rounded while the simple leaves

of *R. tomentosa* have tapering apices. The apices observed on the species of the *R. tridentata* complex are tapering; slightly tapering, as well as truncate for *R. tridentata* subsp. *nov.* c; *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*, respectively.

Figure 17: The leaflet of *R. digitata* subsp. *digitata* with a rounded apex (x 1.46).

Figure 18: The leaflet of *R. schlechteri* with a tapering apex (x 1.40).

Figure19: Terminal leaflet of *R.digitata* subsp. *nov*. b with with an emarginated apex (x 1.20).

3.7 Types of apices on the lateral leaflets

The apices that occur on the lateral leaflets are also varied as much as those that occur on the terminating leaflets of this genus. The lateral leaflets of *R. digitata* subsp. *digitata* (individuals with trifoliate leaves) have rounded apices (Figure 17) while tapering apices (Figure 18) can be seen on leaflets of the individuals with pentafoliate leaves. The lateral leaflets of the new subspecies of *R. digitata* have rounded apices (Figure 17) for both subspecies. Those of *R. revoilii*; *R. rhomboidea* and *R. schlechteri* have tapering (Figure 18) apices while the lateral leaflets of *R. rhomboidea* have a single dentition. *Rhoicissus sessilifolia* have rounded apices. The subspecies of the *R. tridentata* complex (*R. tridentata* subsp. *nov*. c; *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*) have tapering apices (Figure 18) all of which terminate with teeth.

3.8 Types of leaf bases on the terminating leaflets

When it comes to the bases of the terminating leaflets of *Rhoicissus*, all but two species have tapering bases (Figure 20). These two species are *R. sessilifolia* as well as *R. tomentosa* with rounded (Figure 21) and broadly truncate-shaped bases (Figure 22), respectively. The bases for *R. tomentosa* can, however, vary as truncate, cordate and rounded bases are found.

Figure 20: A leaflet with a tapering base of *R. schlechteri* (x 2).

Figure 21: The rounded bases of the leaflets of *R. sessilifolia* (x 0.88).

Figure 22: The leaf of *R. tomentosa* with a broad truncate-shaped base (x 1.56).

3.9 The leaf bases of the lateral leaflets

The bases of the lateral leaflets are so varied for the species of *Rhoicissus* such that, even the two sides of the same lateral leaflet exhibit two types of bases. The majority of the species were found to have lateral leaflets that were rounded on one side and tapering on the other (Figure 23). Generally, the rounded side of the base of the lateral or side leaflet is found on the side that is away from the terminating leaflet, while the tapering side of the lateral or side leaflet is found on the side that is toward the terminating leaflet. Species in which both the rounded and tapering bases are observed are *R. digitata* subsp. *digitata* (trifoliate leaves); *R. digitata* subsp. *nov* a; *R. digitata* subsp. *nov*. b as well as *R. revoilii*.

Another combination of the bases that was observed on the lateral leaflets was a tapering base on one side of the leaflet and a truncate-shaped base on the other side of the same leaflet (Figure

24). Again, the tapering side of the base of the side leaflet was found towards the terminating leaflet while the truncate-shaped side of the side leaflet was away from it. This combination was observed to have occurred on only two species namely *R. rhomboidea* as well as *R. tridentata* subsp. *nov* c.

The lateral leaflets of *R. tridentata* subsp. *cuneifolia* showed an even greater diversity when it came to the bases of these leaflets. Some lateral leaflets of this subspecies were observed to be tapering on one side and rounded (Figure 23) on the other, and others to be tapering on one side and truncate-shaped on the other (Figure 24).

Rhoicissus digitata subsp. *digitata* (pentafoliate leaves); *R. schlechteri* as well as *R. tridentata* subsp. *tridentata* all had tapering lateral leaflets at the base (Figure 20). The lateral leaves of *R. schlechteri* were still, however, observed to be extremely asymmetrical at the base despite having only one leaf base type. *Rhoicissus sessilifolia* is the only species in this genus with lateral leaflets with rounded bases (Figure 21).

This high variation in the lateral leaflets of the species of *Rhoicissus* might be due to these leaflets being asymmetrical.

Figure 23: The base of a leaflet of *R. digitata* subsp. *emarginata* with an asymmetrical base rounded on ones side and tapering on the other (x 2.4).

Figure 24: Leaflets of *R. rhomboidea* with a tapering and truncated base on either side of the leaflets (x 1.56).

3.10 The presence and absence of hairs on the leaves

The presence of hair on the leaves of the species of *Rhoicissus* is a common occurrence. There are, however, differences that might be observed among the hairs on the leaves of the different species. Leaves without hairs have also been observed in some species, such as those of the two new subspecies of *R. digitata* (*R. digitata* subsp. *nov* a and *R. digitata* subsp. *nov*. b) as well as R. *digitata* subsp. *digitata* (Figure 26) which are without rustic, hirsute hairs on their leaves but rather have a very thick layer of wax (cuticle) on their epidermis. The thickness of the wax depends on the type of habitat the subspecies is growing in, as well as where it is located within that habitat. For these subspecies, the waxy layer thickens as they are exposed to dry conditions such as the sun, wind and sandy soil. The waxy layer is not as thick for the individuals of the subspecies which are found growing in moist and shady areas, especially where the soil can retain water. All these leaves are, however, glossy wherever these subspecies are growing.

Rhoicissus revoilii has tiny hairs on the surface of its leaves that are whitish in colour. *Rhoicissus rhomboidea* has hair on its leaves but its density varies based on the habitat it is growing in, as well as on how old the leaves are. Generally, the leaves of this species have white to brownish hairs on their surfaces. Short white hairs are often seen on the old leaves of the species growing

on the borders of forests (Figure 25). The young leaves of these species have long brownish and white hairs that are numerous and have leaves that are clustered together. *Rhoicissus rhomboidea* that grow within forests have extensively reduced hairs on their surfaces and longer internodes. These species are also highly branched unlike their counterparts that grow in sun rich habitats. *Rhoicissus schlechteri* and *R. sessilifolia* have leaves with short, white hairs.

The leaves of *R. tomentosa* have rustic hairs on their surfaces regardless of the habitat individuals are found growing in (Figure 27). The difference between the species found growing in dry habitats and those found growing in moist habitats is in the size of the leaves. The leaves of the species found growing within forests are large, and may become semi divided into three "subleaflets", each one with its own nerve from the base. Some of the leaves of the species found growing in the borders of forests are smaller, sometimes with shorter whitish hair and are not divided. The hairs on the leaves of *R. tomentosa* like those observed on the leaves of *R. rhomboidea* also start from the petioles and extend to the leaves or leaflets. The internodes on the species found growing within forests are also longer than their counterparts found growing on the borders of forests.

The *Rhoicissus tridentata* complex exhibits varying degrees of hairs on the surface of their leaves. Firstly, they all have hairs on their leaves. Secondly, *R. tridentata* subsp. *tridentata* has a high density of hair on its surface and this might be due to this subspecies being mainly found in grasslands. This might occur as a result of the excessive heat experienced at this environment. The excessive hair on the leaflet surfaces might be there to deflect sunlight thus preventing water loss (transpiration). *Rhoicissus tridentata* subsp. *nov.* c has tiny whitish hairs on its leaves especially those found growing within forests. The leaflets of this subspecies also grow to great lengths like the leaves of *R. tomentosa*; despite being trifoliate. The leaves of *Rhoicissus tridentata* subsp. *nov* c when found growing in dry habitats are much smaller and have a high density of white hair. This might be a mechanism by which these subspecies deflect the sun in order to prevent water loss. *Rhoicissus tridentata* subsp. *cuneifolia* has short white hairs on the adaxial surface.

Figure 25: White hairs on the young leaves and stem of *R. rhomboidea*, while the mature leaves are without hair on their surface.

Figure 26: The glossy leaves of *R. digitata* subsp. *digitata* growing on the floor of the Mkhomazi Forest.

Figure 27: Leaves of *R. tomentosa* with rustic red hairs on its surface as well as on its stem.

Chapter 4

Distribution and Ecology

The species of *Rhoicissus* are mostly found distributed in coastal dune forests; forest margins; shrublands; grasslands as well as coastal forests of southern Africa (Wild and Drummond, 1963; Pooley, 1994 and Boon, 2010). All the species of *Rhoicissus* have been reported to have been found along the coastal regions of KwaZulu-Natal (Wild and Drummond, 1963; Pooley, 1994 and Boon, 2010). Other areas of southern Africa, namely Zimbabwe; Mozambique and the North West Province; Western Cape and Eastern Cape of South Africa have only a few species of this genus found in their forests and grasslands. *Rhoicissus revoilii* can be found in the forests of Zimbabwe and the North West Province of South Africa. *Rhoicissus tridentata* subsp. *tridentata* has been collected in the forests and shrublands of the Eastern Cape Province. In all these habitats and locations, these species are mainly climbers, but can sometimes be shrubs as well as small trees (especially the subspecies of the *R. tridentata* complex) (Wild and Drummond, 1963; Pooley, 1994 and Boon, 2010).

Species occuring elsewhere in the South Africa include: *Rhocissus sekhukhuniensis* Retief, Siebert & A.E. van Wyk; *Rhoicissus laetans* Retief; and *Rhoicissus kougabergensis* Retief & van Jaars. these are all narrow endemics that occur outside the province of KwaZulu-Natal and will not be dealt with here.

As primary climbers, many species of *Rhoicissus* need trees (tall and short) to survive in the different types of habitats that they are found in. The environments in which they are found are currently under threats for various reasons which will be discussed below. In South Africa in this century alone, there has been an extensive loss of biodiversity of some habitats through their degradation (Neumann *et al*., 2010). Due to this, the life history characters, like reproductive traits, have fallen under strong selection pressure in order to maximise the fitness of the species for survival in particular habitats, while distinct sets of reproductive traits have changed as a result of the changing environmental conditions, altered pollinators and dispersers (Griffiths and Lawes, 2006). The changing environmental conditions can be caused by increased agricultural activities as well as urban development while climate change poses an even greater threat to the environment (Neumann *et al*., 2010). The change in the environment is a global issue as the attainment of natural resources for human-use has caused various damages to the environment such as its fragmentation, degradation as well as habitat loss (Grainger, 2011). As for cultivation, as a result of an increase in the human population, it now takes up the grazing lands from the

livestock which are in turn left to graze on marginal land (Mpanza *et al*., 2009). Livestock grazing has resulted in the disturbance of the understory which greatly influences the plant diversity in these forests (Mpanza *et al*., 2009). Livestock grazing in these forests affects the species diversity through changing the vegetation structure, species composition, species abundance as well as plant nitrogen cycling and plant productivity (Mpanza *et al*., 2009). The balance between the shade-tolerant and intolerant species which occur within forests have obviously been affected due to fragmentation as a result of deforestation (West *et al*., 2000). Deforestation is a division of a continuous forest into small patches which end up leaving islands of natural habitats with small interior areas still functioning (Weiermans and van Aarde, 2003). Afforestation (artificial forests) poses an even greater threat to the South African grasslands as the most suitable areas for timber plantations overlap with the country's regions which have the highest grassland biodiversity (Lipsey and Hockey, 2010). Approximately 3.3% (which is about 11, 500 km^2) have been cleared for the plantation of exotic trees since 2004 (Lipsey and Hockey, 2010).

This increase in the degradation of natural resources due to human-induced disturbances has resulted in numerous efforts directed at determining the consequences of these disturbances which reflect high environmental awareness (Ferreira and van Aarde, 2000). All surface vegetation is removed during the mining of coastal sand dunes which then leads to the disappearance of the associated animal life of the dunes and thus can be considered as a discrete disturbance event (van Aarde *et al*., 1996). The explicit aim of improving ecosystem structure and function after a modulation change in an ecosystem, due to a discrete disturbance event is known as rehabilitation (van Aarde *et al*., 1996). In the mining business (dune mining especially) ecological restoration is often a legally binding requirement of the mining permission as it is viewed to be integral in the conservation of biological diversity and sustainable development (Grainger, 2011). Ecological restoration involves the transformation of the disturbed habitat in a predetermined direction which is done through rehabilitation and restoration efforts (van Aarde *et al*., 1996). The rehabilitation of coastal dune is of great importance to *Rhoicissus* as the majority of *Rhoicissus* species grow in this coastal zone.

Thus change in the vegetation type in an environment can occur, such as in mesic savannas (such as those in the Hluhluwe-Umfolozi Park in KwaZulu-Natal) where the vegetation can shift from

open grassland to *Acacia* woodland to closed canopy broadleaf thickets all within 40 years (Skowno and Bond, 2003). This acute change in the environment results in significant change in the animal life that is associated with the environment (Skowno and Bond, 2003). Anthropogenic burning, farming, felling and pastoralism are thought to have influenced the recent spread of grasslands at the expense of forests (West *et al*., 2000). To add to this, there has been an increase in the frequency of fires as well as burning during winter months which are thought to have influenced the observed decline of small forest patches in grassland areas (Lawes *et al*., 2004) thus drastically affecting *Rhoicissus* populations which rely on these forest patches to grow.

Grasslands also face difficulties especially when they are replaced by artificial forests which make it impossible for the grass species to recolonise these areas because the forest matrix is impermeable by nature, to these non-forest species (Lipsey and Hockey, 2010). Grasslands are also being extensively transformed and fragmented for human settlement and agricultural activities (as they are very productive) as a result, only about 53% of the biome remains in a semi-pristine state (Lipsey and Hockey, 2010). Most of the 53% is contained in livestock farms and rangelands which is unfortunate because in South Africa they contain endemic and threatened species (Lipsey and Hockey, 2010). All this poses a major threat to the species of *R. tridentata* complex (*R. tridentata* subsp. *cuneifolia*; *R. tridentata* subsp. *diplonerva* and *R. tridenatata* subsp. *tridentata*) as they mostly thrive in grasslands, especially *R. tridenatata* subsp. *tridentata*. In grasslands where grass species are dominant and within the range in which *Rhoicissus* species can be distributed, these species are often seen contributing to the vegetation of these habitats.

Indigenous forests in South Africa are also highly fragmented into various sized patches with an area less than 1 km^2 (Cho *et al*., 2015). The Dukuduku forests is such an example where 29% of this large (largest in KwaZulu-Natal) indigenous coastal lowland forest patch has been lost between 1992 and 2005 (Cho *et al*., 2015). The loss might be due to the conversion of parts of this forest into farmland, pasture and urban development over several decades (Cho *et al*., 2015). Despite the loss of land; fragmentation and the reduction in size, the indigenous forest biome in South Africa supports a high amount of biodiversity in the country (Cho *et al*., 2015). It is also in these types of habitats that the species of *Rhoicissus* has been found (Ngoye Forest and Mkhomazi Forest), both on the floor of these indigenous forests as well as high up in the canopy.

Rhoicissus digitata subsp. *digitata*; *R. tomentosa* as well as *R. rhomboidea* are among the species of *Rhoicissus* seen in these forests during the field work of this study. The conservation of biodiversity in indigenous forests might have resulted in the protection of such forests, as 18% (1285 km^2) of these biomes are estimated to be protected (Eeley *et al*., 2001). In national parks and nature reserves of South Africa, the inclusion of indigenous forests within the these areas is often secondary,while they are well represented within the State Forest reserves which fall under the South African's Forest Act (Eeley *et al*., 2001). The successful conservation of indigenous forests thus lies in State Forest reserves rather than national parks and nature reserves as they might protect them in part and not as a whole. In essence a direct approach into their protection might be more beneficial than an indirect approach.

It is this conservation of habitats which the species of *Rhoicissus* inhabit that will ensure their continuous existence in the flora of southern Africa, as it is their habitats that are under threat and not actual species of *Rhoicissus*. To date, all these species are not threatened or endangered, rather they are often found to be common among the vegetation where they are found. In general, conservation is thus important not only for the species growing in the conservation areas, but also important for increasing the biodiversity of the conserved and surrounding areas.

Chapter 5

Materials and Methods

Due to the flowers of this genus (and the family in general) being small and generic, the analyses of the genus in this study was largely based on the morphological characters of the leaves; which are very diagnostic. The leaves of the different species were extensively analysed due to the obvious and distinct features they possess, and which upon observation were found to be specific to individual species. These morphological characters were measured at various states of maturity within and between the different species in order to separate as much as possible the specimens used into different taxa. Using the inherent characters of *Rhoicissus* at varying levels enabled the variation that exists within the genus to be examined and used to determine the total number of species within this genus. The taxonomic hypothesis in Boon (2010) was tested to see if the results came to the same or to different conclusions. Boon (2010) proposed two new species, one in the north coast of KwaZulu-Natal (e.g. False Bay) and the other in the south coast of KwaZulu-Natal (along Pennington to Port St. Johns).

Old as well as recently collected specimens were utilised during the gathering of data and the total number of species that resulted from the data collected reflected the total number of species found within this genus *sensu* Boon (2010). This literature (Boon (2010)) has the latest classification of *Rhoicissus* which is in turn a revision of the old classifications of this genus. The hypothesized species, as well as classification, were largely based on Boon's Trees of Eastern South Africa (2010) as it contains both old and new information pertaining to this genus.

In total, 120 specimens were used to gather data but only the data gathered from 113 specimens were used. Multiple reasons caused this, e.g. some specimens lacked crucial information that was needed for the study, some were extensively damaged such that some characters that were needed for the analysis were missing and some specimens had reduced plant material which made it difficult to place them into any species. All the specimens used for the analyses can be seen listed in Table 1 of the Appendices. Table 2 of the Appendices has all the characters that were used to generate data for this study, as well as their varying states or levels. The data generated from measuring multiple morphological characters were then used to produce multiple graphs which include scatter graphs, polygonal graphs as well as phenograms.

5.1 Field Studies

Field studies were also done, where the different species were observed in their natural habitats in order to supplement the information provided in the literature and on herbarium labels. Field work was also done in order to study the manner in which the different species grow in different environments; as well as how they contribute to the biodiversity of the environment that they grow in. The areas in which field work was conducted include Hluhluwe Game Reserve; the Twinstreams Forest, the coastal and dune forests of False Bay as well as the dune forest and coastal forests of the KwaZulu-Natal south coast and northern Eastern Cape including Mtwalume, Amanzimtoti, Port Shepstone, Port Edward and Mkambati Nature Reserve. Specimens were collected in some of the above areas and pressed; Voucher specimens were deposited at the Ward Herbarium, University of KwaZulu-Natal, Westville Campus

5.2 Phenetics

For the phenetic study a maximum of two character states was maintained for each character (as much as possible).The outcome of this would be the production of a phenogram. For the phenograms three analyses were used: i) Nearest Neighbour; ii) Between group (or UPGMA) and; iii) Ward's Method. The Nearest Neighbour used the Eucledian Distance as the similarity co-efficient. The Between Group (UPGMA) used the unweighted paired group method with arithmetic means algorithm as the similarity co-efficient. The Ward's Method used the hierarchical clustering analysis which is known as the Ward's minimal varience method which works by using objective functioning to form an agglomerative hierarchical clustering. Phenograms show the similarity of the specimens based purely on their overall morphological similarity. The analyses were done in IBM SPSS (version 21) including phenetic tests which produced dendrograms. Phenon lines were not drawn because of the subjectiveness of this methodology (Nicholas Pers. comm.) This is confirmed by Stace (1989) who considers this as arbitrary.

5.3 Two Way ANOVA

IBM SPSS version 21 was used to do all the statistical analyses conducted in this study. Two Way ANOVA tests were used to test the significance of morphological differences among the subspecies of the *R. tridentata* complex and those of the *R. digitata* group. This was done using a Two Way ANOVA statistical test. Characters such as the size of the leaflets and the total number of teeth on both lateral and terminating leaflets of the subspecies of *R. tridentata* were used to measure the level of difference among them. Only the size of the lateral and terminating leaflets of the proposed new species as well as of those of *R. digitata* (refered to as *R. digitata* subsp. *digitata* in this study) were used in Two Way ANOVA tests which were conducted to test their similarity. All data used for the statistical tests for all the species in which the tests were done, fulfilled all the assumptions (i.e. normal distribution and equal variances between the residuals).

5.4 Scatter Diagrams

Scatter diagrams, which visually displayed the difference of the three species of the *R. tridentata* complex as well as the *R. digitata* complex, were also produced using SPSS version 21.

5.2 Polygonal Graphs

Microsoft Excel (2010) was used to produce polygonal graphs which further showed the difference between the species of the two complexes

Chapter 6

Results

6.1 Result Analyses

Phenetics Analyses

In all the three analyses (Nearest Neighbour, Between-groups linkage and the Ward's methods) used to analyse the simiarity between the different species of *Rhoicissus* in this study, the same trends were observed in the resulting dendrograms. These trends were that of *R. tomentosa*; *R. sessilifolia* as well as *R. rhomboidea* formed separate and well defined clusters and in some analyses, the clusters were grouped one after the other. The *R. tomentosa* and *R. sessilifolia* clusters were grouped close to one another in two (Between-groups linkage and the Ward's method) of the three analyses while the *R. rhomboidea* cluster was only grouped closer to these clusters by the Ward's method. Outliers of these species were also observed, such as that of *R. rhomboidea* (*R. rhomboidea* 1) which was found within the cluster of the species of *R. tridentata* in all the three analyses. This phenomenon is not unusual in both phenetics and cladistics and there are many reasons why this happens (Nicholas pers com,). The three subspecies making up the *R. tridentata* complex did not form three clusters that were grouped together as was expected. The three subspecies from this complex formed different clusters that were grouped together in some analyses, but also the species of the complex were always outliers among the clusters of other species. Also, a clear separation into clusters of the species of this complex was not observed in all analyses i.e. the three subspecies of the *R. tridentata* complex were not placed into clusters that grouped together. The different subspecies of the complex were lumped together and not separated into different entities.

The common trend observed on the dendrograms resulting from the three tests was that the species of *Rhoicissus* which had similar characters were always grouped closer to one another. Such was observed in the species of this genus (in KwaZulu-Natal) which have looping veins, which are the subspecies of the *R. digitata* group; *R. revoilii* as well as *R. schlechteri* (Figures 28-30). *Rhoicissus schlechteri* was found clustering around the subspecies of the *R. digitata* group (Figure 28-30) while, *R. revoilii* formed a cluster of its own or clustered around the subspecies of the *R. digitata* group (Figures 28-30). All in all though, these species were always found around each other in the dendograms that resulted from the analyses. However, in the end it must be emphasized that the resolution for the *Rhoicussus digiatata* group is not well resolved and may require more than the 60 characters usually reqired for phenetics.

This trend was also observed in the species with dentations along the margins which are *R. sessilifolia*, *R. tridentata* and *R. rhomboidea*. These species were found clustering around each other in dendrogram that was obtained during the phenetic analyses. The cluster of *R. romboidea* and that formed by the subspecies of the *R. tridentata* complex were also found clustered around each other in the dendrograms in all the analyses (Figure 28-30). *Rhoicissus sessilifolia* also occurred around the clusters of these two species, even though it was in two of the three analyses, and those were the Nearest Neighbour and Ward's Method (Figure 28 and 30, respectively).

Even though the placement of the subspecies of the two groups was not what was expected and *R. schlechteri* did not form a separate cluster as a species, two things remained the same in all the analyes. Firstly, the clusters of the species of this genus (in KwaZulu-Natal) with similar characters were always found near each other and secondly, *R. tomentosa* always formed a cluster of its own without outlires in all the analyses.

Statistical Analysis of the *Rhoicissus tridentata* Complex

The difference between the total number of lateral veins on both terminating and lateral leaflets of the three species of the complex was found to be different, and statistically the difference was found to be significant. The total number of lateral veins found on terminating leaflets of *R. tridentata* subsp. *cuneifolia* was statistically found to be significantly different to those found on *R. tridentata* subsp. *tridentata* ($p < 0.005$). The same p-value was obtained when those found on the terminating leaflets of *R. tridentata* subsp. *nov* c and *R. tridentata* subsp. *tridentata* were compared. Those found on the terminating leaflets of *R. tridentata* subsp. *nov* c, although found to be slightly different to those on the terminating leaflets of *R. tridentata* subsp. *cuneifolia*, the difference was, however, found not to be significantly different ($p = 0.082$).

The total number of teeth found on the terminating leaflets of each species of the complex was found to be significantly different from each other as the p-value was < 0.005 when the different subspecies were compared. The obtained p-value of < 0.005 is below that of the study which is 0.05 thus making the difference between the total number of teeth on the terminating

leaflets of the subspecies of the complex significantly different from each other. Visually this difference in the total number of teeth and lateral veins on the terminating leaflets of the species of the *R. tridentata* complex can be seen in Figure 28, where both these characters are plotted against each other.

The difference found between the total number of lateral veins on the lateral leaflets of (*R. tridentata* subsp. *nov* c and *R. tridentata* subsp. *cuneifolia*) complex was found to be statistically insignificant as the p-values were above the critical p-value of this study (0.05). When the total number of lateral veins of the lateral leaflets of the two subspecies were compared, $p = 0.212$ was obtained while $p = 0.076$ was obtained when those of *R. tridentata* subsp. *cuneifolia* were compared to those of *R. tridentata* subsp. *tridentata*. In both the above mentioned cases the existing differences observed between the lateral leaflets of *R. tridentata* subsp. *cuneifolia* and the other two subspecies of *tridentata* is statistically not significant as the p-values obtained are above that of the study (0.05). The difference observed between the total number of the lateral veins of the lateral leaflets of *R. tridentata* subsp. *nov* c and *R. tridentata* subsp. *tridentata* was, however, found to be statistically significant ($p = 0.004$).

The differences observed between the total number of teeth found on lateral leaflets of each species of the complex was found to be statistically significant as $p < 0.005$ when all comparisons of the species of the *R. tridentata* complex were made. Visually this difference in the total number of teeth and lateral veins on the lateral leaflets of the species of the *R. tridentata* complex can be seen in Figure 29, where both these characters are plotted against each other.

When the difference in length between the terminating leaflets of *R. tridentata* subsp. *cuneifolia* was compared to that of *R. tridentata* subsp. *nov*. c a p of 0.020 was obtained which is below0.05, thus making this difference statistically significant. A statistical significant difference was also found when the length of the terminating leaflets of *R. tridentata* subsp. *nov*. c and *R. tridentata* subsp. *tridentata* were compared, as $p< 0.005$ was obtained. When the length of the terminating leaflets of *R. tridentata* subsp. *cunefolia* were compared to those of *R. tridentata* subsp. *tridentata*, $p = 0.131$ was obtained, making the length of the terminating

leaflets of these subspecies statistically the same as the obtained p-value was above the critical p-value. When the differences in breadth of the terminating leaflets of the species of the *R. tridentata* complex were statistically analysed, it was found that the breadth of the terminating leaflets is different and the difference is statistically significant as $p < 0.005$. Visually this difference in the length and breadth of the terminating leaflets of the species of the *R. tridentata* complex can be seen in Figure 33, where both these measurements are plotted against each other.

A statistical comparison of the length of the lateral leaflets of the species of the complex revealed that the lateral leaflets of *R. tridentata* subsp. *tridentata* are significantly different to those of *R. tridentata* subsp. *cuneifolia* as well as *R. tridentata* subsp. *nov.* c as $p = 0.005$ and $p = 0.001$. The difference in length of the lateral leaflets of the between the leaves of *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *nov*. c. was however found to be statistically insignificant ($p = 0.417$). P-values below the critical p-value of the study (0.05) were obtained when the breadths of the lateral leaflets of the subspecies of the *R. tridentata* complex were compared. When the breadths of the lateral leaflets of *R. tridentata* subsp. *cuneifolia* were compared to those of *R. tridentata* subsp. *nov*. c and *R. tridentata* subsp. *tridentata*, $p = 0.006$ and $p = 0.003$ were obtained, respectively. When the breadths of the lateral leaflets of *R. tridentata* subsp. *nov.* c and *R. tridentata* subsp. *tridentata* were compared, $p< 0.0005$. In both these cases, stastically, the difference between them is significant. Visually this difference in the length and breadth of the lateral leaflets of the species of the *R. tridentata* complex can be seen in Figure 34, where both these measurements are plotted against each other.

In Figure 37, Figure 38 and Figure 39, the three species of the *R. tridentata* complex formed different shapes in polygonal graphs using eight characters, measured during the gathering of data in this study. These different shapes (in size but not in structure) were also seen when the data from the three species of the *R tridentata* complex were combined such that only one polygonal graph resulted (Figure 40). In such graphs the taxa have exactly the same morphological structure but only differ in size. The difference between the three subspecies of this complex can be further seen in Figures 60, 61 and 62 where the compound leaves of the three species are displayed. The terminating leaflets of the three species are different from

species to species and the main differences between them include the number of teeth (or dentition) along the margin, their sizes, shapes as well as the number and the organization of the lateral veins; especially at the base. The same differences can also be seen in the two lateral leaflets of the compound leaves of the three subspecies of the complex, i.e. they also differ in size, shape etc.

In Figure 63, an overlap in the distribution of these subspecies is shown. An overlap between *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata* occurred along the southern coast of KwaZulu-Natal. *Rhoicissus tridentata* subsp. *tridentata* can be seen mostly distributed along the south coast of South Africa, while *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *nov.* c can be seen mostly distributed in the mid-eastern (KwaZulu-Natal and Mpumalanga) and the northern areas of South Africa, respectively.

Statistical Analysis of the *Rhoicissus digitata* group

Comparing the lengths and breadths of the terminating and lateral leaflets of the subspecies of the *R. digitata* group yielded a result of no statistical difference as p-values obtained were above the critical p-value of the study. Please (see Tables 2-5).

The variation in the length and breadth between the terminating leaflets of the three subspecies of this group can be seen in Figure 35. In this figure, no subspecies formed a distinct cluster of its own which is separate from the other subspecies of this group. In Figure 36, the subtle difference (in terms of length versus breadth) that exists between the lateral leaflets of these subspecies can be observed. In this figure, although *R. digitata* subsp. *digitata* almost formed an isolated cluster, the subspecies belonging to *R. digitata* group are found spread throughout the phenogram, with no distinction shown by one species from the other.

This lack of distinction can also be seen in Figures 41 to 43 and more clearly 44, where the resulting polygonal graphs obtained from analysing the same 8 main characters appeared to be of one shape. The overall shape observed in these graphs is generally the same with slight differences such as the slight increase in the size of some of these characters as in those of *R. digitata* subsp. *digitata* in Figure 41. Even with the slight increases in the size of the characters of this species, the overall shape of the polygonal graphs obtained from the subspecies of *R.*

digitata is still the same. This can be better seen in Figure 44, where data from all the subspecies of *R. digitata* was combined to produce one polygonal graph in which all the graphs lumped together underneath one another.

In Figures 45 to 48, where the compound leaves of the subspecies of the *R. digitata* group are seen, greater differences can be seen between them. In Figures 45 a and b where the leaves of *R. digitata* subsp. *digitata* the 3-foliate and 5-foliate types are respectively displayed, they other appear different to those of the possible subspecies as they have relatively truncate and obtuse apices on the terminating leaflets of these respective types. *Rhoicissus. digitata* subsp. *nov*. b in Figure 47 and Figure 48, has emarginate terminating leaflets and lateral leaflets with truncate apices on one or both lateral leaflets. *Rhoicissus digitata* subsp. *nov*. a (in Figure 46) has, unlike the other species of the group, extremely spatulate terminating leaflets and distinct looping veins on the leaf blades (both terminating and lateral leaflets). Also, the leaflets of this subspecies are seen to be broader and not narrow like ones of the other two subspecies, and have fewer lateral veins than the leaflets of the two subspecies.

Analysis of Other *Rhoicissus* Species

The other species of *Rhoicissus* which are *R. tomentosa, R. rhomboidea, R. sessilifolia, R. revoilii* as well as *R. schlechteri* showed little variation within themselves as no subspecies were shown to exist within each of these species. The comparison of the leaves of the above species yielded similar results as those obtained from the phenetic analyses in that, each of these species possess a different leaf shape which is unique.

Rhoicissus tomentosa

Upon analyses, the leaf of *R. tomentosa* was the only one found to be of a simple form. Also, out of all the leaves of the species of *Rhoicissus*, it was the only leaf found to have lobes around the margin. Also unique to this species were the three veins found at the base of the individual leaves which, when the leaves were extremely large formed three lobes each with its own vein as it diverged at the base (see Figure 58). The leaves of *R. tomentosa* also possessed notably long petioles but not as long as those observed on the leaves of *R. rhomboidea* (Figure 53).

Rhoicissus rhomboidea

Rhoicissus rhomboidea had upon analyses, 3-foliate leaves with very long petioles as well as an average of six dentitions along the margins of each leaflet, especially the terminating leaflets. Usually the terminating leaflets had three dentitions on each side while the lateral leaflets had four and two (sometimes three and two) dentitions on either sides of the leaflet. Overall though, it was the rhomboid-shape of the leaflets that was the consistent prominent character for the leaves of this species which also set them apart from other species (Figure 53).

Rhoicissus sessilifolia

Rhoicissus sessilifolia was found to be the only species of this genus with sessile 3-foliate leaves. Also, unlike the other species within this genus, this species was found to be the only species with lateral and terminating leaflets of different shapes. Lateral leaflets were found to be orbicular while terminating leaflets were found to be elliptic in shape. Both leaflets, however, had dentitions along the margins. Terminating leaflets were found with four (two on either side) or more dentitions depending on the size of the leaflet, the bigger the leaflet the more dentitions it had. Lateral leaflets were usually found to be small and had 5 dentitions along the margin (three and two on each side). Both the leaflets of *R. sessilifolia* had petiolules unlike the compound leaf (Figure 57).

Rhoicissus revoilii

The leaves of *R. revoilii* (Figure 51) have the same shape in both the terminating and lateral leaflets. These leaves were also smooth around the margins, had looping lateral veins as well as being elliptic in shape and asymmetrically elliptic for the lateral leaflets.

Rhoicissus schlechteri

The leaves of *R. schlechteri* (Figure 55) had lanceolate terminating leaflets unlike those of *R. revoilii*. Lateral leaflets were, however, linear in shape and sickle-shaped, unlike the ones of the other species of this genus. Overall though, the leaves of this species were found to be very narrow in comparison to those of the other species within this genus. They were also found to have looping lateral veins as well as smooth margins like the leaflets of the species of *R. digitata* as well as those of *R. revoilii*.

6.2 Phenetic Results

6.3 Statistical Results for the subspecies of *Rhoicissus digitata*

Table 2: The resulting p-values for the comparison of the lengths of the terminating leaflets of the *R. digitata* group.

Species	*R. digitata* subsp. *digitata*	*R. digitata* subsp. *emarginata*	*R. digitata* subsp. *oravivens*
R. digitata subsp. *digitata*	-	0.252	0.473
R. digitata subsp. *emarginata*	0.252	-	0.835
R. digitata subsp. *oravivens*	0.473	0.835	-

Table 3: The p-values that resulted when the differences in the breadths of the terminating leaflets of the *R. digitata* group were statistically compared.

Species	*R. digitata* subsp. *digitata*	*R. digitata* subsp. *emarginata*	*R. digitata* subsp. *oravivens*
R. digitata subsp. *digitata*	-	0.909	0.220
R. digitata subsp. *emarginata*	0.909	-	0.510
R. digitata subsp. *oravivens*	0.220	0.510	-

Table 4: The resulting p-values for the statistical comparison of the lengths of the lateral leaflets of the subspecies of the *R. digitata* group.

Species	*R. digitata* subsp. *digitata*	*R. digitata* subsp. *emarginata*	*R. digitata* subsp. *oravivens*
R. digitata subsp. *digitata*	-	0.194	0.634
R. digitata subsp. *emarginata*	0.194	-	0.599
R. digitata subsp. *oravivens*	0.634	0.599	-

Table 5: The resulting p-values for the statistical comparison of the breadths of the lateral leaflets of the subspecies of the *R. digitata* group.

Species	*R. digitata* subsp. *digitata*	*R. digitata* subsp. *emarginata*	*R. digitata* subsp. *oravivens*
R. digitata subsp. *digitata*	-	0.802	0.879
R. digitata subsp. *emarginata*	0.802	-	0.543
R. digitata subsp. *oravivens*	0.879	543	-

6.4 Scatter Plots

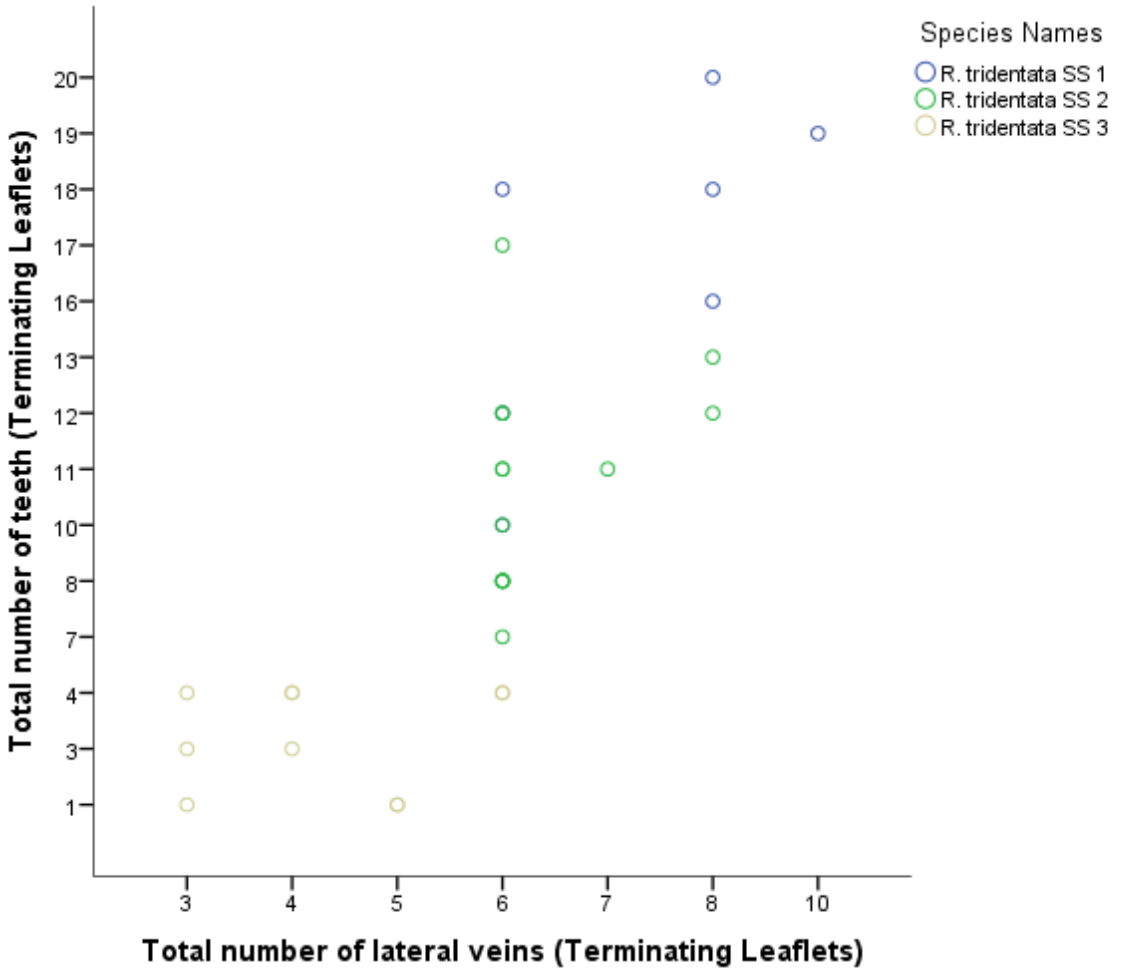

Figure 31: The relation between dentitions (teeth) along the margins and lateral veins of terminating leaflets in the different members of the *R. tridentata* complex. *R. tridentata* SS 1 refers to *R. tridentata* subsp. *nov*. c; *R. tridentata* SS 2 refers to *R. tridentata* subsp. *cuneifolia* and *R. tridentata* SS 3 refers to *R. tridentata* subsp. *tridentata*.

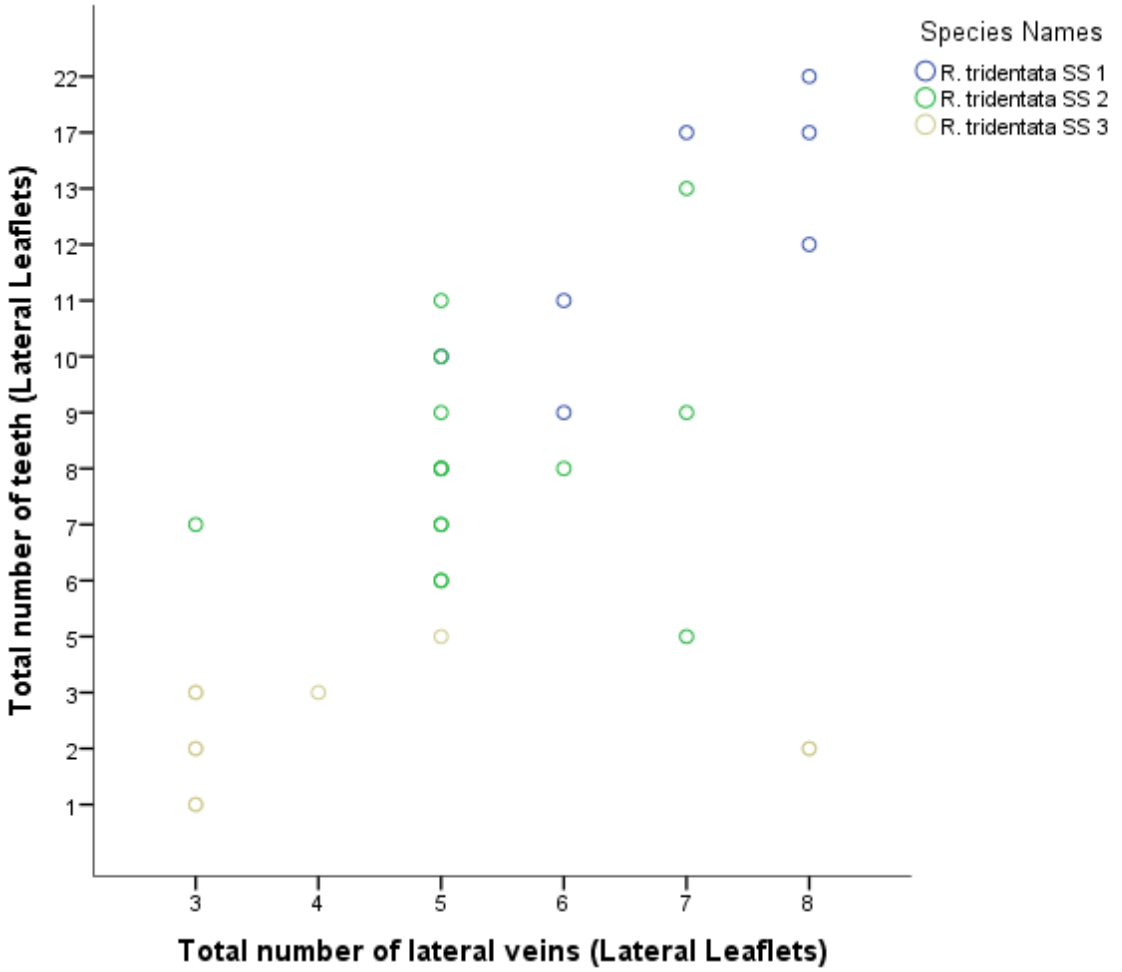

Figure 32: The difference in the total number of dentitions (teeth) in relation to lateral veins of the lateral leaflets different members of the *R. tridentata* complex. *R. tridentata* SS 1 refers to *R. tridentata* subsp. *nov*. c; *R. tridentata* SS 2 refers to *R. tridentata* subsp. *cuneifolia* and *R. tridentata* SS 3 refers to *R. tridentata* subsp. *tridentata*.

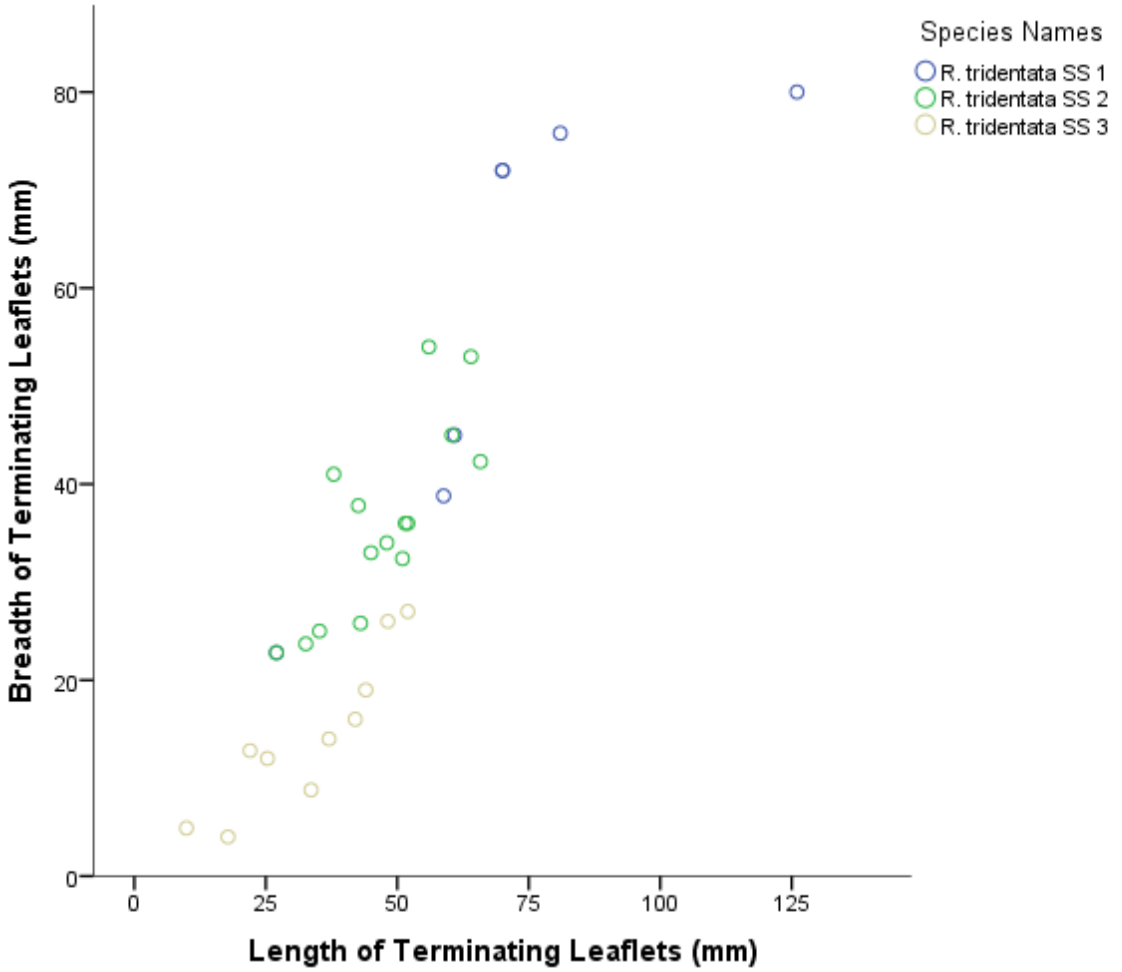

Figure 33: The difference in the leaf sizes (comparing the length and breadth of terminating leaflets) between the different members of the *R. tridentata* complex. *R. tridentata* SS 1 refers to *R. tridentata* subsp. *nov. c*; *R. tridentata* SS 2 refers to *R. tridentata* subsp. *cuneifolia* and *R. tridentata* SS 3 refers to *R. tridentata* subsp. *tridentata*.

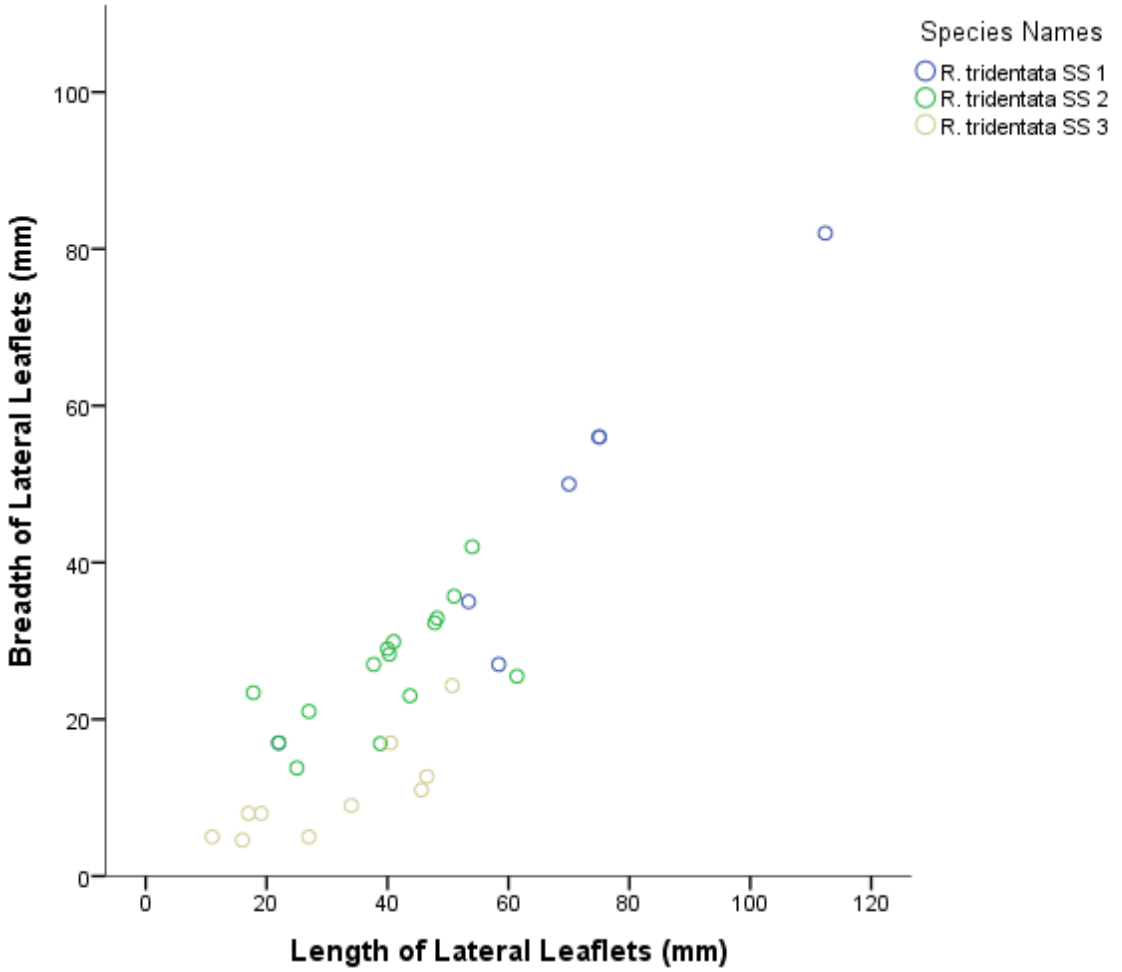

Figure 34: The difference in the leaf sizes (comparing the length and breadth of lateral leaflets) between the different members of the *R. tridentata* complex. *R. tridentata* SS 1 refers to *R. tridentata* subsp. *nov*. c; *R. tridentata* SS 2 refers to *R. tridentata* subsp. *cuneifolia* and *R. tridentata* SS 3 refers to *R. tridentata* subsp. *tridentata*

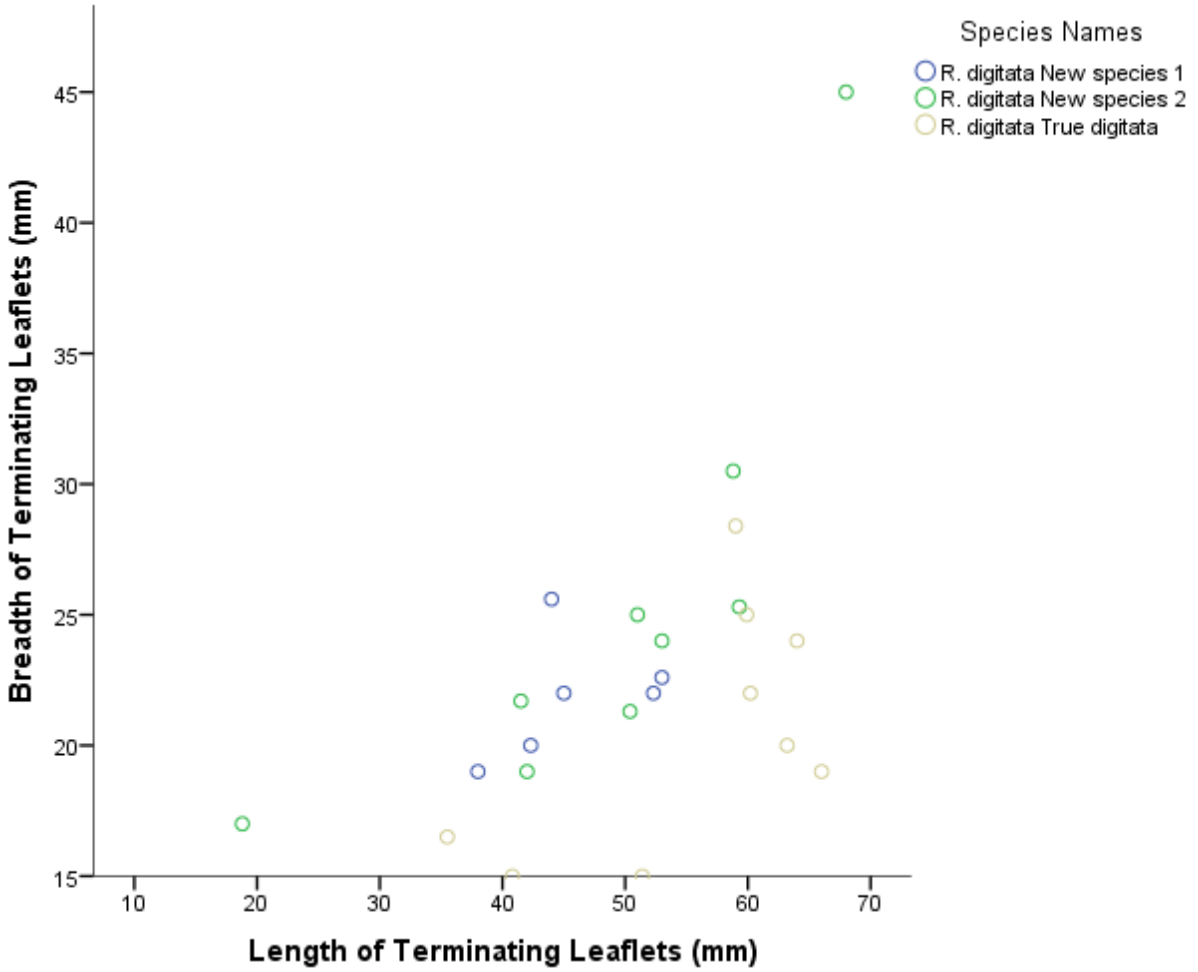

Figure 35: The length and breadth ratio of the terminating leaflets of the three species of the *R. digitata* group (the possible two new species as well as the 5-foliate *R. digitata* subsp. *digitata*). *R. digitata* New species 1 refers to *R. digitata* subsp. *nov*. b, *R. digitata* New species 2 refers to *R. digitata* subsp. *nov*. a, and *R. digitata* True *digitata* refers to *R. digitata* subsp. *digitata*.

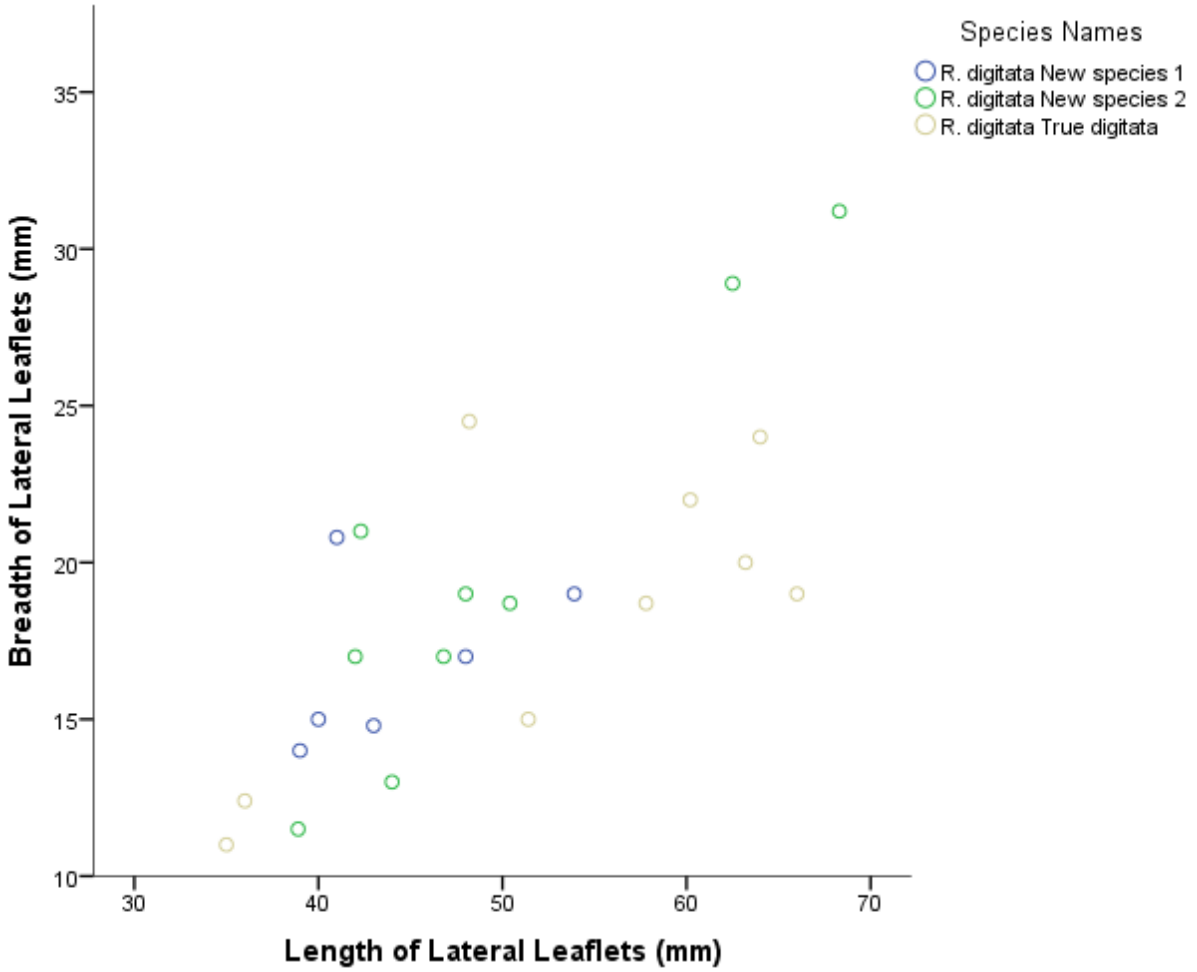

Figure 36: The length and breadth ratio of the lateral leaflets of the three species of the *R. digitata* complex (the possible two new species as well as the 5-foliate R. *digitata* subsp. *digitata*). *R. digitata* New species 1 refers to *R. digitata* subsp. *nov*. b, *R. digitata* New species 2 refers to *R. digitata* subsp. *nov*. a, and *R. digitata* True *digitata* refers to *R. digitata* subsp. *digitata*.

6.5 Polygonal Graphs

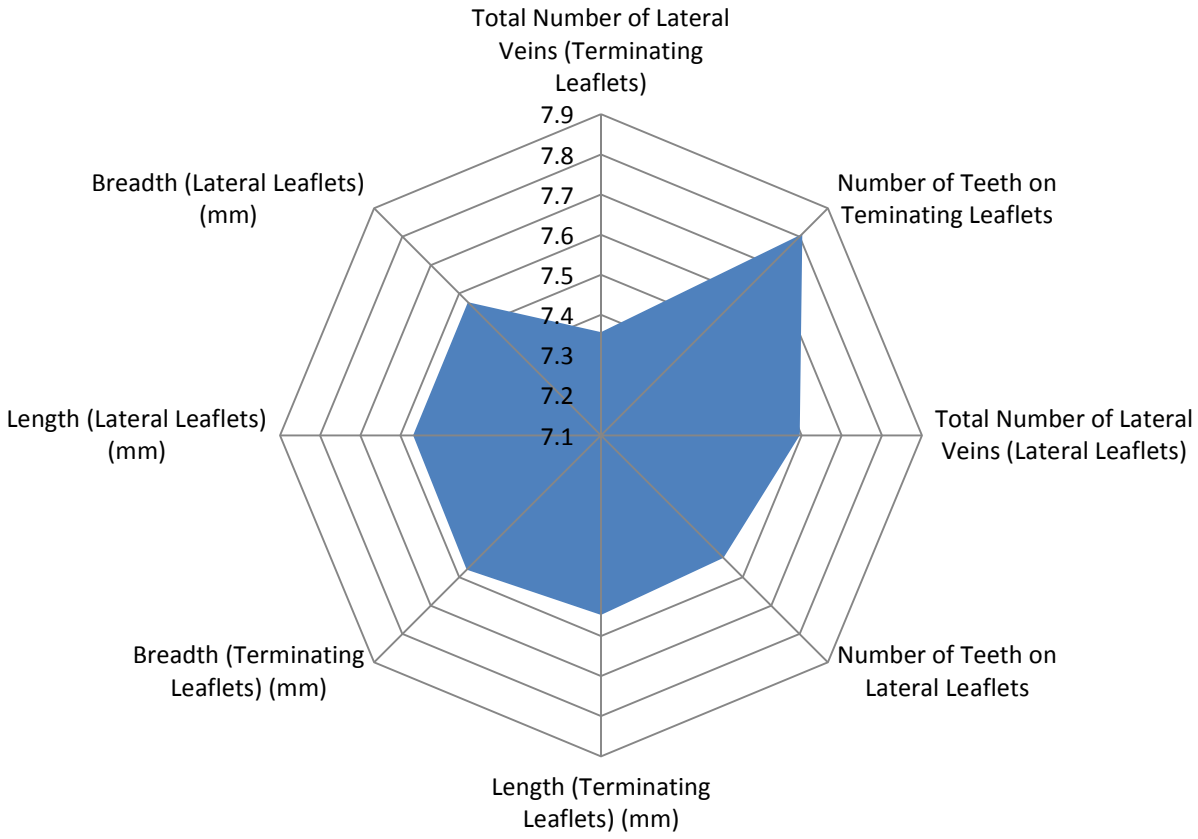

Figure 37: Polygonal graph of *R. tridentata* subsp. *nov*. c. of the *R. tridentata* complex.

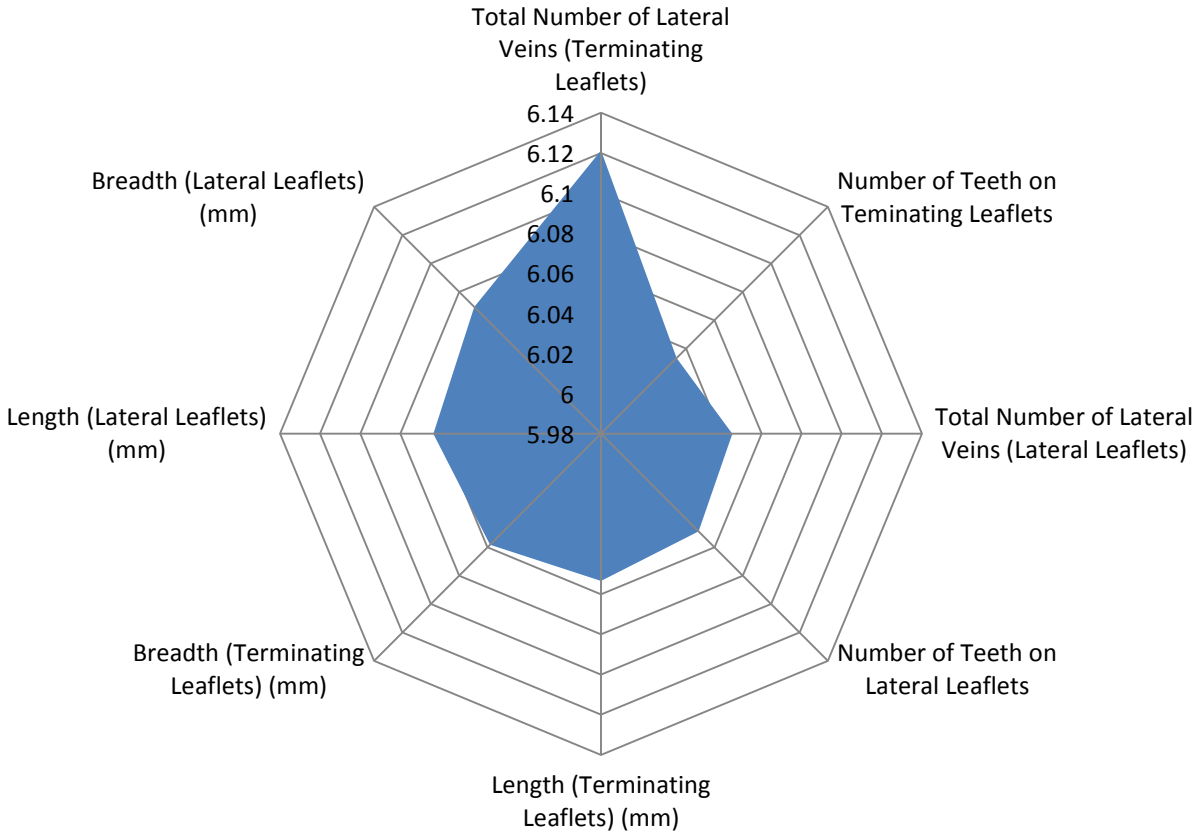

Figure 38: The polygonal graph of *R. tridentata* subsp. *cuneifolia* this graph shows how unique and different this subspecies is to the rest of the taxa in the *R. tridentata* complex.

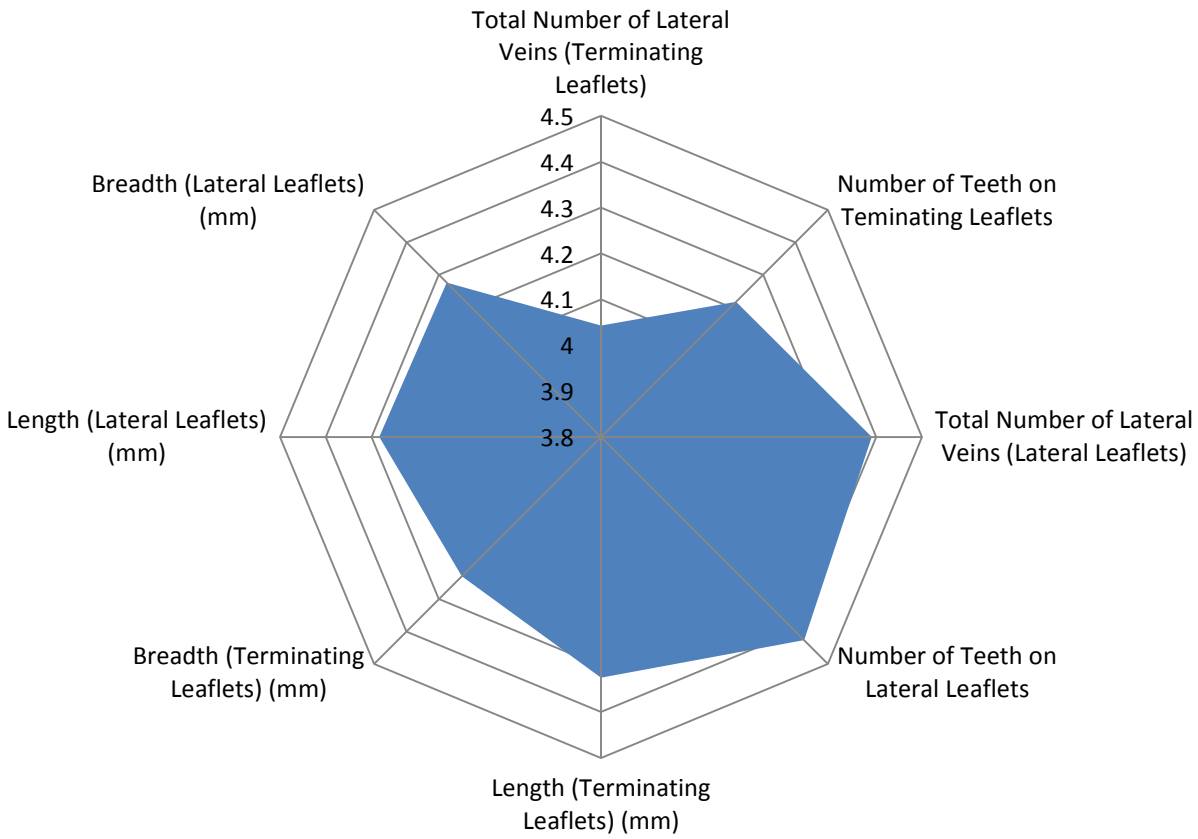

Figure 39: The polygonal graph of *R. tridentata* subsp. *tridentata* showing the uniqueness of this subspecies within the *R. tridentata* complex.

Figure 40: The combined polygonal graphs of the three subspecies (*R. tridentata* subsp. *nov*. c.; *R. tridentata* subsp. *cuneifolia* and *R. tridentata* subsp. *tridentata*) of the *R. tridentata* complex which shows the difference (in size, but not in structure) between the three subspecies.

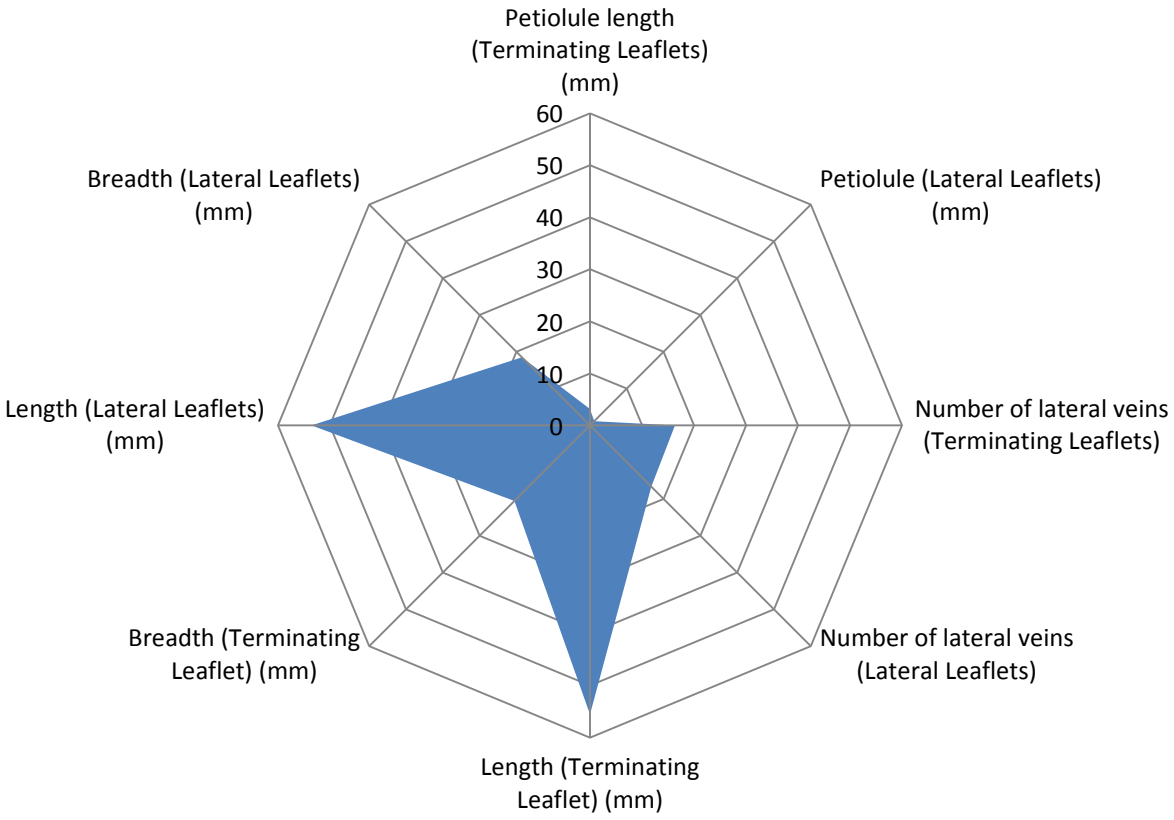

Figure 41: The resulting polygonal graph of *R. digitata* subsp. *digitata* which belongs in *R. digitata* group.

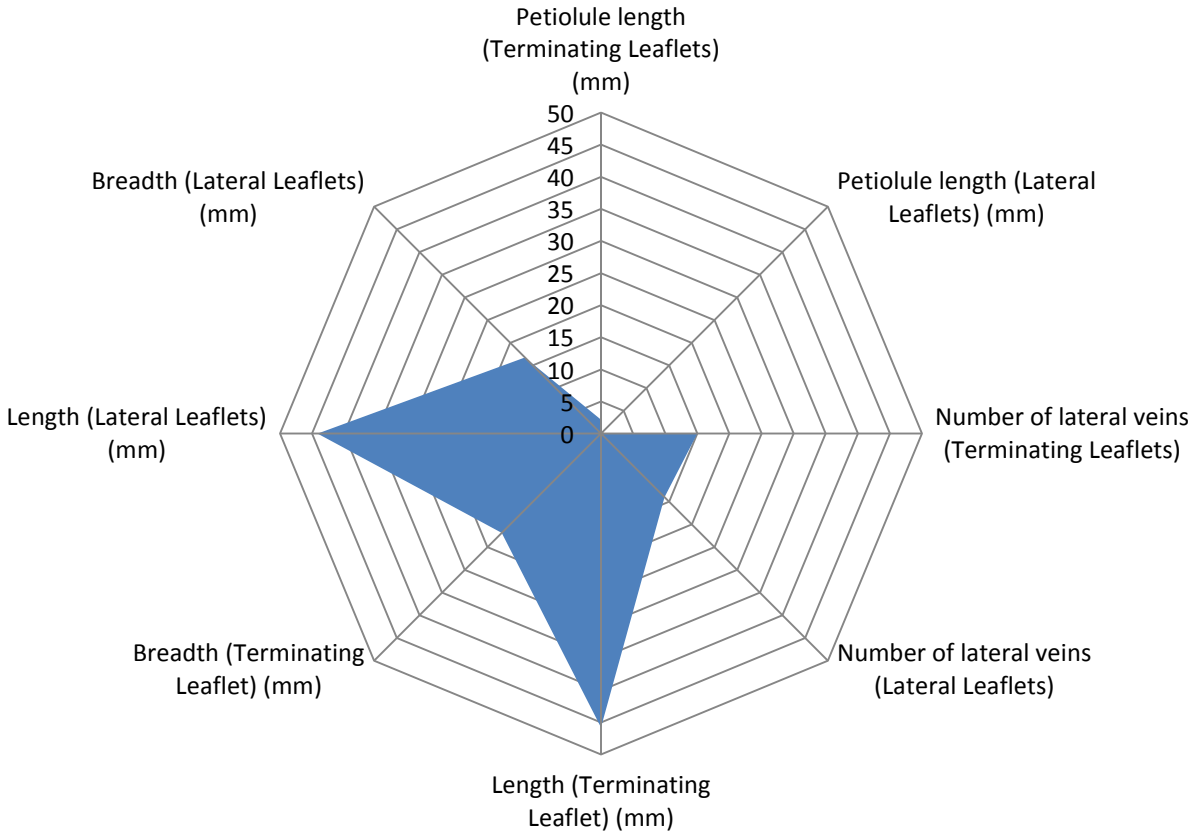

Figure 42: The resulting polygonal graph of *R. digitata subsp. nov* b of the *R. digitata* group.

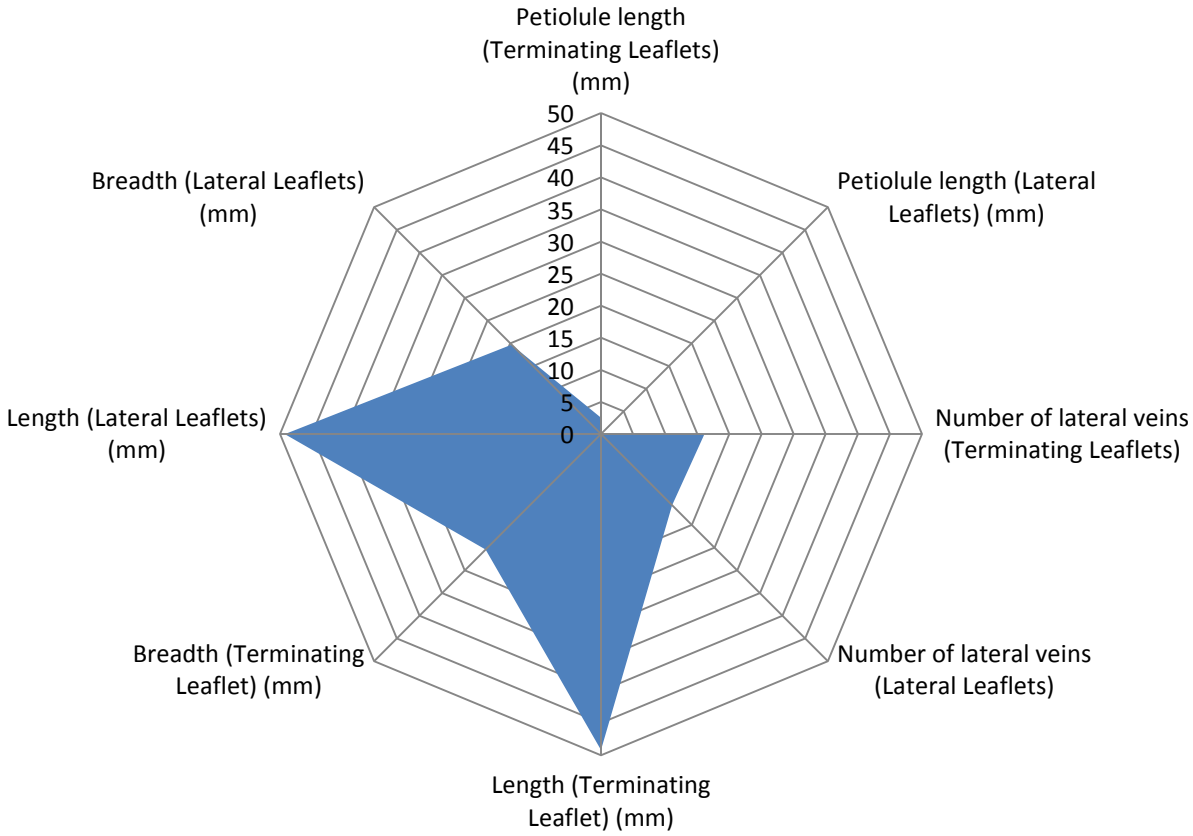

Figure 43: The polygonal graph of the possible new species *R. digitata* subsp. *nov.* a of the *R. digitata* group.

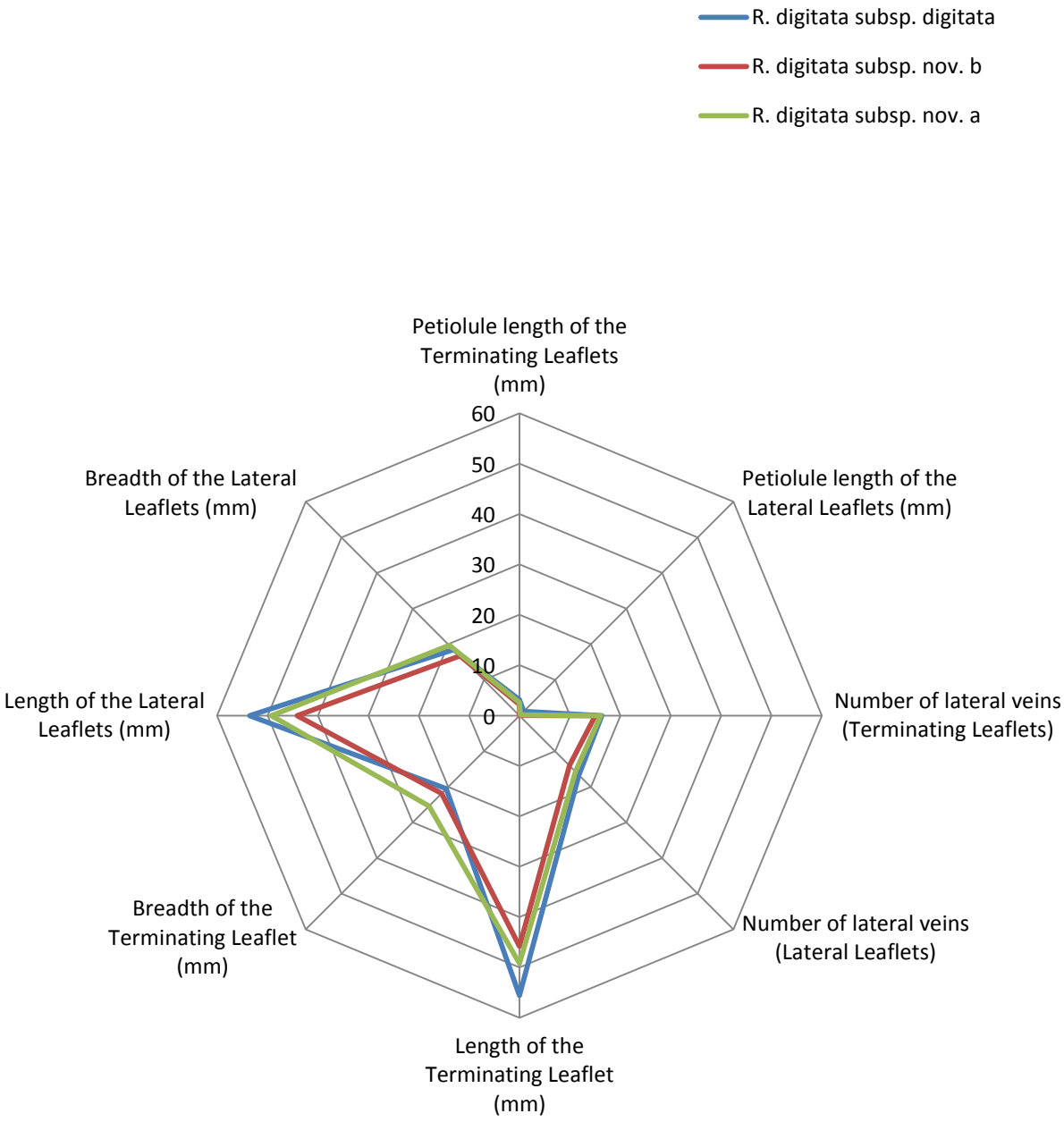

Figure 44: Polygonal graphs of the three *R. digitata* subspecies combined into one set of axes which did not differ greatly as their overall shape and size is similar for all the subspecies of this group.

Chapter 7

Discussion

From the resulting phenograms, *Rhoicissus* appeares to have six species that more or less, separated from each other. These species are *R. tomentosa*, *R. rhomboidea*, *R. sessilifolia*, *R. revoilii*, *R. tridentata* as well as *R. digitata*. This largely concurs with the species concepts of Pooley (1994). The above species, although separate from each other, were found clustering around species that they shared similar characters with. *Rhoicissus revoilii* which was placed among the specimens that in this study were classified as belonging to the *R. digitata* group, in all the dendrograms which were obtained from the phenetic analyses (Figure 28 to Figure 30). Both these species have looping veins as well as entire margins.

In addition to the common leaf traits observed in both these species (*R. revoilii* and *R. digitata*), the distribution of these species overlapped i.e. in some areas of southern Africa. However, despite the specimens of *R. revoilii* being among those of *R. digitata*, most of the specimens of *R. revoilii* did cluster together forming a group of their own which could mean that *R. revoilii* is a separate species from *R. digitata*. However, this all points to a possible close phylogenetic relationship between the two. *Rhoicissus revoilii* being the most widespread of the species is likely to be the parent species giving rise to both *R. digitata* and *R. schlechteri* as well. The latter might explain why the two species were grouped together during the phenetic analysis. The observed distribution overlap of the two species in some areas of southern Africa might explain how the two species are related to one another as both would need to be able to tolerate the same environmental conditions for one to have diverged from the other. For both these species to occur in one area and still be identifiable as two species suggests that the diverging of one species from the other has occurred to such an extent that these species are now discernable separate species. The lack of hybridization being reported in areas where both these species occur might indicate that there is no longer gene exchange taking place between these species.

The northwards distribution of *R. revoilii* in southern Africa might have resulted in further segregation between the two species as the northern and southern areas of southern Africa do not experience the same climatic conditions. Biotic as well as abiotic pressures might be different for both these areas which also propels, via natural selection, both these two species in different evolutionary directions. Also, *R. revoilii* has a northern and inland distribution while *R. digitata* and *R. schlechteri* are more southern and restricted to the coastal zone. *Rhoicissus revoilii* has, in the past, been reported by Wild and Drummond (1963) as the northern representative of the *R.*

revoilii complex and, *R. schlecteri* as the southern representative of the complex when *R. revoilii* was thought to have subspecies. *Rhoicissus revoilii* as well as *R. schlecteri* were recognized as separate species by Boon (2010). The lumping of *R. schlechteri* and *R. revoilii* into one species is plausible, as in the iSimangaliso Wetland Park, a plant that had adult leaves resembling those of *R. schlechteri*, and young leaves resembling *R. revoilii* was observed. This phenomenon is known as neotany, and it is when traits previously seen only in juveniles of an organism are then retained in adults, thus delaying the somatic development of that organism.

Rhoicissus schlechteri unlike *R. revoilii* did not form a cluster in the phenetic analyses. This species was scattered around the *R. digitata* species in the dendrograms and did not form an isolated cluster as expected. Like *R. revoilii*, *R. schlechteri* greatly resembles the species of *R. digitata*, with the exception of narrow leaves and a more clear "angel wing" shape of the lateral leaflets. *Rhoicissus schlechteri* has looping veins, entire margins as well as being mostly a climber or creeper than a shrub as it is mostly collected in this form along the forest margins. *Rhoicissus schlechteri*, however, has a northern KwaZulu-Natal distribution as is seen in Figure 54 where most of the specimens collected were from this area; with the exception of one specimen which was collected in the Western Cape. This specimen needs further investigation. The specimens of *R. digitata* and *R. schlecheri* collected from this area (northern KwaZulu-Natal) look distinct from each other. Intermediates of these species have been reported from areas where both these species are found which could mean that these species still have the ability to breed with one another. This suggests that *R. revoilii*, *R. schlechteri* and *R. digitata* are possibly undergoing mosaic evolution. The evolution of organisms can be defined as a process by which different characteristics of organisms evolve at different rates and times, as a result of selection or mutation pressures except if they are bound together by their contribution to the same adaptive syndrome, or due to developmental constrains, pleiotropic action of genes or genetic linkages (Stebbins, 1983). When the anatomical characteritics evolve independently such that they result in a major transition between groups of similar organisms (e.g. vertebrates), this is said to be "mosaic evolution" as a mix of independently evolved characteristics resulted in the change of one major anatomical characteristic (Stebbins, 1983). Multiregional evolution (MRE) or the polycentric hypotheis could also apply here. (Newmaster *et al*., 2007).
Rhoicissus digitata might still be in the process of diverging into three subspecies, with *R. digitata* subsp. *digitata* being the "prime" subspecies while *R. digitata* subsp. *nov, b* and *R.*

digitata subsp. *nov*. *a* being the new subspecies of this group. *Rhoicissus digitata* subsp. *nov. b* and *R. digitata* subsp. *nov.* a occur in two different locations of KwaZulu-Natal. One subspecies (*R. digitata* subsp. *nov.* b in this thesis) has been reported by Boon (2010) to occur primarily on the southern coastal areas of KwaZulu-Natal while the other (*R. digitata* subsp. *nov.* a in this thesis) mostly occurs along the coastal areas of northern KwaZulu-Natal. The distribution of the specimens used for both these respective subspecies in this study, also reflects this pattern of distribution. The slight difference between the two subspecies might have been caused by the different coastal areas that the two subspecies are found at, as both these subspecies are yet to be collected in one area. This could add further support to the conclusion that the difference in location that both these subspecies are found in, has given rise to the difference observed in the two new subspecies of *R. digitata*. Although significant differences between the two subspecies were not found throughout the different statistical analyses that were performed, morphological differences exist though that indicate that *R. digitata* is diverging.

The apices of the terminating leaflets of both the new subspecies of *R. digitata* are different from each other. The apices on the terminating leaflets of *R. digitata* subsp. *nov. b*. have an emarginate apex while those of *R. digitata* subsp. *nov*. *a* have an obtuse apex. They are mostly like those of *R. digitata* subsp. *digitata* especially the leaves that are 5-foliate. Also, the leaves of *R. digitata* subsp. *nov* b are much smaller than those of *R. digitata* subsp. *nov*. a which are much broader, even to those of *R. digitata* subsp. *digitata*. The looping veins of *R. digitata* subsp. *nov.* a are much more obvious and clearer in this subspecies, in that these veins are not faint as they are visible on both the ad- and the abaxial surfaces of the leaves (both terminating and lateral leaflets). Also, there is a larger space between the looping veins and the margin of the leaflets of this subspecies making the veins even more obvious and clear. Those observed on the leaflets of both *R. digitata* subsp. *nov*. b as well as *R. digitata* subsp. *digitata* are less obvious, and the space between their looping veins and the margins of the leaflets is also smaller. The looping veins on these leaves are also clearly visible on the adaxial surface while not on the adaxial surface. These physical differences between the two subspecies as well as *R. digitata* subsp. *digitata* gives substantial support to the reports that *R. digitata* might be a complex having three subspecies.

This, however, was not supported by the statistical results obtained when measurements taken from three species of *R. digitata* were compared. There was no significant difference found

between the lengths and breadths of the leaflets of these species, for both terminating and lateral leaflets. The lack of the difference between the leaflets of these species might mean that the diversion of these species is still at the early stages. Also, it might happen that the existing differences between these subspecies are too subtle to be picked up by the statistical tests used hence no significant differences were found between them.

The same cannot be said for the species of the *R. tridentata* complex which showed differences both in appearance and when the species were statistically analysed for these differences. In the phenetics analyses that were conducted in this study, the species of this complex (*R. tridentata* complex) were found among those of *R. sessilifolia* which formed a cluster. The resulting dendrograms displaying the similarities between the species of this genus (*Rhoicissus*) showed similar patterns in terms of the manner in which clusters of these species formed alongside one another in all the dendrograms. The clustering of these species among one another was relatively the same throughout all the dendrograms which were obtained during the phenetic analysis. The subspecies of the *R. tridentata* complex were divided into two groups by two of the phenetics analyses (Nearest Neighbour and Between Groups method) that were conducted. The subspecies of this complex did not however form separate clusters within the cluster of the complex. This means that the phenetic analyses did not find any major differences between the subspecies of this complex. Apart from being relatively indistinguishable from each other (as per the test results), these species were found to be closely linked to *R. revoilii*, *R. digitata*, *R. rhomboidea* as well as *R. sessilifolia* by the phenetic analyses. However, the sessile leaves of *R. sessilifolia* make it a clear and distinct species. It is well know among pheneticists that when the number of OTUs are above or comes close to the number of characters (as it does in this case), the resolution turns out to be generally poor (Nicholas pers com.). Small number of OTUs with large numbers of characters usually give good clustering, but can be regarded as being borderline science (Nicholas pers com.)

Of the above four species, the species of the *R. tridentata* complex greatly resemble *R. rhomboidea* as well *R. sessilifolia*, both of which have toothed margins. All these species have dentitions in the form of teeth along their margins. The subspecies of the *R. tridentata* complex have more teeth along their margins than those of the other two species with the exception of *R. tridentata* subsp. *tridentata*. *Rhoicissus tridentata* subsp. *nov.* c especially has very deep

dentitions along its margins; *R. tridentata* subsp. *cuneifolia* has medium sized dentitions compared to those of the two other subspecies while in *R. tridentata* subsp. *tridentata* the dentitions are very shallow and sometimes, absent. The three subspecies of the *R. tridentata* complex were found to be similar in the phenetic analyses that were conducted.

Rhoicissus tridentata subsp. *nov*. c even has the secondary lateral veins (at the base of the leaflets) terminating with dentitions unlike those of *R. tridentata* subsp. *cunefolia*. *Rhoicissus tridentata* subsp. *tridentata* does not have secondary lateral veins and has few to zero dentitions at the end of the lateral veins of its leaflets. This difference in the number of dentitions, their depth, the total number of lateral veins as well as the length and the breadth of the leaflets of the subspecies of this complex was found to be slight different by the phenetic analyses conducted. The statistical tests, however, revealed a significant difference between the leaflets of these subspecies. The total numbers of the lateral veins as well as the dentitions found on both the lateral and terminating leaflets of these subspecies were found to be significantly different between them. These measurements were found to be of one size between the specimens of one subspecies but different to those of the other subspecies of the same complex. This might be due to the difference in the length and breadth of the lateral and terminating leaflets of one subspecies against the others. *Rhoicissus tridentata* subsp. *nov.* c has the biggest leaflets out of the three subspecies and this is probably why its leaves have the greatest number of both lateral veins and dentitions along the margin. The great surface area observed on the leaflets of this species could be an adaptation as mostly this subspecies is found within forests where light is limited. By increasing its surface area, this species ensures that it captures as much of the limited light when it is available, thus ensuring its survival in these environments. *Rhoicissus tridentata* subsp. *cuneifolia* is mostly found in shrublands and occasionally along forest margins, has medium sized leaflets compared to the other two subspecies of the complex. These leaflets are without dentitions at the end of the secondary lateral veins which originate at the base of the leaflets. The dentitions on the margins at the end of the lateral veins are not very deep, especially when compared to those of *R. tridentata* subsp. *nov*. c. Apart from the leaves of *R. tridentata* subsp. *cuneifolia* being medium sized, the individuals of this subspecies at the above mentioned habitats are also medium in size. This size in these individuals might be an adaptation, especially in shrublands, since by being medium in height, and size in general, the individuals are small

enough to avoid excessive water loss but large enough to reduce the space where the other species might grow. Their size also allows them to grow in greater numbers within one habitat thus enabling their survival as a species in that habitat.

Rhoicissus tridentata subsp. *tridentata* is afforded its survival in grasslands and shrublands due to the extremely small and highly indumented leaflets that the individuals of this subspecies possess. This subspecies is mostly found at these habitats and usually with its leaves highly reduced in size, unlike those of the other two species of the *R. tridentata* complex. It also has reduced dentitions (sometimes zero) along the margin and has no secondary lateral veins originating from the base of the leaflets. The small size and excessive indumentum on the leaflets extensively suppresses water loss thus enabling this subspecies to survive at these environments. The lack of dentitions along the margin of the leaflets of *R. tridentata* subsp. *tridentata* might be because they are not glandular, the reason for this is unknown.

Unfortunately both the scatter diagrams and polygonal graphs showed no major significance between the subspecies of *R. tridentata*-complex and the *R. digitata*-group. As a result they have little scientific value. However, the results favouring some separation of the subspecies in the *R. tridentata*-compex is supported by the results obtained through a Two-Way ANOVA statistical analyses that showed three groups within this complex.

The other species of *Rhoicissus* (*R. sessilifolia*; *R. rhomboidea*; *R. tomentosa*) form clusters of their own. *Rhoicissus sessilifolia* with the sessile lateral leaflets was separated into its own cluster by the phenetic analyses that were conducted. This clear separation of *R. sessilifolia* from the other species of *Rhoicissus* might be explained by this species being the only one in this genus with sessile lateral leaflets and a distribution primarily in northern KwaZulu-Natal. Even the dentitions on the margins of the leaflets of this species are different from those of the other species with dentitions in this genus. The lateral leaflets of this species are always with dentitions (sometimes reduced to 1 or 2) while the terminating leaflets are sometimes without dentitions, especially if the leaflets are small or medium sized. Also, the terminating and the lateral leaflets of *R. sessilifolia* have different shapes from each other, which is unlike those of the other species of *Rhoicissus*.

Almost all the species of this genus have the lateral leaflets in an asymmetrical shape of the terminating leaflets. Such is *R. rhomboidea* which has its leaflets in a unique rhomboid-shape. Apart from this unique shape though, *R. rhomboidea* usually has six dentitions along the margins of its leaflets unlike those of the other species of *Rhoicissus*, which vary greatly. When it comes to the distribution of *R. rhomboidea*, like *R. revoilii* and *R.tomentosa*, it is among the few species of this genus that are found both along the coastal and inland areas. *Rhoicissus rhomboidea* is also found within forests and usually has very large internodes in these environments.

Rhoicissus tomentosa like *R. rhomboidea*, it has large internodes when it is found within forests. Unlike the other species of *Rhoicissus*, however, *R. tomentosa* is the only species in this genus with simple leaves. In addition, its leaves are the only leaves with lobes along the margins. The rest of the species of this genus either have entire margins or dentitions along the margin. It is also the only species that has three veins which originate at the base of the leaves.

The last three species (*R. sessilifolia*, *R. rhomboidea* and *R. tomentosa*) of *Rhoicissus* were found to be very distinct both through observation as well as through the phenetic analyses that were conducted. No subdivisions into complexes or groups were observed in these three species thus, no statistical analyses were conducted. Also, the existence of these species as separate species of this genus has been long recognised (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010) and no evidence of their separation within species have been either reported or observed; thus further analyzing these species through statistics was not necessary.

As described in this dissertation, the analyses of all the species of this genus were based on the leaves of the species of this genus because they are more diagnostic than any other organ of the species. The results obtained in this report might be supplemented better by DNA analysis which is why these analyses are suggested to be done in future studies. A full DNA analyses done on the vegetative materials of the species of this genus might further clarify the relationships of the species of *Rhoicissus*. This would be possible because the changes observed phenotypically are initiated by and come about as a result of the changes in the genes of the species. Sometimes changes might occur in the genotype of the species and still not be the phenotype of that same species because there is a time lapse between the changes that occur in the genotype to those which occur in the phenotype. That is why DNA analyses would be highly helpful to include in

future studies of both this genus and others. Also, generally, the presence of latent genes is also well known.

Chapter 8

Taxonomy

INTRODUCTION

This taxonomic section is based primarily on the leaves of the *Rhocissus* species of the KwaZulu-Natal region. There are no full descriptions for each of the species. The reason for this is that this work is meant to help conservationists, environmental managers, rangers, amateur botanists and others who will usually only encounter these species in their vegetative state. It is at this audience that this dissertation is aimed.

8.1 Key to the species of *Rhoicissus* in southern Africa

1. Species with simple leaves (sometimes with lobes along the margins)……..……..*R. tomentosa*
   Species with compound leaves……...…….....2
2. Leaves with entire/smooth margins. Veins on leaves looping at margin.…….……..…3
   Leaves with dentitions along the margins. Veins terminating at the margin with a tooth…….....7
3. Leaves digitate and/ or trifoliate leaflets. Lateral leaflets slightly acute at the tip…….*R. digitata* subsp. *digitata*.
   Leaves trifoliate. Lateral leaflets never acute at the tip…….……..4
4. Leaves with emarginated terminating leaflets…….……5
   Leaves with terminating leaftlet never emarginate…….……...6
5. Leaves with thin but noticeable, looping about 1mm away from leaflet margins…….*R. digitata* subsp. *oravivens* (= a)
   Leaves veins that loop at least 2mm away from the leaflet margin…….…….....……*R. digitata* subsp. *emarginata* (= b)
6. Terminal leaflets extremely narrow and lanceolate. Lateral leaflets with an "angel wing" or subfalcate-shape…..……..*R. schlechteri*
   Terminating and lateral leaflets large, broad and elliptic leaflets…..……*R. revoilii*
7. Species with sessile trifoliate leaves……...….……*R. sessilifolia*
   Species with petiolate leaves and leaflets…….……...……....8

8. Species predominately a climber with terminating leaflets with a rhomboid in shape and with about 6 dentations along the margin……*R. rhomboidea*
   Species predominately a shrub within the habitat and has dentations along the margin…….9
9. Leaves tiny with few dentition (2 or 3)……...…..……*R. tridentata* subsp. *tridentata*
   Leaves large with many dentitions (> 10)……10
10. Leaves with deep dentations (up to 18) along the margins and double veined at the base of the leaflets…….*R. tridentata* subsp. *diplonerva* (= c)
    Species with wedge shaped terminating leaflets and medium sized dentations (12 and up), secondary lateral veins without dentations…….……..*R. tridentata* subsp. *cuneifolia*

8.2 ***RHOICISSUS*** **Planch.**

Rhoicissus Planchon in Alph. de Candolle et A. C. de Candolle, Monogr. Phan. 5: 320, 463. Oct 1887. Type Species: *Rhoicissus capensis* (Burm. *f*.) Planch. LT designated by Suessenguth in Engler et Prantl, Nat. Pflanzenfam. ed. 2. 20d: 329 (1953)

Gilg & Brandt. 1912. *Botanische Jahrbücher* 46: 436-442; Wild & Drummond. 1963. *FZ* 2: 444-448; Retief. 1980. *Bothalia 13*: 146, 147; Urton *et al*. 1986. *South African Journal of Botany* 52: 389-396; Retief. 1993. *Bothalia* 23: 231-233; Retief & Van Jaarsveld. 1997. *Bothalia* 27: 49-51; Retief & Herman. 1997. *Strelitzia* 6: 650; Retief. 2000. In Goldblatt & Manning in *Strelitzia* 9: 688; Retief *et al*. 2001. *South African Journal of Botany* 67: 230-234.

8.3 The Leaf Taxonomy of the Species of *Rhoicissus*

8.3.1 The *Rhoicissus digitata* group

8.3.1a *Rhoicissus digitata* (L.*f*) Gilg & M. Brandt. **subsp. *digitata***

Rhoicissus digitata (L.*f*) Gilg & M. Brandt. in Engl., Bot. Jahrb. 46: 439 (1911). Type: South Africa, Cape Province; *Thunberg s.n.* [S not seen] Suesseng. in Engl. & Prantl, Nat. Pflanzenfam., ed. 2, 20d: 330 (1953).

Rhus digitata L.*f.* Suppl. Pl.: 184 (1781). Type: same as above.

Cissus thunbergii Eckl. & Zeyh. Enum. Pl. Afr. Austr.: 56 (1835). Type: same as above

Cissus thunbergii Harv. in Harv. & Sond., F.C. 1: 250 (1860), nom. illegit. Type: same as above.

Rhoicissus thunbergii Planch. in A. & C. DC., Mon. Phan. 5 (2): 469 (1887), nom. illegit. Type: same as above.

Rhus cirrhiflora L.*f.* Suppl. PL: 184 (1781). Type: South Africa, Cape Province. *Thunberg s.n.* [S not seen].

Rhoicissus cirrhiflora (L.*f.*) Gilg & Brandt. Pl. Afr. Austr.: 56 (1835). Type: South Africa, Cape Province. *Thunberg s.n.* (S not seen). Harv. in Harv. & Sond., F.C. 1: 250 (1860).

Description

Rhoicissus digitata is a woody climber or scandent shrub with young parts ferruginous-villous with rather long hairs which later become glabrescent. The branches of this species have pale lenticels and tendrils that are glabrescent. The leaves are 3-5-foliolate (specimens almost invariably with some 5-foliolate leaves) and their petiole grows up to be 2.8 cm long. The stipules of these leaves are 5 mm long and approximately oblong in shape, ferruginous-villous and very caduceus. The leaflet-lamina grows up to be 9 × 2.8 cm (the terminating leaflet is the longest) and narrowly oblong to oblong-oblanceolate in shape. The apices on the leaflets are acute or obtuse, margins entire or with a few dentations and approximately revolute. The bases of these leaflets are cuneate. The leaflets are glabrous on adaxial surfaces and appressed-ferruginous-pubescent on abaxial surfaces, at least on the

main nerves and midrib. The main nerves are approximately prominent on the abaxial surface and usually have domatia in their axils. The petiolules grow up to be 0.8 mm long.

Habitat and Ecology

This species can grow and reach 15m in length and is usually a woody climber or a scrambling vine in riverine fringing vegetation, forest, forest margins, grasslands as well as valley bushveld (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Retief *et al*., 2001; Boon, 2010). Besides South Africa this species can be found in Swaziland and Mozambique (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Boon, 2010).

Distribution

This robust woody climber (*R. digitata* subsp. *digitata*) can be found distributed in the valley bushveld, forests, forests margins and grasslands (Pooley, 1994; Boon, 2010). *Rhoicissus digitata* subsp. *digitata* is often found commonly occurring on the coastal dunes of KwaZulu-Natal and the Eastern Cape (Pooley, 1994). Apart from KwaZulu-Natal and Eastern Cape, this species can also be found distributed in North-West, Northern Cape; Mpumalanga and the Western Cape (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). Outside South Africa, this species can be found in Swaziland and Mozambique (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

Leaves

Figure 45a: The trifoliate leaves of *R. digitata* subsp. *digitata* (L.*f*.) Gilg & M. Brandt. (x 1.16)

Figure 45b: The pentafoliate leaves of *R. digitata* subsp. *digitata* (L.*f*.) Gilg & M. Brandt. (x 1.12).

Specimen Citation

South Africa: Eastern Cape: 3228 (Transkie): Eliordale (The Haven) (-BB), *Gordan-Gray, J.H. 1364* (NU). KwaZulu-Natal: 2230 (Zululand): Mtunzini (Port Durnford), *Venter, H.J.T 1834* (NH). 2930 (Pietermaritzburg): Table Mountain (-DA), *Killick, D.J.B 514* (NH). 3030 (Port Shepstone): Umtamvuna Nature Reserve (Hiden Valley, South Rigde) (-CC), *Abbott, A. 800* (NH); Umtamvuna Nature Reserve (Crocodile), *Abbott, A. 3496* (NH); Nquabeni (Nort west facing arid slopes above Umtamvuna grassland), *Abbott, A. 4475* (NH). Western Cape (Western Cape): *Thode, J. A. 2626* (NH).

8.3.1b *Rhoicissus digitata* subsp. *oravivens* Kunene, Nicholas & Boon subsp. nov

Type: South Africa, KwaZulu-Natal, Port Durnford, Drift Sand Beach, *H.J.T. Venter 1834*, [PRE! Holotype designated here]. Was *Rhoicissus digitata* subsp. *nov.* a. in first part of dissertation.

Diagnosis

This subspecies has overly broad leaflets that have the looping veins at least 2mm away from the leaflet margin.

Description

This is the only species of this complex with the looping veins that are excessively visible on the leaf surfaces. The looping veins of this species are also located a few mm (2mm) away from the leaflet margins. This is unlike those of the other two species (*R. digitata* subsp. *digitata* (L.*f*.) Gilg & M. Brandt. and *R. digitata* subsp. *emarginata*), which have their looping veins positioned closer to the margins and sometimes on the margins themselves. Terminating leaflets are 6 x 2.6 cm while the lateral leflets are 5.5 x 2.4 cm. the length of the leaves is 8 cm. The apices of the leaves are usually rounded or obtuse. The branching stems of this species are smooth and usually without lenticels or with small (1mm) lenticels if they are present. The main stem at which the branching stems originates from is, however, corky and woody.

Distribution and, Habitat and Ecology

Rhoicissus digitata subsp. *oravivens* is largely found distributed along the coastal, and dune forests of northern KwaZulu-Natal. This species is usually a climber in these forests and not a creeper like *R. emarginata*.

Leaves

Figure 46: The trifoliate leaves of *R. digitata* subsp. *oravivens*. (x 1.33).

Specimen Citation

South Africa: KwaZulu-Natal 2732 (Jozini): Ubombo in a dune bush near Raphia grove (-BB), *Strey R.G. 8242* (NH). 2831 (Mtunzini): Twinstream Project (-CC), *Hutchings, A. & Geheeb-Keller, M 3AH & MG-K* (NH); Umlalazi Nature Reserve (-DD), *Ward, C.J. 4234* (NH). Port Durnford, Drift Sands Beach, Coastal Forest (-DD), *Venter, H.J.T. 1834* (NH). 2832 (Mtubatuba): In the vicinity of the Lutheran Mission Station near Kwa-mbonambi forest reserve (-CA), *du Toit, P.C.V. 1254* (NH). 2930 (Isipingo): Isipingo (-DD), *Forbes & Obermeyer 23* (NH). 2931 (Tugela): Lower Tugela, Tugela mouth (-AB), *Edwards, D. 1724* (NH). 3030 (Port Shepstone): Port Shepstone, dune bush on the white sand, facing sea (-CB), *du Toit P.C.V. 1224* (NH). 3030 (Port Shepstone): South Coast, Mpenjati Nature

Reserve (-CD), *von Fintel, M. 516* (NH). 3030 (Port Shepstone): Uvongo Beach Port Shepstone (-CD), *Coleman, T.A. 416* (NH).

8.3.1c *Rhoicissus digitata* subsp. *emarginata* Kunene, Nicholas & Boon subsp. nov.

Type: South Africa, KwaZulu-Natal, Umdloti Park, *Jarman & Guy, 375* [NU! Holotype designated here]. Was *Rhoicissus digitata subsp. nov.* b. in first part of dissertation.

Diagnosis

Most of the terminating leaflets of this subspecies are emarginate unlike those of the other subspecies of *R. digitata*. The plant has a tendancy to creep or crawl rather than to climb.

Description

The leaves of this species are trifoliate, much like those of *R. digitata* subsp. *digitata*. Most of the terminating leaflets of this species are, however, emarginated unlike those of *R. digitata* subsp. *digitata* and *R. digitata* subsp. *oravivens*. The main stem of this species is found within the trees of dune forests and is thick (± 50mm) and woody, while the branching stems are thin and flexible. This allows this species to grow around other vegetation in its vicinity and to wrap itself around them for support as well as for anchorage. Terminating leaflets are 4.6 x 2.5 cm while the lateral leaflets are 4.4 x 1.6 cm. The length of the leaves is 5.3 cm.

Specimen Citation

South Africa: KwaZulu-Natal: 2831 (Zululand): Mtunzini District (-DD), *Ward, C.J. 6075* (NH). 2931 (Durban): Salisburg Island (-CC), *Forbes, H.M. 337* (NH); *Tyrrell, I.C. NH 21311* (NH) 3030 (Port Shepstone): Umsumbe sand dune at beach (-DA), *Strey, R.G. 6871 II* (NH). 3030 (Isipingo): Isiphingo North (-BB), *Ward, J.C. 356* (NU). 3030 (Umdoni Park): Umdoni Park (-BC), *Jarman & Guy NU 47737* (NU).

Leaves

Figure 47: The trifoliate leaves of *R. digitata* subsp. *emarginata*. (x 1.01).

Figure 48: *Rhoicissus digitata* subsp. *emarginata* found along the dunes of Pennington Beach.

Distribution Map of the *R. digitata* group

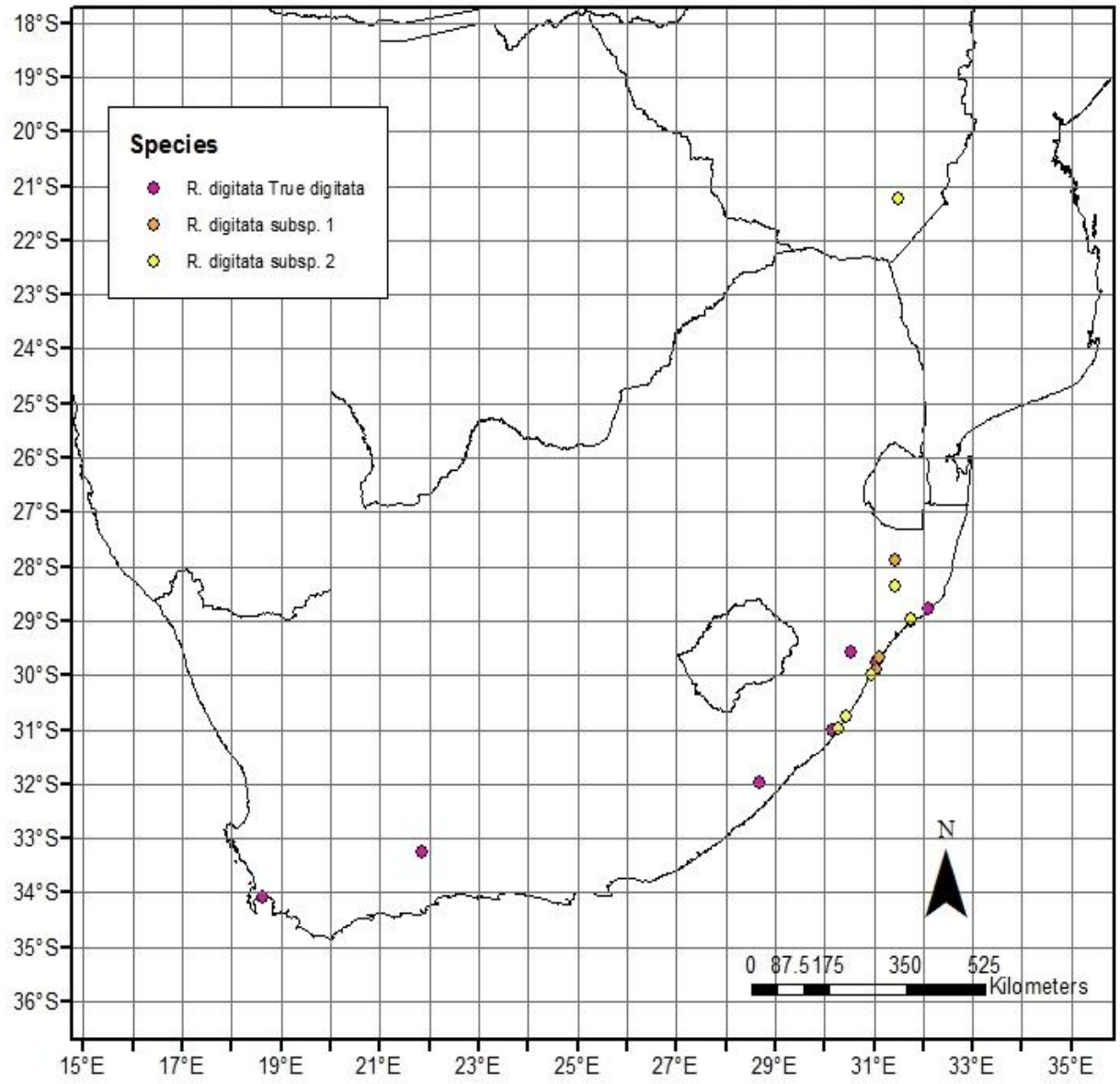

Figure 49: The distribution of the species of *R. digitata* group.* True *digitata* refers to *R. digitata* subsp. *digitata*; *R. digitata* New species 1 refers to *R. digitata* subsp. *emarginata* and *R. digitata* New species 2 refers to *R. digitata* subsp. *oravivens*.

8.3.2 ***Rhoicissus revoilii* Planch.**

Rhoicissus revoilii Planch., in A. & C. DC., Mon. Phan. 5, 2: 469 (1887). Type Somalia, Djibouti (Djibouti), *G. Revoil 26* [P – photo of type seen]. Gilg & Brandt in Engl., Bot. Jahrb. 46: 440 (1911). Brenan, T.T.C.L.: 31 (1949). Suesseng. in Engl. & Prantl, Nat. Pflanzenfam., ed. 2, (20d): 332 (1953). Keay, in F.W.T.A., ed 2, 1 (2): 681 (1958). Willems, in F.C.B. 9: 566 t 56 (1960).

Rhoicissus sansibarensis Gilg , in Engl., Pflanzenw. Ost-Afr. C: 257 (1895). Type from Zanzibar but stipulated in protologue. Bak. *f.* in Journ. Linn. Soc., Bot. 40: 47 (1911). Eyles in Trans. Roy. Soc S. Afri. 5: 408 (1916).

Rhoicissus erythrodes var. *ferruginea sensu* Eyles, in Engl., Pflanzenw. Ost-Afr. C: 438 (1911). Type: Mozambique, Delagoa Bay, *Schlechter 11990* [Holo B†; Lecto BM selected here]; Syntype: *Junod 304* (Z). Burtt Davy, F.P.F.T. 2: 473 (1932). Suesseng., F.P.F.T. 2: 330 (1953).

Rhoicissus schlechteri Gilg & Brandt., in Engl., Pflanzenw. Ost-Afr. C: 438 (1911). Type: As above. Burtt Davy, in F.P.F.T. 2: 473 (1932). Suesseng., in F.P.F.T. 2: 330 (1953).

Rhoicissus spp., Eyles, in Engl., Pflanzenw. Ost-Afr. C: 438 (1911). Type: As above. Burtt Davy, in F.P.F.T. 2: 473 (1932). Suesseng., in F.P.F.T. 2: 330 (1953).

Description

Rhoicissus revoilii can be a shrub or small tree to 3.3 m tall with drooping branches or sometimes with sarmentose branches. This species can also be a climber with young branches being appressed-ferruginous-pubescent. They can also be densely fulvous-ferruginous, -pubescent or -tomentose. They later become glabrescent, and have tendrils that are tomentose, pubescent or glabrescent and they are often absent in herbarium specimens. *Rhoicissus revoilii* has leaves that are 3-foliolate and petioles that can grow up to approximately 4 cm long. Indumentum can also be seen in young stems while the stipules on leaves are absent. The leaflet-lamina can grow to be 12 × 6 cm; the terminating leaflets are

narrowly lanceolate, lanceolate, oblanceolate or ovate. Lateral leaflets on the other hand are lanceolate, subfalcate-oblong or rhomboid. The apices on the leaflets can be obtuse or acute while the bases can range from narrowly to broadly cuneate. Margins can be entire (or slightly undulate-lobed on the lateral leaflets) or sometimes revolute. The leaflets can be thinly pubescent to glabrous on the adaxial surface and ferruginous or fulvous-tomentose to glabrous on the abaxial surface. The axils of the main nerves sometimes have domatia. Petiolules grow up to 2 cm long.

Habitat and Ecology

Not much has been reported about the ecology of this species. However, Boon (2010) reported that it also produces edible fruits. Also, at higher latitudes it is often found in *Brachystegia* woodlands especially those found occurring on rocky hills (Wild & Drummond, 1963). In these areas it is found in forest margins; bushveld; riverine shrubs or woodlands (Wild and Drummond, 1963; Retief and Herman, 1997; Retief, et al., 2001; Boon, 2010).

Distribution

Rhoicissus revoilii is widely distributed not only here within South Africa (KwaZulu-Natal and less commonly in the Eastern Cape Province), but also in Africa as a whole (Boon, 2010). This species can even be found in areas such as the Comoros Islands, Saudi Arabia, Mozambique, Zimbabwe, Ghana, Congo as well as East Africa (Wild and Drummond, 1963; Boon, 2010).

Distribution Map

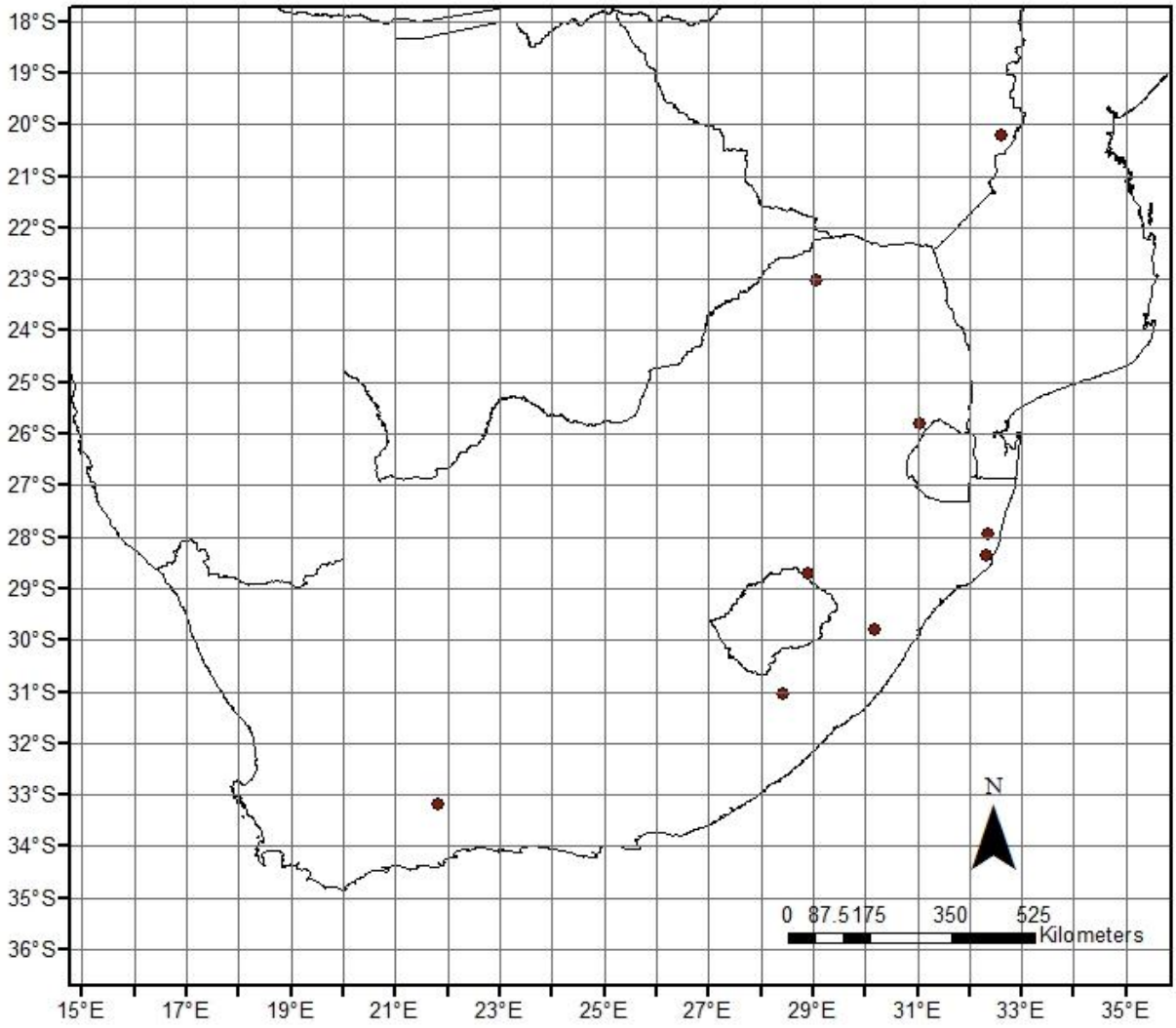

Figure 50: The distribution of *R. revoilii* in South Africa.

Leaves

Figure 51: The leaves of *R. revoilii* (x 0.87).

Specimen Citation

South Africa: Eastern Cape: 3128 (Maclear): Farm Tsitsa, ± 14 km east from Maclear on the border with the former Transkei. KwaZulu-Natal: 2930 (Richmond): Byrne Valley. Minerv Private Nature Reserve. 400m from Tamarin Cottage (-CD), *Ntuli, R.N. 207 (Sheet 3 of 3)* (NH). North West: 2329 (Transvaal, North East): Blouwberg Nature Reserve (-AA), *Vos, W. 202* (NU). 2531 (Mpumalanga): Barberton District. Besides road between Havelock and Barberton. Highlands Estate of Twello Forest (-CC), *Balkwill, K. 1511* (NU). Western Cape: 3227 (Toise River): (-AD), *Scin, T.R. 1819* (NU).

8.3.3 *Rhoicissus rhomboidea* (E. Mey. ex Harv.) Planch.

Rhoicissus rhomboidea (E. Mey. ex Harv.) Planch. in A. & C. DC., Mon. Phan. 5 (2): 467 (1887). Type: South Africa, KwaZulu-Natal, Port Natal, *J.F. Drege s.n.* [S Lectotype selected here. Photo seen]. Epitype: South Africa, Eastern Cape Province, Howison's Poort, *H. Hutton* [TCD not seen]. Gilg & Brandt in Engl., Bot. Jahrb. 46: 439 (1911). Bak. *f.* in Journ. Linn. Soc., Bot. 40: 47 (1911). Eyles in Trans. Roy. Soc. S. Afr. 5: 408 (1916). Burtt Davy, F.P.F.T. 2: 473 (1932). Suesseng. in Engl. & Prantl, Nat. Pflanzenfam., ed. 2 (20d): 332 (1953).

Cissus rhomboidea E. Mey. ex Harv. (Vitaceae), in Harv. & Sond., F.C. 1252 (1860). Type: As above.

Description

Rhoicissus rhomboidea can be a scrambling vine or tall liana. The young parts are ferruginous-villous with long weak hairs which soon become glabrescent. The tendrils are glabrescent. The leaves are 3-foliolate; the petiole can grow up to 2.3 cm long and the stipules are absent. The leaflet-lamina can grow up to be 6 × 4 cm. The terminating leaflets are obovate in shape while the lateral leaflets are asymmetrical and rhomboid in shape. The apices are acuminate, and the bases are cuneate. The margins of the leaflets have approximately 6 acuminate dentations and have petiolules that grow up to be 1-4 cm long.

Habitat and Ecology

The fruits of *R. rhomboidea* are eaten by both people and birds while its stem is used to make ropes (Pooley, 1994; Boon, 2010). In terms of habitat, this species is found in forests; forest margins and thickets of areas such as KwaZulu-Natal, Eastern Cape as well as the north-west regions of South Africa (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

Distribution

The distribution *R. rhomboidea* extends beyond the bounds of South Africa. It can be found in areas such as Swaziland, Mozambique and Zimbabwe (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010). Within South Africa, however, it can be found in KwaZulu-Natal, Eastern Cape as well as the north-west regions of South Africa (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

Distribution Map

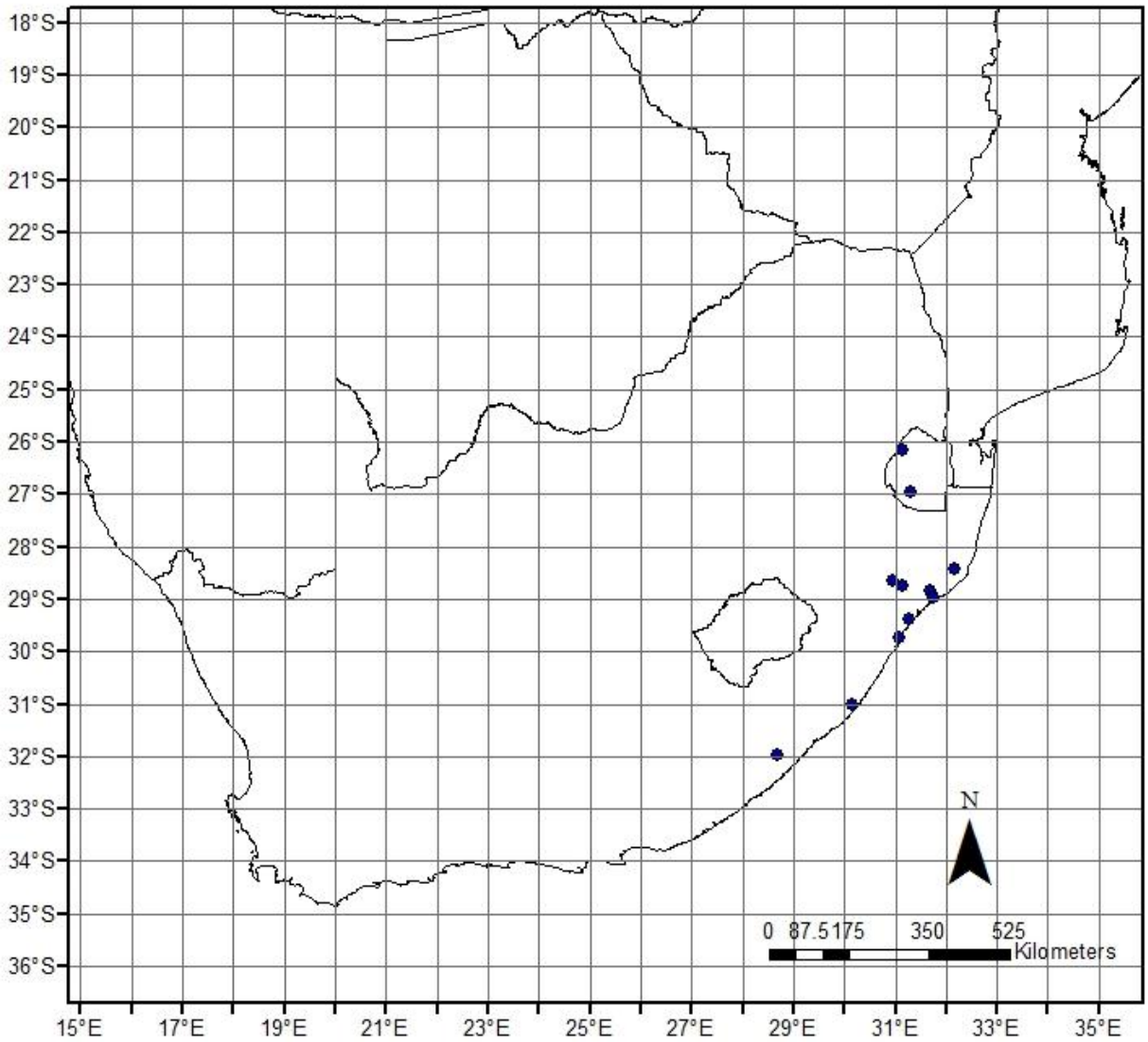

Figure 52: The distribution of *R. rhomboidea* in South Africa.

Leaves

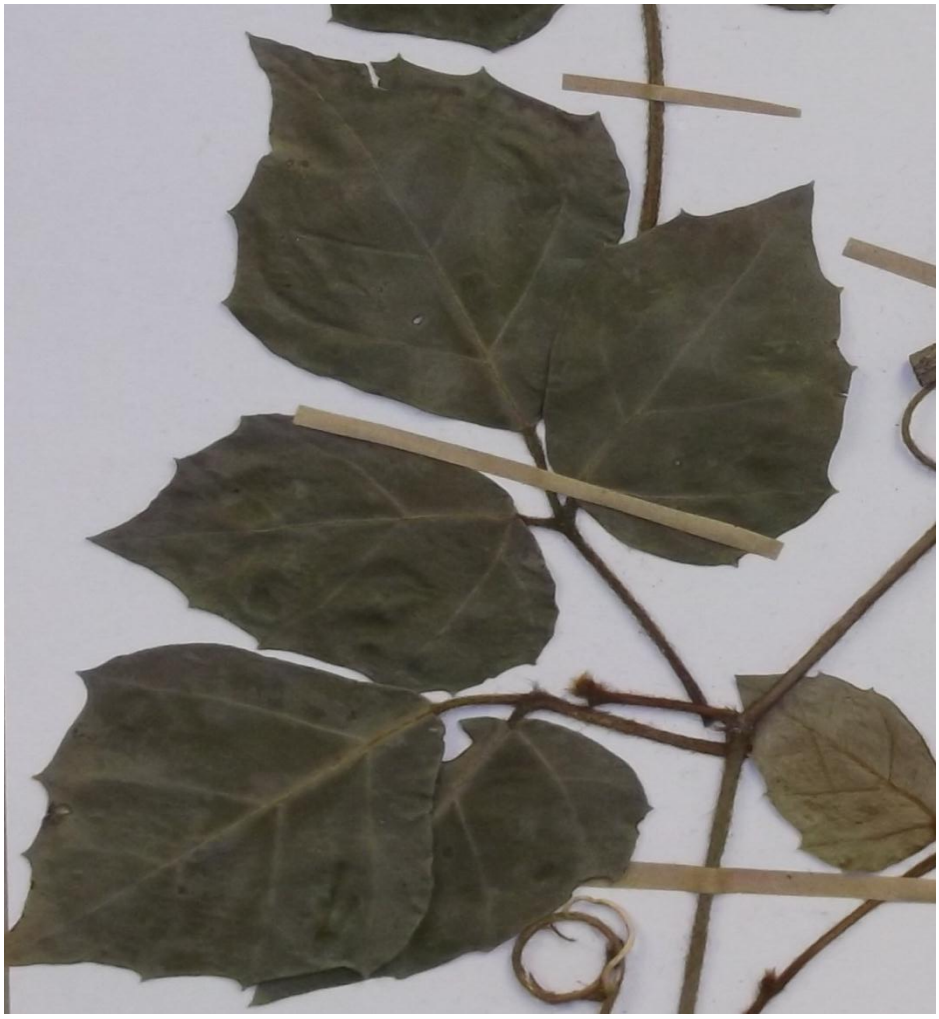

Figure 53: The leaves of *R. rhomboidea* (x 1.09).

Specimen Citation

South Africa: Eastern Cape 3228 (Transkie): Elliotdale, Bashee River Mouth, road verge from hotel to river (-BD), *Cloete, E. 1477* (NH). Swaziland 2631 (Malangwane): Malangwane Hill Valley. Mbabane (-AC), *Dlamini, B. NH 107 996* (NH); *Dlamini, B. NH 107 732* (NH). KwaZulu-Natal: 2831 (Nkandla): Sinkwazi Dune bush (-DC), *Strey, R.G. 11077* (NH). 2831 (Nkandla): Nkandla District. Nkandla Forest Reserve. Machubeni Village,

c. 50m from Chibini Camp (-CA), *Ngwenya, A.M. 2163 (Sheet I of II)* (NH). 2831 (Nkandla): Nkandla District. Nkandla Forest Reserve. Machubeni Village, c. 50m from Chibini Camp (-CA), *Ngwenya, A.M. 2163 (Sheet II of II)* (NH). 2831 (Nkandla): Nkandla District, UMphundumani Village. Nkandla Forest Reserve, EMdonini. c. 10m from local bus stop on Nkandla/Eshowe road (-CA), *Ngwenya, A.M. 2406 (Sheet 1 of 2)* (NH); *Ngwenya, A.M. 2406 (Sheet 2 of 2)* (NH). 2832 (Mtubatuba): Eastern Shores State Forest. Dune forest immediately north of Perriers Rocks (-AD), *MacDevette, D.R. 426* (NH). 2931(Inanda): Umhlanga Rocks. Dune Forest (-CA), *Moll, E.J. 1812* (NH). 2931 (Stanger): Hawaan forest, south bank of Umhlanga River (-CA), *Ross, J.H. & Moll, E.J. 2308* (NH). 2931 (Stanger): Seaton Park, Durban North. Forest on E. facing slope (-CC), *Mills, A.P. 355* (NH). 2931 (Mtunzini): Twinstream, Dune forest (-AC), *Strey, R.G. 6456* (NH). 3130(Umtamvuna): Amphitheatre (-AA), *Abbott, A. 3487* (NH). 2830 (Hlatikulu): Hlatikulu Forest. Hlatikulu District (-AA), *Compton, R.H. 28953* (NH). 2831(Mtunzini): Mtunzini District, Ngoya Forest Reserve (-DC), *Huntley B.J. 217* (NH).

8.3.4 *Rhoicissus schlechteri* Gilg & M. Brandt.

Rhoicissus schlechteri Gilg & M. Brandt. TYPE Mozambique, Provincia de Maputo, Baia de Maputo; *Schlechter, F.R. 1990* (Photo of type seen).

Description

This species is an erect shrub or a sparingly subscandent with tendrils. Its branches gracefully spreading and have dense grooved all around the whole plant, except the petals. Juvenile leaves are covered with silky reddish brown or cinnamon coloured hair. Mature leaves are somewhat smooth and glabrous. The terminating leaflets are intermediate lance with short petiolules. The terminating leaflets equally and gradually narrowed towards the base. The lateral leaflets are narrow-lanceolate shaped, slightly oblique, subfalcatic. The apices of these leaves (terminating and lateral leaflets) are narrow and the lateral veins are in 9-10 pairs. At

the leaf margin they become bent and conjoined to each other when they are dry. The veins on these leaflets are also densely reticulate.

Habitat and Ecology

Unlike *R. revoilii*, *R schlechteri* is a low altitude coastal forest, bushveld and sandy area climber that can grow and reach lengths of 5m (Boon, 2010).

Distribution Map

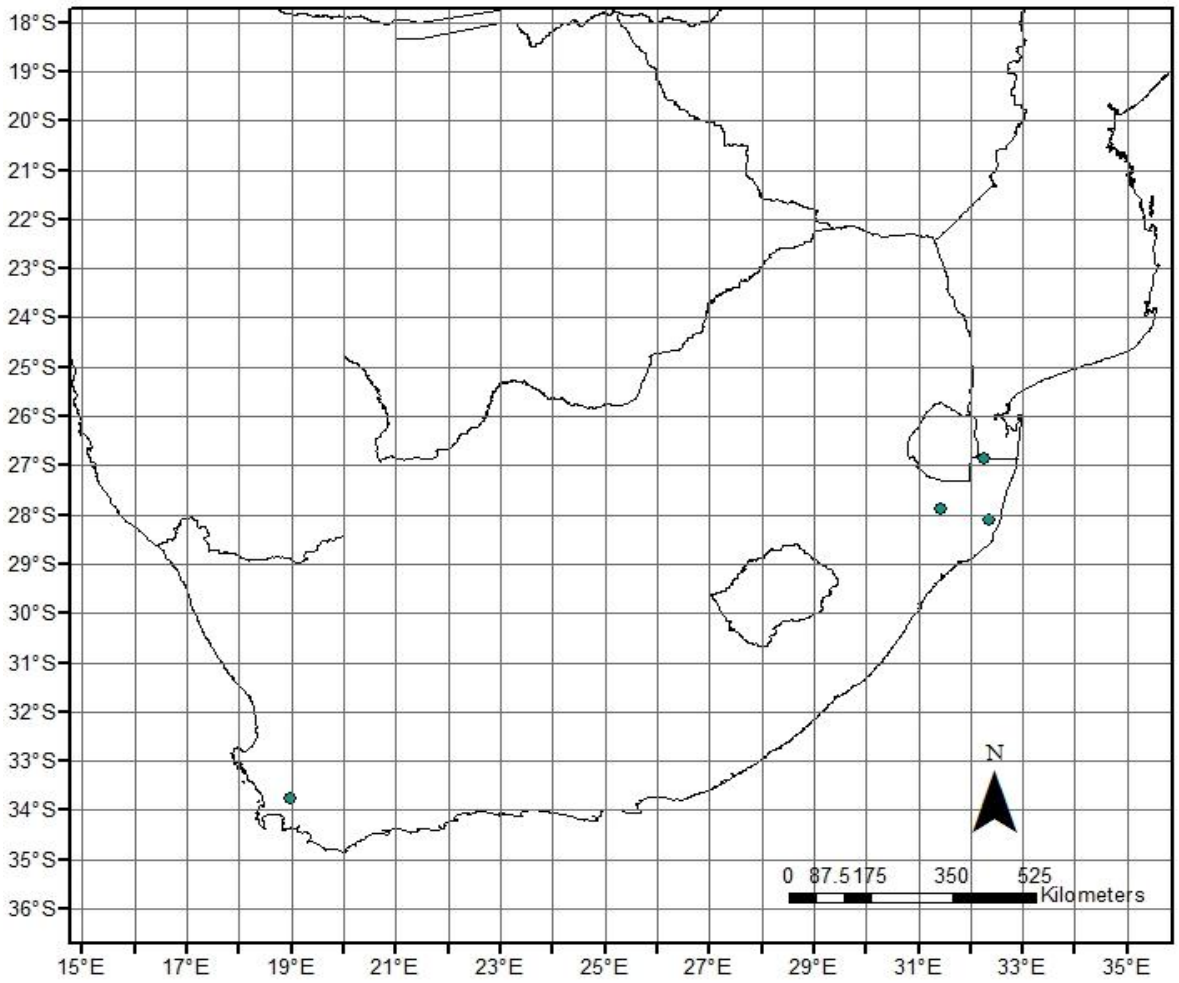

Figure 54: The distribution of *R. schlechteri* in South Africa.

Leaves

Figure 55: The leaves of *R. schlechteri* (x 1.05).

Specimen Citations

South Africa: KwaZulu-Natal: 2632 (Ubombo): Ndumu hill, Ndumu Game Reserve. Ingwavuma district (-CD), *Pooley, E.S. 390* (NH); *Pooley, E.S. 390* (NU). 2632 (Ubombo): Ndumu GR. Ndumu Hill (-CD), *Moll, E.J. 5356* (NH). 2632 (Ubombo): 8 miles from Makanes Bridge on road to Sihangwa (-CD), *Ross, J.H. 2417* (NH). 2732 (Ubombo): Ingwavuma District, Ndumu Game Reserve, Ndumu Hill (-AA), *Tinley, K.L. 982* (NH). 2732 (Ubombo): *Dhlamini 13811* (NH); adjacent the Nibela location, Zululand (-CD), *Ward, M.C. 69* (NH). 2832 (Zululand): Dukuduku (-AD), *Bayer, A.W. 441* (NU).

8.3.5 *Rhoicissus sessilifolia Retief*

Rhoicissus sessilifolia Retief in Bothalia 13: 146-147 (1980). Type: South Africa, KwaZulu-Natal, Ubombo (eastern shores of Lake Sibayi), *Moll & Nel 5619* [PRE, holo!].

Description

Rhoicissus sessilifolia is a climber with warty stems. It has tendrils that are glabrous. The leaves of this species are spirally arranged, sessile, glabrous and 3-foliate. The terminating leaflets of this species are distinctly petiolated and have petiolules that grow up to be 10 and (sometimes 27) mm long. Their lamina are obovate to elliptic in shape and can grow up to be 43-70 mm long and 19-32 mm broad. Lateral leaflets have shorter petiolules 2-3 mm long. The lamina of the lateral leaflets are ovate in shape and 20 mm long and 12-35 mm broad. They have an acuminate apex and an asymmetrical base. The leaflets (terminating and lateral) have entire margins or have 2-3 (sometimes 1) dentitions along the margin. All the leaflets have major veins on both surfaces (adaxial and abaxial) and they are raised to form a conspicuously reticulate venation.

Habitat and Ecology

Ecologically, there is not a lot of information that is known about this species. This might be because it has only recently been correctly described. Thus its ecological contributions might have been mistaken with those of the other species. Also, because this species is reportedly endemic, this might also have resulted in a limited amount of knowledge about this species generally because it is not encountered enough in its habitat. This species occurs in a restricted area of the coastal dune forests of KwaZulu-Natal making it endemic to this area (Retief, 1980). Rhoicissus sessilifolia is a climber in the dune and coastal forests of KwaZulu-Natal (Retief, 1980; Boon, 2010).

Distribution

This species can be found distributed from Mtunzini to Kosi Bay, and possibly southern Mozambique.

Distribution Map

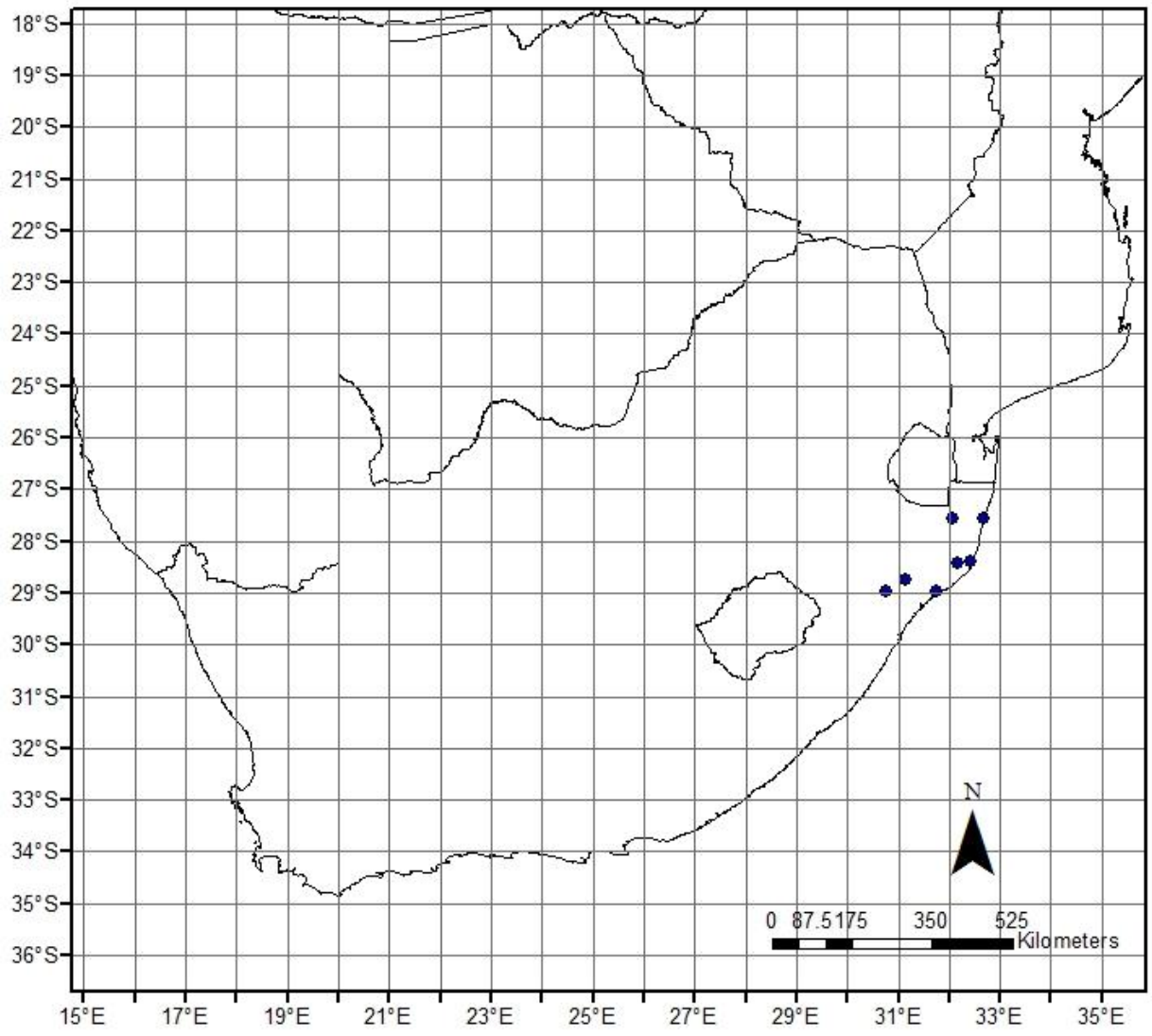

Figure 56: The distribution of *R. sessilifolia* in South Africa.

Leaves

Figure 57: The leaves of *R. sessilifolia* (x 0.78).

Specimen Citation

South Africa: KwaZulu-Natal: 2732 (St. Lucia): Sodwana (-DA), *Bodenstein, J. NH 122182* (NH). 2831 (Nkandla): Twinstreams, Dune bush (-DC), *Strey, R.G. 11079 (I-III)* (NH); *Strey, R.G. 11079 (II)* (NH); *Strey, R.G. 11079 (III)* (NH). 2831 (Eshowe): Mtunzini, Umlalazi Lagoon, Dune Forest (-DD), *Venter, H.J.T. 6029* (NH). 2831 (Nkandla): Umlalazi Nature Reserve (-DD), *Moll, E.J. 4979* (NH). 2832 (Mtubatuba): St. Lucia, Eastern Shores Sate

Forest (-AB), *MacDevette, D.R. 358* (NH). 2832 (Mtubatuba): Richards Bay, Dune Bush (-CC), *Strey, R.G. 11300* (NH). 2832 (Mtubatuba): Richards Bay, Dune Bush (-CC), *Strey, R.G. 11300* (NH). 2831 (Zululand): Mtunzini (-DD), *Lawn, J.G. 1545* (NH). 2831 (Zululand): Mtunzini (-DD), *Lawn, J.G. 2222* (NH). 2831 (Zululand): Mtunzini Dunes (-DD), *Lawn, J.G. 1968* (NH). 2831 (Zululand): Mtunzini (-DD), *Lawn, J.G. 958* (NH). 2831 (Mtunzini): Twin Streams Farm (-DD), *McAllister, H.J. 24* (NU). Swaziland 2732 (Ubombo): (-BB), *Strey, R.G. 8246* (NU).

8.3.6 *Rhoicissus tomentosa* (Lam.) Wild & R.B. Drumm.

Rhoicissus tomentosa (Lam.) Wild & R.B. Drumm. in Kirkia, 3: 18 (1963). Type: Mauritius, *Commerson s.n.*(P – Holo. SRGH – Iso photo). Likely to be from a cultivated specimen.

Cissus tomentosa Lam., III. Gen.: 330 (1791). Type: as above.

Vitis capensis Thunb., Prodr. Pl. Cap. 1: 44 (1784). Type: From South Africa, Cape Province *Collector Unknown*. (Holo probably in Herb Thunberg). *non Vitis capensis* Burm. *f.* (1768). Dandy in Bothalia, 7: 427 (1961).

Rhoicissus capensis Planch., in A. & C. DC., Mon. Phan. 5 (2): 463 (1887). Type: Isotype South Africa, Cape, s. lat: *Collector unknown* (S – photo of isotype seen). Gilg & Brandt in Engl., Bot. Jahrb. 46: 436 (1911). Bak. *f.* in Journ. Linn. Soc., Bot. 40: 46 (1911). Eyles in Trans. Roy. Soc. S. Afr. 5: 408 (1916). Burtt Davy, in F. P. F. T. 2: 473 (1932). Brenan, T.T.C.L.: 31 (1949). Suesseng. in Engl. & Prantl, Nat. Pflanzenfam. Ed. 2 (20d): 329 (1953). Non illegit.

Description

Rhoicissus tomentosa is a high climbing liana with ferruginous-tomentose young branchlets which later glabrescent and are found with large pale lenticels. The tendrils of this species are tomentose. Leaf-lamina grows up to 20 × 16 cm and is broadly transversely elliptic to reniformin shape while the apex is obtuse and margin repand-dentate or in some older leaves,

repand. The bases of these leaves are cordate with a wide sinus which grows up to 6 cm across. They are also very shallowly 3-5-lobed or entire in the Western Cape but not in KwaZulu-Natal, sometimes more deeply lobed or occasionally 3-partite. They are 3-nerved at the base, glabrescent above and approximaely ferruginous-tomentose below. Their petiole grows up to approximately 6 cm long, ferruginous-tomentose while stipules grow up to be approximately 8 × 8 mm. They are very broadly ovate, entire and ferruginous-tomentose.

Habitat and Ecology

The swollen tubers have a red outer flesh (Pooley, 1994; Boon, 2010). The fruits of *R. tomentosa* are eaten by birds, mammals and people, and grown as an attractive vigorous climber, it makes a good screen patio cover (Pooley, 1994; Boon, 2010). This high climbing liana can be found distributed in forests (fringing forests or in gaps in closed forests) as well as on riverine bushes (Pooley, 1994; Retief and Jaarsveld, 1997; Boon, 2010).

Distribution

Specifically in South Africa it can be found in KwaZulu-Natal, Eastern Cape, and Western Cape to the Mpumalanga Province (Wild and Drummond, 1963; Pooley, 1994; Retief, 2000; Boon, 2010).

Distribution Map

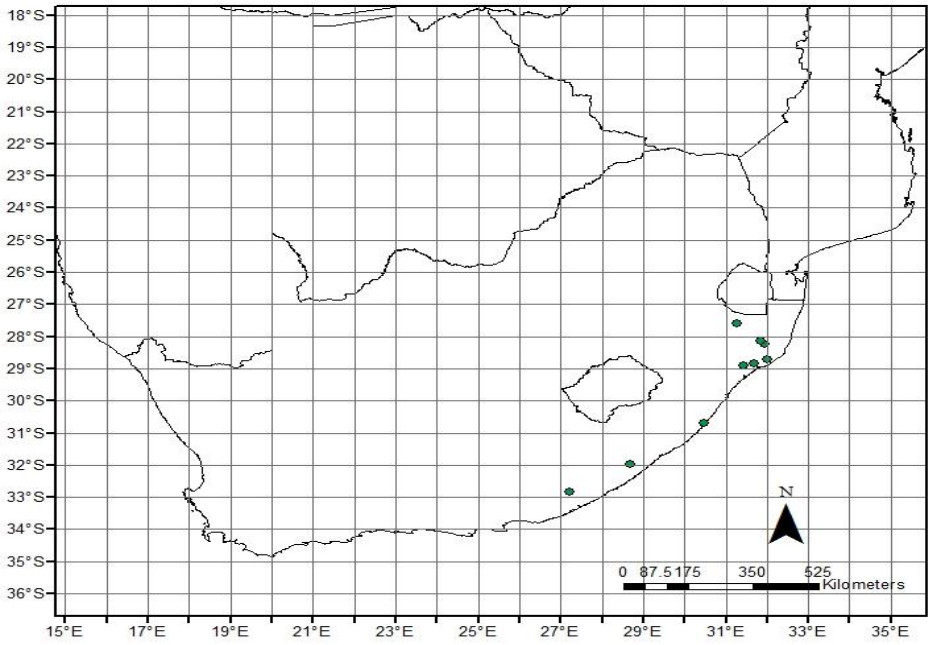

Figure 58: The distribution of *R. tomentosa* in South Africa.

Leaves

Figure 59: The leaves of *R. tomentosa* (x 0.73).

Specimen Citation

South Africa: KwaZulu-Natal: 2831 (Nkandla): Ngoya Forest Reserve, Mtunzini district (-DC), *Huntley, B.J. 224* (NU). 2832 (Zululand): Hlabisa district, Hluhluwe Game Reserve (-AC), *Ward, C.J. 2953* (NU). Western Cape 3124 (Pirie District) (-AD), *Scin, T.R. 1813* (NU). 3128 (Elliotdale District), The Haven (-DC), *Gordon-Gray, J.L. 892* (NU).

8.3.7 ***Rhoicissus tridentata* (L.f.) Wild & Drummond**

Rhoicissus tridentata (L.*f*.) Wild & Drummond, in Kirkia, 3: 19 (1963). TAB. 94. Type South Africa,Somerset East Div.: Lower part of Bruintyies Hoojbe [illegible], *Burchell 3009* (K – photo of type seen).

Rhus tridentata L.*f*. Suppl. PI.: 184 (1781). Type: As above.

Vitis erythrodes Fresen. in Mus. Senckenb. 2: 284 (1837). Type: *Rüppel, E., # s.n.*, Ethiopia, Holotype: FR-CJ Store Global Plants. Epitype: *Schimper, G.W # 198*, Ethiopia, REG × 2 HOH, TUB × 2; *Schimper # 358* TUB × 2, HOH × 2. Bak. in Oliv., F.T.A. 1: 401 (1868).

Rhoicissus erythrodes Fresen. Planch.: 465 (1887). Type: As above. Gilg. & Brandt, in Engl., Bot. Jahrb. 46: 440, fig. 3A-L (1911). Eyles, loc. cit. Burtt Davy, in A. & C. DC., Mon. Phan. 5, 2: 465 (1887): fig. 75A. Brenan, T.T.C.L.: 31 (1942); Mem. N.Y. Bot. Gard. 8: 240 (1953). Suesseng. in Proc. & Trans. Rhod. Sci. Ass. 43:111 (1951); Rhod. Sci. Ass. 43: 332 (1953) O.B. Mill., Rhod. Sci. Ass. 43: 332 (1953). Exell & Mendonca, C.F.A. 2: 39 (1954). Keay, in F.W.T.A., ed. 2: 681 (1958). Willems, F.C.B. 9: 565 (1960). White, F.F.N.R.: 231 (1962).

Rhoicissus cirhiflora sensu Gilg & Brandt.: 438 (1911) *pro parte quoad syn*. Type South Africa, Somerset East Div.: Lower part of Bruintyies Hoojbe [illegible], *Burchell 3009* (K – photo of type seen).

Description

Firstly, the leaves of the species of the *R. tridentata* complex are trifoliate with a wedge-shaped terminating leaflet (Pooley, 1994; Boon, 2010). The leaflets also have a few to multiple dentations along the margin (Pooley, 1994; Boon, 2010). The size of the leaflets as well as the total number and depth of toothing along their margins is highly variable (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

The high variation to both these characters (leaflet size and the depth of toothing along the leaflet margins) might have occurred as a result of the species of this complex tolerating a wide range of altitude. The tolerance of a wide range of climatic conditions might have been key in the formation of the subspecies in this complex. The species of this complex are *R. tridentata* subsp. *diplonerva, R. tridentata* subsp. *cuneifolia* as well as *R. tridentata* subsp. *tridentata*. These species are further described below.

Uses

Overall, the species of this complex are extensively used in the traditional medicine trade. These species are used as concoctions which are generated from their plant material (Katsoulis *et al*., 2002). These concoctions are then made available in most vending stores around Johannesburg (Katsoulis *et al*., 2002). In general, the subspecies of the *R. tridentata* complex are used to treat various ailments, and these include kidney and bladder complications, stomach ailments, cold, infertility as well as to facilitate childbirth (Boon, 2010). Primarily, it is the roots and tubers of the subspecies of this complex that are mainly used by traditional healers to prepare concoctions which are then used to treat various ailments (Katsoulis *et al*., 2002).

Habitat and Ecology

The subspecies of this complex have a varied distribution in a variety of habitats which include extreme habitats such as grasslands. This might be as a result of the subspecies of this complex tolerating a wide range of climatic conditions as well as altitude.

Distribution

Besides South Africa these species of this complex can be found distributed as far north as Arabia and it is also found all across central Africa to Ethiopia (Wild and Drummond, 1963). In the northern ares of Nigeria it grows as a trailer in the rocky areas of the savannas, it is also found in Angola; Mozambique; Lesotho and Swaziland.

8.3.7a *Rhoicissus tridentata* (L. *f*.) Wild & R. B. Drumm. subsp. *tridentata*

Rhoicissus tridentata (L. *f*.) Wild & R. B. Drumm. subsp. *tridentata* in Fl. Zambes. 2 (2): 444-446 (1966). Type: C Thunberg 04869 (PRE 47895), [PRE!]. Mem. Bot. Surv. South Africa: 585 (1966). Fl. Zambes. 2[2]: 445 (1966). Food plants of Zimbabwe: 13 (1986). Gen. Gram.: 563 (1986). S. African J. Bot. 52: 392 (1986). Trees Natal, Zululand & Transkei: 306 (1993). Wild Flrs north. South Africa: 244 (1997).

Description

Rhoicissus tridentata subsp. *tridentata* can be a shrub that grows up to 1 m or more, scandent branches or erect. Occasionally this species can have a cinereous appearance. The leaves are usually small, glabrous or more rarely cinereous pubescent. The petioles can be 2-3 mm long. The lamina of the terminating leaflets can grow up to be 15-25 mm long and 5- 15 mm broad. The lamina of the lateral leaflets can grow up to be 12-25 mm long and 6-10 mm broad. Margins on leaflets can be entire or have up to 4 (relatively 6) dentations or crenations in all the leaflets.

Habitat and Ecology

Rhoicissus tridentata subsp. *tridentata*, it chiefly grows in sandy soils of permanent coastal dune bushes.

Distribution

The distribution of *R. tridentata* subsp. *tridentata* extends inland to the southern Eastern Cape and into the Karoo (Urton *et al.*, 1986). In the Karoo, this subspecies forms part of the dry Valley Bushveld with the other vegetation (Urton *et al.*, 1986).

Leaves

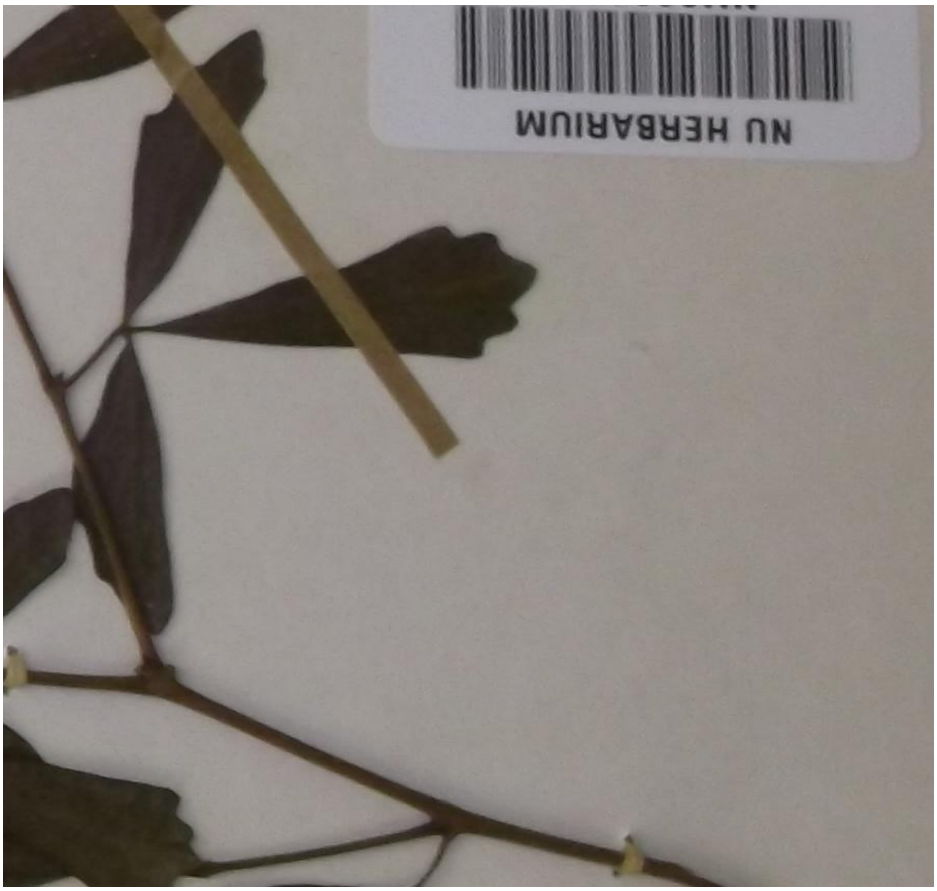

Figure 60: The trifoliate leaves of *R. tridentata* subsp. *tridentata* with reduced dentitions on the margins (x 1.27).

Specimenn Citation

South Africa: Eastern Cape 2922 (Spekboomveld): Koedoeskop farm (-BB), *Bourquin, O. NU 0038119* (NU). KwaZulu-Natal 3030 (Port Shepstone): Margate, grassland near

rocks (-CD), *Strey, R.G. 10953* (NH) 3130 (Port Edward): Beacon Hill, forest margin (-AA), *Strey, R.G. 11125* (NH). 2732 (Zululand): Ubombo district, Mkuzi Game Reserve (-CB), *Ward, C.J. 3622* (NH). 2732 (Zululand); Mshopi (-CB), *Goodman, P.S. 528* (NU). 2631 (Lebombo Mts): 3 miles.West of Jozini Dam Village. Ubombo District (-BD), *Edwards, D. 2901* (NU). 2731 (Ingwavuma district): Gwalaweni forest, distributed forest margin (-BB), *Scott Shaw, C.R 160* (NU). Western Cape (Cape): *Thode, J A. 779* (NH). 2821 (Albany district): Farm Proctorsfontein, 28m from Grahamstown on Alicedale road (-BC), *Marais, W. 889* (NH). 2126 (Queenstown District): In woods near mtn (-DD), *Galpin, E.E. 1814* (NU).

8.3.7b *Rhoicissus tridentata* subsp. *cuneifolia* (Eckl. & Zeyh.) Urton

R. tridentata subsp. *cunefolia* (Eckl. & Zeyh.) Urton. Type: Angola; F. Welwitsch 1455 (BR – photo of type seen). Syntypes: South Africa; A.O.D. Mogg & T.T. Barnard 685 (IFAN − photo of specimen seen)

Cissus cuneifolia Eckl. & Zeyh. , Enum. PI. Afr. Austr.: 56 (1835). Type: South Africa, Adow (Uitenhage), mountain near Grahamstown (Albany), Chumiberg, Ecklon, *C.F.; Zeyher, C.L.P.*, 431 (S – photo of type seen).Harv. in Harv. & Sond., F.C. 1: 251 (1860).

Rhoicissus cuneifolia Eckl. & Zeyh. Planch. in A. & C. DC., Mon. Phan. 5 (2): 466 (1887). Syntype: South Africa, Cap., Ecklon, C. F *sn* (Enum.: 431) [1837-01] (W – photo of syntype seen). Bak. f. in Journ. Linn. Soc., Bot. 40: 47 (1911). Eyles in Trans. Roy. Soc. S. Afr. 5: 408 (1916). Burtt Davy, F.P.F.T. 2: 473 (1932). Steedman, Trees, ect., S. Rhod.: 44 (t.) 44 (1933). O.B. Mill. In Journ. S. Afr. Bot. 18: 52 (1952). Suesseng. in Engl. & Prantl, Nat. Pflanzenfam., ed. 2 (20d): 330 (1953).

Description

Rhoicissus tridentata subsp. *cuneifolia* can be a small shrub that can grow and reach approximately 2 m in length. It can also be a tall climber which can grow and reach lengths up to 10 m or taller. Also, this species sometimes have scandent branches. The young branches of this subspecies are greyish- or fulvous-pubescent or occasionally ferruginous-tomentose. The tendrils are fulvous-pubescent or glabrescent. The leaves are 3-foliolate and have 0.2-4 cm long petioles that are pubescent or tomentose. Stipules grow up to be 2 mm long, tomentose and very caduceus. The leaflet-lamina grows up to be 9 × 5.5 cm and is narrowly obovate to broadly obovate in shape. The apices on leaflets are truncate or, more rarely subacute while bases are cuneate. At the base, the lateral leaflets can be cuneate, asymmetrically subcuneate to rounded on one side. The margins on the leaflets are dentate towards the apex and these dentitions range from 3-c. 18 (in S. Africa forms occur with leaflets entire or with only 1–3 teeth). The adaxial surface can be glabrous or fulvous-pubescent while the abaxial surface ranges from thinly fulvous-pubescent to densely fulvous- or rarely ferruginous-tomentose (forms with glabrous leaves occur in S. Africa). The nerves are also prominent on the abaxial surface. The petiolules can grow up to 5 mm long.

Uses

Rhoicissus tridentata subsp. *cuneifolia* is used as a herbal oxytocics by nearly 80% of the South African Zulu and Xhosa populations, and it is among the six most frequently used species in such herbal remedies (Brookes and Katsoulis, 2006). This subspecies was also found to have a higher antineoplastic activity against the HepG2 cell line (cancer cells) than the other plant species from which crude extracts were prepared. Their antiproliferation activity was tested on the HepG2 cell line (Opoku *et al*., 2000). All these findings have crucial implications for cancer treatment particularly by this subspecies in the future.

Distribution

For the other two subspecies, the general trend is that *Rhoicissus* subsp. *tridentata* is distributed in the southern parts of South Africa, while *Rhoicissus* subsp. *cuneifolia* is distributed in the northern parts of South Africa (Urton *et al*., 1986). These two groups are however sympatric and where they occurs, such as in Grahamstown, the greatest diversity of form is observed where intermediates of the two forms are encountered, indicating hybridisation (Urton *et al*., 1986). The high level of hybridization shown by the *R. tridentata* complex might explain why there has been six different names given to these subspecies before the nomenclature was corrected and established by Wild and Drummond (1963).

Leaves

Figure 61: The trifoliate leaf of *R. tridentata* subsp. *cuneifolia* (x 1.14).

Specimen Citation

South Africa: Gauteng 2528 (Bronberg Conservancy): Lynnwood Road Ext. (-CB), Shongwe, M 46 (NH). KwaZulu-Natal 2229 (Zoutpausfere): (-DC), *Galpin, E.E. 14216* (NH). 2730 (Vryheid): Vryheid Hill Nature Reserve. Forest-margin near illuminated cross (-DB), *Glen, H.F. & Mbuqe, V. 4214* (NH). 2731 (Lauwsburg): Itala Nature Reserve, Potwe Section Scrubs forest, on mountainside (-CB), *Porter & Ward 54* (NH). 2929 (Impendle District): Uplands. Lotheni Nature Reserve. C. 1km from Tebetebe Bridge Slopes of Ndlovini Mountain. (-AD), *Ngwenya, A.M. 1941* (NH). 2931 (Stanger): Brighton Beach (-CC), *Coleman, T.A. 344* (NH). 3029 (Kokstad): Mt. Frere-Cedarville, cattle dip, between rock (-CC), *Strey, R.G. 10795* (NU). 3030 (Norburg): In coastal grassveld (-CB), *Edwards, T. 157* (NU). 3030 (Oribi Flats): Along theriver valleys of Oribi Flats (-CA), *McClean, A.P.D. 556* (NH). 3030 (Allenrton): (-DA), *Mogg, A.O.D. 6350* (NH). 2930 (Pinetown District): New Germany (-DD), *Gibson, J. NU 0038118* (NU). 2931 (Durban): Hillary Nursery, Shrub on edge of bush, Hillside (-CC), *Coleman, T.A. 385* (NH). (Mandeni): 3 miles on Tugela mouth Rd., Mtunzini Dist, *Edwards, E. 1571* (NU). 2929 (Estcourt district): Kamberg (-BC), *Wright, F.B. 1692* (NU). 2930 (Lions River District): 5 miles along Merrivale-Boston Rd. (-AC), *Moll, E.J. 750* (NU).

8.3.7c *Rhoicissus tridentata* subsp. *diplonerva* Kunene, Nicholas & Boon subsp. nov

Description

Rhoicissus tridentata subsp. *diplonerva* has the largest leaflets in this complex. The actual leaves are, however, still trifoliate with the lateral leaflets asymmetrical. Terminating leaflets are 9.4 x 7.7 cm while the lateral leaflets are 7.8 x 56 cm. The total length of the leaves is around 12.7 cm in length. The leaflets also have the deepest dentitions as well as the largest total number of dentitions along their margins. The secondary lateral veins of this subspecies terminate with a tooth. The lateral leaflets are 2-nerved at the base, the left leaflets have the secondary lateral veins branching towards

the right while those on the right have the secondary lateral veins branching towards the left.

Habitat and Ecology

Rhoicissus tridentata subsp. *diplonerva* can be found distribution in dune forests, forest margins and grassy hillsides, thickets as well as in woodlands (Wild and Drummond, 1963; Poooley, 1994; Boon, 2010).

Distribution

This subspecies can be seen in all the above habitats particularly here in South Africa in areas such as KwaZulu-Natal; Eastern Cape; Western Cape; Free State; Northern Cape as well as the North West Province (Wild and Drummond, 1963; Pooley, 1994; Boon, 2010).

Leaves

Figure 62: The leaves of *R. tridentata* subsp. *diplonerva* with extensively deep dentitions on the margin (x 0.82).

Specimen Citation

South Africa KwaZulu-Natal: 2531: (-AC), *Holt,* W.E. *172* (NH). 2829 (Drankensberg): Umlonbonja River, Cathedral Area (-CC), *Schelpe, E. 838* (Duplicate) (NH). 2931 (Durban): Umdloti (-CA), *Tyrrell, I. NH 21303* (NH). North West 2531 (Mpumalanga): Komatipoort (-AA), *Jordaan, M. 446* (NH). 2630 (Mpumalanga): Carolina, Near The Brook, granite hills, bush between rocks (-BA), *Strey, R. G 8012* (NH). 2630 (Transvaal): Carolina, Near The Brook, granite hills, bush between rocks (-BA), *Strey, R. G 8012* (NU). **Swaziland**: 2631(Mankaiana Hillside): Mankaina District (-CA), *Compton, R.H. 27472* (NH).

Distribution Map

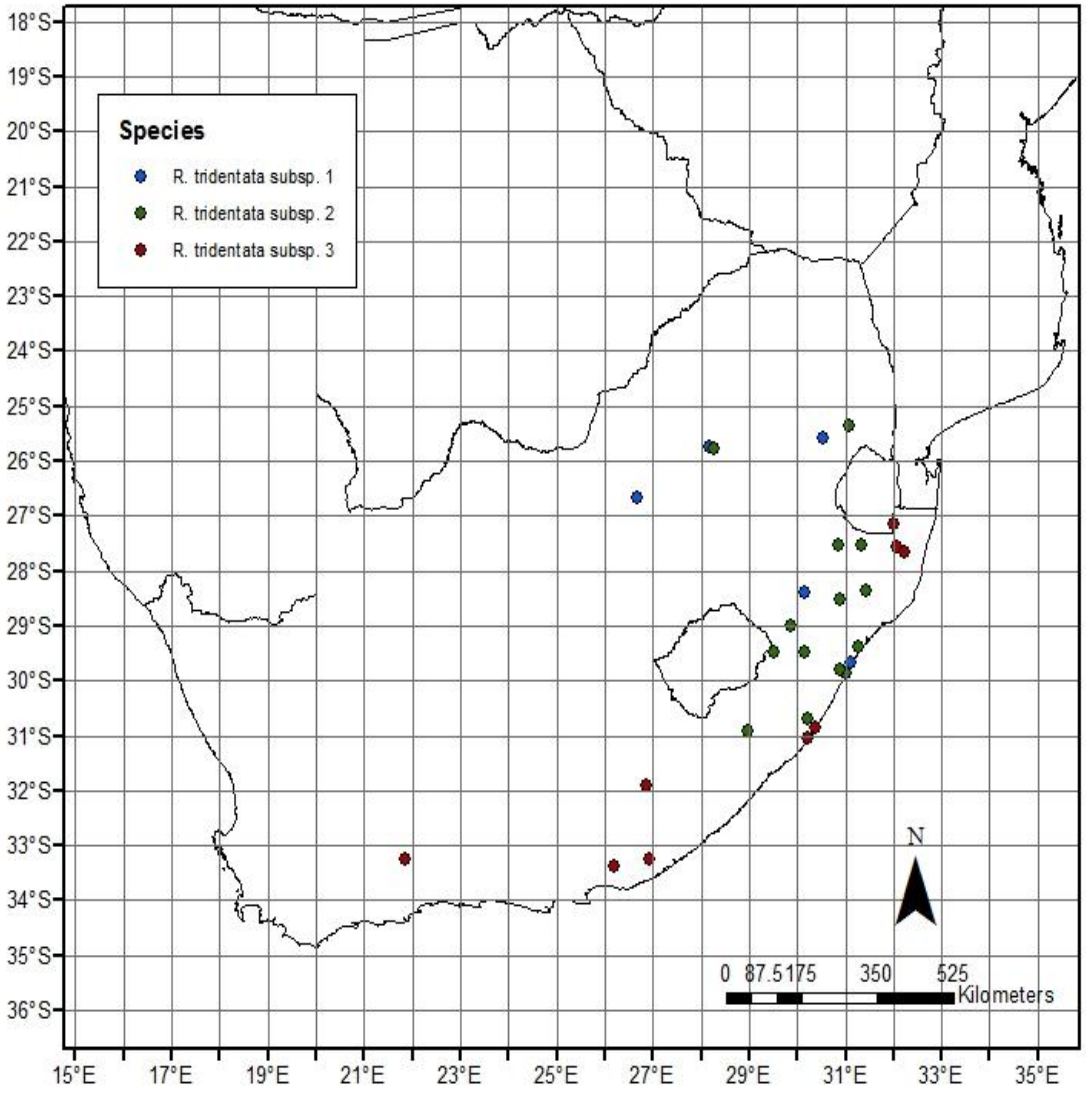

Figure 63: The distribution of the *R. tridentata* complex. *R. tridentata* SS 1 refers to *R. tridentata* subsp. *diplonerva*; *R. tridentata* SS 2 refers to *R. tridentata* subsp. *cuneifolia* and *R. tridentata* SS 3 refers to *R. tridentata* subsp. *tridentata*.

Chapter 9

Conclusion

This study was undertaken because a number of apparently new species were reported by Boon (2010) in his tree book to KwaZulu-Natal and the eastern regions. A number of doctral students at the University of KwaZulu-Natal were working on the known anticancer properties of *Rhoicissus* species and were bringing sterile specimens into the herbarium for identification. Most of the specimens brought to the herbarium were among some of the unnamed species pointed out by Boon. As a result, this project was initiated to test this hypoyhesis of Boon (2010).The questions that this study was answering were, (among others), are there new species? New subspecies? New varieties? Or maybe no new species exist in *Rhoicissus*? Due to the scarcity of flowering and fruiting specimens (and also the fact flowers carry no useful taxonomic characteristics except possibly when using Scanning Electron Microscope (SEM)), all keys to the genus *Rhoicissus* have relied primarily on habit and leaf characteristics. The aim of this dissertation was to study the leaves of the known species along side those of the suspected new species and to produce a unified taxonomy based only on the leaf morphology. This taxonomy would be accompanied by a key that would be useful to conservationist, environmental managers, game rangers and amaterure botanists.

The new "species" of Boon (2010) did all have minor unique characters that became clear as the study progressed. There is a problem with the word "minor" but in defence, at no time were any hybrid specimen seen or encountered in the field. On fieldtrips taken during and near the end of the study, most of the species growing in their natural habitats were seen and hybrids of the two new subspecies of *R. digitata* were not seen.

Short-commings of the study:

- More specimens need to be seen. Unfortunately this was not done due to an unstable herbarium environment at UDW.
- Better more informative maps need to be done based on these new specimens.
- More critical thought needs to go into the phenetics especially using added characters and cutting down on the number of specimens.

- Describing most of the new taxa as subspecies is probably too ambitious except for *Rhoicissus tridentata* susp. *diplonerva*. The others should probably be recognised as varieties of *R. digitata* at this stage.

For future studies:

- The candidate acknowledges that her work is a start towards a more comprehensive taxanomic studies of *Rhoicissus*. The next phase should be a more indepth study of all the species of *Rhoicissus* in South Africa.
- A phylogenetic study, using molecular genetics, shoud be undertaken to establish a phylogeny for this group in the South Africa as it has not been done as yet. The possible use of a molecular clock analysis could be considered in order to look back in time, and assess divergence events.
- An SEM study of all the flowers is required, and this could be accompanied by a study of the trichomes on the leaves. The veins that end in what appears to be a glandular tip needs to be studied by both SEM and Transmission Electron Microscope (TEM) in order to establish whether it is glandular or not.
- Also, a phytogeographical study is needed.

The candidate believes she has fulfilled the aims and objectives of this study, and is aware of its strengths and weaknesses.

References

Boon, R. 2010. Pooley's Trees of Eastern South Africa. A Complete Guide. Durban: Flora and Fauna Publications Trust.

Brookes, K. and Katsoulis, L. 2006. Bioactive components of *Rhoicissus tridentata*: a pregnancy-related traditional medicine. South African Journal of Science.102: 267-272.

Cho, M.A., Malahlela, O. and Ramoelo, A. 2015. Assessing the utility World View-2 imagery for tree species mapping in South African subtropical humid forest and the conservation implications: Dukuduku forest patch as case study. International Journal of Applied Earth Observation and Geoinformation. 38: 349-357.

Eeley, H.A.C., Lawes, M.J. and Reyes, R. 2001. Priority areas for the conservation of subtropical indigenous forest in southern Africa: a case study from KwaZulu-Natal. Biodiversity and Conservation. 10: 1221-1246.

Ferreira, S.M. and van Aarde, R.J, 2000. Maintaining diversity through intermediate disturbances: evidence from rodents colonizing rehabilitating coastal dunes. African Journal of Ecology. 38: 286-294.

Gerrath, J. and Posluszny, U. 2007. Introduction to "Biology of the Vitaceae - a global perspective". Canadian Journal of Botany. 85: i-ii.

Gerrath, J. Wilson, T. and Posluszny, U. 2004. Morphological and anatomical development in the Vitaceae. VII. Floral development in *Rhoicissus digitata* with respect to other genera in the family. Canadian Journal of Botany. 82: 198-206.

Grainger, M.J., 2011. An evaluation of coastal dune forest restoration in northern KwaZulu-Natal, South Africa. PhD Thesis. University of Pretoria.

Griffiths, M.E. and Lawes, M.J. 2006. Biogeographic, environmental, and phylogenetic influences on reproductive traits in subtropical forest trees, South Africa. Ecography. 29: 614-622.

Hutchings, A. and Staden, J. 1994. Plants used for stress-related ailments in traditional Zulu, Xhosa and Sotho medicine. Part 1: Plants used for headaches. Journal of Ethnopharmacology. 43:89-124.

Ingrouille, M., Chase, M.W., Fay, M.F., Bowman, D., van der Bank, M. and Bruijn, A.D.E. 2002. Systematics of Vitaceae from the viewpoint of plastid *rbcL* DNA sequence data. Botanical Journal of the Linnean Society. 138: 421-432.

Katsoulis, L., Veale, D. and Havlik, I. 2000. The pharmacological action of *Rhoicissus tridentata* on isolated rat uterus and ileum. Phytotherapy Research. 14: 460-462.

Katsoulis, L., Veale, D. and Havlik, I. 2002. Seasonal variation in uterotonic activity of *Rhoicissus tridentata* extracts. South African Medical Journal. 92(5): 375-377.

Lawes, M.J., MacFarlane, D.M. and Eeley, H.A. 2004. Forest landscape pattern in the KwaZulu-Natal midlands, South Africa: 50 years of change or stasis? Austral Ecology. 29: 613-623.

Lin, J., Opoku, A.R., Geheeb-Keller, M., Hutchings, A.D., Terblanche, S.E., Jäger, A.K and van Staden, J. 1999. Preliminary screening of some traditional Zulu medicinal plants for anti-inflammatory and anti-microbial activities. Journal of Ethnopharmacology. 68: 267-274.

Lipsey, M.K. and Hockey, P.A.R, 2010. Do ecological networks in South African commercial forests benefit grassland birds? A case study of a pine plantation in KwaZulu-Natal. Agriculture, Ecosystems and Environment. 137: 133-142.

Mpanza, T.D.E., Scogings, P.F., Kunene, N.W. and Zobolo, A.M. 2009. Impacts of cattle on ecological restoration of coastal forests in KwaZulu-Natal, South Africa. African Journal of Range and Forage Science. 26(1): 1-7.

Naidoo, V., Chikoto, H., Bekker, L. and Eloff, J. 2006. Antioxidant compounds in *Rhoicissus tridentata* extracts may explain their antibabesial activity. South African Journal of Science.102: 198-200.

Neumann, F.H. Scott, L., Bousman, C.B. and van As, L. 2010. A Holocene sequence of vegetation change at Lake Eteza, coastal KwaZulu-Natal, South Africa. Review of Palaeobotany and Palynology. 162: 39-53.

Newmaster, S.G., Fazekas, A.J., Steeves, R.A.D and Janovec, J. 2007. Testing candidate plant barcode regions in the Myristicaceae. Molecular Ecology Notes. doi: 10.1111/j.1471-8286.2007.02002.x

Opoku, A., Geheeb-Keller, M., Lin, J., Terblanche, S.E., Hutchings, A., Chuturgoon, A. and Pillay, D. 2000. Preliminary screening of some traditional Zulu medicinal plants for antineoplastic activities versus the HepG2 Cell Line. Phytotherapy Research. 14: 534-537.

Opoku, A., Ndlovu, I., Terblanche, S. and Hutchings, A. 2007. In *vivo* hepatoprotective effects of *Rhoicissus tridentata* subsp. *cuneifolia*, a traditional Zulu medicinal plant, against CCl4-induced acute liver injury in rats. South African Journal of Botany. 73: 372-377.

Pooley, E. 1994. The Complete Field Guide to Trees of Natal, Zululand and Transkei. Durban: National Flora Publication Trust.

Retief, E. 1980. A new species of *Rhoicissus* from Natal. Bothalia, 13(1&2): 146-147.

Retief, E., 2000. Vitaceae. In Goldblatt and Manning (eds), 2000. Cape plants: A Conspectus of the Cape flora of South Africa *Strelitzia* 9: 688.

Retief, E. and Herman, P. 1997. Plants of the northern provinces of South Africa: keys and diagnostic characters. *Strelitzia*. 6: 647-650.

Retief, E., Siebert, S. and van Wyk, A. 2001. A new species of *Rhoicissus* (Vitaceae) from Sekhukhuneland, South Africa. South African Journal of Botany. 67: 230-234.

Retief, E. and van Jaarsveld, E. 1997. A new species of *Rhoicissus* from the Eastern Cape. Bothalia. 27(1): 49-51.

Rossetto, M., Crayn, D., Jackes, B. and Porter, C. 2007. An updated estimate of intergeneric phylogenetic relationships in the Australian Vitaceae. Canadian Journal of Botany. 58: 722-732.

Rossetto, M., Jackes, B., Scott, K. and Henry, R. 2001. Intergeneric relationships in the Australian Vitaceae: new evidence from cpDNA analysis. Generic Resources and Crop Evolution. 58: 307-314.

Shah, J. and Dave, Y. 1970. Morpho-histogenic studies on tendrils of Vitaceae. American Journal of Botany. 57(4): 363-373.

Siebert, S., Van Wyk, A. and Bredenkamp, G. 2001. Endemism in the flora of ultramafic areas of Sekhukhuneland, South Africa. South African Journal of Science. 97: 529-532.

Skowno, A.L. and Bond, W.J. 2003. Bird community composition in an actively managed savanna reserve, importance of vegetation structure and vegetation composition. Biodiversity and Conservation. 12: 2279-2294.

Stace, C.A. 1989. Plant taxonomy & Biosystematics. 2nd edn. Cambridge Press, Cambridge.

Statistical Package for the Social Science 52014 SPSS version 21 Manufactured by IBM.

Stebbin, G.L. 1983. Mosaic evolution: an intergrating principle for the modern synthesis. Experientia. 39: 823-824.

Urton, N., Olivier, M. and Robertson, B. 1986. The taxonomy of the *Rhoicissus tridentata* (Vitaceae) complex in southern Africa. South African Journal of Botany. 52(5): 289-396.

van Aarde, R.J., Ferreira, S.M., Kritzinger, J.J., van Dyk, P.J., Vogt, M. and Wessenaar, T.D. 1996. An evaluation of habitat rehabilitation on coastal dune forests in northern KwaZulu-Nata, South Africa. Restoration Ecology. 4(4): 334-345.

Weiermans, J. and van Aarde, R.J. 2003. Roads as ecological edges for rehabilitating coastal dune assemblages in northern KwaZulu-Natal, South Africa. Restoration Ecology. 11: 43-49.

Wen, J., Nie, Z., Soejima, A. and Meng, Y. 2007. Phylogeny of Vitaceae based on the nuclear GAI1 gene sequences. Canadian Journal of Botany. 58: 731-745.

West, A.G., Midgley, J.J. and Bond, W.J. 2000. Regeneration failure and the potential importance of human disturbance in a subtropical forest. Applied Vegetation Science. 3: 223-232.

Wild, H. and Drummond, R. 1963. Vitaceae in Flora of Zambesiaca. 54: 444-448

Appendices

Table 6: Details of the specimens used to analyse the relationship of species within *Rhoicissus* [Vitaceae], including the name of the herbarium in which they are kept.

	Species Name	Specimen name	Collector	Collection no.	Herbarium
1.	*R. tomentosa*	*R_tomentosa*_1	Ward, C.J.	2953	Natal University
2.	*R. tomentosa*	*R_tomentosa*_2	Gordon-Gray, J.L.	892	Natal University
3.	*R. tomentosa*	*R_tomentosa*_3	Scin, T.R.	1813	Natal University
4.	*R. tomentosa*	*R_tomentosa*_4	Huntley, B.J.	224	Natal University
5.	*R. tomentosa*	*R_tomentosa*_5	Ward, C.J.	2953	Natal Herbarium
6.	*R. tomentosa*	*R_tomentosa*_6	Guy, R.D.	16	Natal Herbarium
7.	*R. tomentosa*	*R_tomentosa*_7	Strey, R.G.	5695	Natal Herbarium
8.	*R. tomentosa*	*R_tomentosa*_8	Strey, R.G.	8865	Natal Herbarium
9.	*R. tomentosa*	*R_tomentosa*_9	Ngwenya, A.M.	1862	Natal Herbarium
10.	*R. tomentosa*	*R_tomentosa*_10	Nel, M.D.S.	202	Natal Herbarium
11.	*R. tomentosa*	*R_tomentosa*_11	Lawn, J.G.	1351	Natal Herbarium
12.	*R. tridentata*	*R_tridentata*_SS_1_1	Schelpe, E.	838	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
13.	*R. tridentata*	*R_tridentata*_SS_1_2	Jordaan, M.	446	Natal Herbarium
14.	*R. tridentata*	*R_tridentata*_SS_1_3	Strey, R.G.	8012	Natal Herbarium
15.	*R. tridentata*	*R_tridentata*_SS_1_4	Compton, R.H.	27472	Natal Herbarium
16.	*R. tridentata*	*R_tridentata*_SS_1_5	Strey, R.G.	8012	Natal University
17.	*R. tridentata*	*R_tridentata*_SS_1_6	Holt, W.E.	172	Natal Herbarium
18.	*R. tridentata*	*R_tridentata*_SS_1_7	Tyrrell	NH 21303	Natal Herbarium
19	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_1	Shongwe, M.	46	Natal Herbarium
20.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_2	Ngwenya, A.M	1941	Natal Herbarium
21.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_3	Mogg, A.O.D.	6350	Natal Herbarium
22.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_5	Coleman, T.A.	344	Natal Herbarium
23.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_7	McClean, A.P.D.	556	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
24.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_8	Glen, H.F. & Mbuqe, V.	4214	Natal Herbarium
25.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_9	Galpin, E.E.	14216	Natal Herbarium
26.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_10	Porter & Ward	54	Natal Herbarium
27.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_11	Coleman, T.A.	385	Natal Herbarium
28.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_12	Edwards, T.	157	Natal University
29.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_13	Edwards, D.	1571	Natal University
30.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_14	Moll, E.J.	750	Natal University
31.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_15	Wright, F.B.	1692	Natal University
32.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_16	Strey, R.G.	10795	Natal University

	Species Name	Specimen name	Collector	Collection no.	Herbarium
33.	*R. tridentata* subsp. *cuneifolia*	*R_tridentata*_SS_2_18	Gibson, J.	NU 0038118	Natal University
34.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _1	Bourquin, O.	NU 0038119	Natal University
35.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _2	Strey, R.G.	10953	Natal Herbarium
36.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _3	Ward, C.J.	3622	Natal Herbarium
37.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _4	Galpin, E.E.	1814	Natal University
38.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _5	Scott-Shaw, C.R.	160	Natal University
39.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _6	Edwards, D.	2901	Natal University
40.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _7	Goodman, P.S.	528	Natal University
41.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _8	Marais, W.	889	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
44.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3 _9	Thode, J.	A779	Natal Herbarium
43.	*R. tridentata* subsp. *tridentata*	*R_tridentata*_SS_3_10	Strey, R.G.	11125	Natal University
44.	*R. rhomboidea*	*R_rhomboidea*_1	Compton, R.H.	28953	Natal Herbarium
45.	*R. rhomboidea*	*R_rhomboidea*_2	Dlamini, B.	NH 107 732	Natal Herbarium
46.	*R. rhomboidea*	*R_rhomboidea*_3	MacDevette, D.R.	426	Natal Herbarium
47.	*R. rhomboidea*	*R_rhomboidea*_4	Huntley, B.J.	217	Natal Herbarium
48.	*R. rhomboidea*	*R_rhomboidea*_5	Strey, R.G.	6456	Natal Herbarium
49.	*R. rhomboidea*	*R_rhomboidea*_6	Strey, R.G.	11077	Natal Herbarium
50.	*R. rhomboidea*	*R_rhomboidea*_7	Cloete, E.	1477	Natal Herbarium
51.	*R. rhomboidea*	*R_rhomboidea*_8	Mills, A.P.	355	Natal Herbarium
52.	*R. rhomboidea*	*R_rhomboidea*_9	Moll, E.J.	1812	Natal Herbarium
53.	*R. rhomboidea*	*R_rhomboidea*_10	Ross, J.H. & Moll, E.J.	2308	Natal Herbarium
54.	*R. rhomboidea*	*R_rhomboidea*_11	Abbott, A.	3487	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
55.	*R. rhomboidea*	*R_rhomboidea*_12	Ngwenya, A.M.	2163	Natal Herbarium
56.	*R. rhomboidea*	*R_rhomboidea*_13	Ngwenya, A.M.	2163	Natal Herbarium
57.	*R. rhomboidea*	*R_rhomboidea*_14	Ngwenya, A.M.	2406	Natal Herbarium
58.	*R. rhomboidea*	*R_rhomboidea*_15	Ngwenya, A.M.	2406	Natal Herbarium
59.	*R. sessilifolia*	*R_sessilifolia*_1	Bodenstein, J.	NH 122182	Natal Herbarium
60.	*R. sessilifolia*	*R_sessilifolia*_2	Lawn, J.G.	2222	Natal Herbarium
61.	*R. sessilifolia*	*R_sessilifolia*_3	MacDevette, D.R.	358	Natal Herbarium
62.	*R. sessilifolia*	*R_sessilifolia*_4	Lawn, J.G.	958	Natal Herbarium
63.	*R. sessilifolia*	*R_sessilifolia*_5	Lawn, J.G.	1545	Natal Herbarium
64.	*R. sessilifolia*	*R_sessilifolia*_6	Lawn, J.G.	1968	Natal Herbarium
65.	*R. sessilifolia*	*R_sessilifolia*_7	Strey, R.G	11079 I	Natal Herbarium
66.	*R. sessilifolia*	*R_sessilifolia*_8	Strey, R.G	11079 II	Natal Herbarium
67.	*R. sessilifolia*	*R_sessilifolia*_9	Strey, R.G	11079 III	Natal Herbarium
68.	*R. sessilifolia*	*R_sessilifolia*_10	Strey, R.G	11300	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
69.	*R. sessilifolia*	*R_sessilifolia*_11	Strey, R.G	11300	Natal Herbarium
70.	*R. sessilifolia*	*R_sessilifolia*_12	Moll, E.J.	4979	Natal Herbarium
71.	*R. sessilifolia*	*R_sessilifolia*_13	Venter, H.J.T.	6029	Natal Herbarium
72.	*R. sessilifolia*	*R_sessilifolia*_14	Strey, R.G.	8246	Natal University
73.	*R. sessilifolia*	*R_sessilifolia*_15	McAllister, H.J.	24	Natal University
74.	*R. revoilii*	*R. revoilii*_1	Bester, S.P.	2794	Natal Herbarium
75.	*R. revoilii*	*R. revoilii*_2	Balkwilli, K.	1511	Natal University
76.	*R. revoilii*	*R. revoilii*_3	Ward, C.J.	4153	Natal Herbarium
77.	*R. revoilii*	*R. revoilii*_4	MacDevette, K.	1053	Natal Herbarium
78.	*R. revoilii*	*R. revoilii*_5	Gibbs Russell, G.E.	2720	Natal University
79.	*R. revoilii*	*R. revoilii*_6	Vos, W.	202	Natal University
80.	*R. revoilii*	*R. revoilii*_7	Scin, T.R.	1819	Natal University
81.	*R. revoilii*	*R. revoilii*_8	Edwards, D.	2020	Natal University
82.	*R. revoilii*	*R. revoilii*_9	Ntuli, R.N.	207	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
83.	*R. revoilii*	*R. revoilii*_10	Ntuli, R.N.	207	Natal Herbarium
84.	*R. schlechteri*	*R_schechteri*_1	Bayer, A.W.	441	Natal University
85.	*R. schlechteri*	*R_schechteri*_2	Tinley, K.L.	982	Natal Herbarium
86.	*R. schlechteri*	*R_schechteri*_3	Ross, J.H.	2417	Natal Herbarium
87.	*R. schlechteri*	*R_schechteri*_4	Pooley, E.S.	390	Natal University
88.	*R. schlechteri*	*R_schechteri*_5	Ward, M.C.	69	Natal Herbarium
89.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 1	Nicholson, H.B.	172	Natal Herbarium
90.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 2	Abbott, A.	3496	Natal Herbarium
91.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 3	Abbott, A.	4475	Natal Herbarium
92.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 4	Killick, D.J.B.	514	Natal Herbarium
93.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 5	Strey, R.G.	6778	Natal Herbarium
94.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 6	Venter, H.J.T.	1925	Natal Herbarium
95.	*R. digitata* "true *digitata"*	*R. digitata* true *digitata* 7	Thode, J.	A2626	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
96.	*R. digitata "*true *digitata"*	*R.digitata* true *digitata* 8	Killick, D.J.B.	514	Natal Herbarium
97.	*R. digitata "*true *digitata"*	*R. digitata* true *digitata* 9	Gordon-Gray, J.H.	1364	Natal University
98.	*R. digitata* New Species 1	*R. digitata* New Species 1_1	Ward, C.J.	6075	Natal Herbarium
99.	*R. digitata* New Species 1	*R. digitata* New Species 1_2	Tyrrell, I.C.	NH 21311	Natal Herbarium
100.	*R. digitata* New Species 1	*R. digitata* New Species 1_3	Strey, R.G.	6871 II	Natal Herbarium
101.	*R. digitata* New Species 1	*R. digitata* New Species 1_4	Forbes, H.M.	337	Natal Herbarium
102.	*R. digitata* New Species 1	*R. digitata* New Species 1_5	Ward, C.J.	356	Natal University
103.	*R. digitata* New Species 1	*R. digitata* New Species 1_6	Jarman and Guy	375	Natal University
104.	*R. digitata* New Species 2	*R. digitata* New Species 2_1	Hutchings, A.; Geheeb-Keller, M.	3 AH & MG-K	Natal Herbarium
105.	*R. digitata* New Species 2	*R. digitata* New Species 2_2	Forbes and Obermeyer	23	Natal Herbarium
106.	*R. digitata* New Species 2	*R. digitata* New Species 2_3	Colemal, T.A.	416	Natal Herbarium
107.	*R. digitata* New Species 2	*R. digitata* New Species 2_4	du Toit, P.C.V.	1224	Natal Herbarium
108.	*R. digitata* New Species 2	*R. digitata* New Species 2_5	von Fintel, M.	516	Natal Herbarium

	Species Name	Specimen name	Collector	Collection no.	Herbarium
109.	*R. digitata* New Species 2	*R. digitata* New Species 2_6	Ward, C.J.	4234	Natal Herbarium
110.	*R. digitata* New Species 2	*R. digitata* New Species 2_7	Venter, H.J.T.	1834	Natal Herbarium
111.	*R. digitata* New Species 2	*R. digitata* New Species 2_8	Du Toit, P.C.V.	1254	Natal Herbarium
112.	*R. digitata* New Species 2	*R. digitata* New Species 2_9	Edwards, D.	1724	Natal University
113.	*R. digitata* New Species 2	*R. digitata* New Species 2_10	Strey, R.G.	8242	Natal Herbarium

Table 7: Characters of *Rhoicissus* that were used to gather data for the phenetic analysis in this study.

	Character	**States or Levels**
1.	Leaf Form	Simple (0); Compound (1)
2.	Hair Presence On Leaf	Absent (0); Present (1)
3.	Tendril Form	Not Branched (0); Branched (1)
4.	Inflorescence On Tendrils	No (0); Yes (1)
5.	Presence Of Lenticels	Absent (0); Present (1)
6.	Leaf Petiole	Leaf Sessile (0); Leaf Petiolate (1)
7.	Leaf Colour	Dark Green (0); Pale Green (1)
8.	Stipule Existence	Absent (0); Present (1)
9.	Leaves Bicoloured	No (0); Yes (1)
10.	Leaflets With Large Amount Of Cuticle (Glaucous)	No (0); Yes (1)
11.	State Of Pulvinus	Absent (0); Present (1)
12.	Size Of The Lenticels	Small (0); Medium (1)Large (2)
13.	Frequency Of The Lenticels	Not Frequent (0); Frequent (1)
14.	Stamens Over Gynoecium	No (0); Yes (1)
15.	Hair Presence On Branches	No (0); Yes (1)
16.	Main Lateral veins Terminate With Spine Tooth	No (0); Yes (1)
17.	Branch Stem Texture	Smooth (0); Rough (1)
18.	Leaflets Asymmetrical At The Base Oblique	No (0); Yes (1)
19.	Leaves Of Different Types In Appearance	No (0); Yes (1)
20.	Young Leaflets Below Old Leaflets	No (0); Yes (1)
21.	Presence Of Compound And Simple Leaves In The Specimen	No (0); Yes (1)

	Characters	**States Or Levels**
22.	Leaf Widest At The Top	No (0); Yes (1)
23.	Leaf Widest In The Middle	No (0); Yes (1)
24.	Leaves With Smooth Margins	Smooth (0); With Dentition (1)
25.	Leaves Terminates With Teeth Or Lobes	Lobes (0); Teeth (1)
26.	Hairs Absent Or Present On Petiole	Absent (0); Present (1)
27.	Hairs Rusted Or Brown	No (0); Yes (1)
28.	Species Habit	Shrub (0); Climber (1)
29.	Species Collected In Grasslands Or Forests	Grasslands (0); Forests (1)
30.	Leaf Veins	Opposite (0); Alternating (1)
31.	Number Of Leaflets	One (0); Three (1); Five (2)
32.	Hairs On Adaxial	No (0); Yes (1)
33.	Hairs On Abaxial	No (0); Yes (1)
34.	Hairs On Both Sides	No (0); Yes (1)
35.	Leaf Texture	Leathery (0); Hard and Dry (1); Light and Dry (2)
36.	Leaves Waxy Or Not So	Not So (0); Waxy (1)
37.	Dalmatia Present Or Absent	Absent (0); Present (1)
38.	Dalmatia Sunken Or Protruding	Sunken (0); Protruding (1)
39.	Venation Pattern On The Leaves (Terminating Leaflets)	Opposite (0); Alternating (1)
40.	Venation Pattern On The Leaves (Lateral Leaflets)	Opposite (0); Alternating (1)
41.	Apex Pointed Or Blunt (Terminating Leaflets)	Blunt (0); Pointed (1)
42.	Apex Pointed Or Blunt (Lateral Leaflets)	Blunt (0); Pointed
43.	Terminating Leaflets One Or Not One	Not One (1); One (1)
44.	Length vs Breadth (Terminating Leaflets)	Breadth longer than Length (0); Length longer than Breadth (1)

	Characters	**States Or Levels**
45.	Length vs Breadth Lateral Leaflets	Breadth longer than Length (0); Length longer than Breadth (1)
46.	Terminating Leaflet Petiolate	Sessile (0); Petiolate (1)
47.	Lateral Leaflet Petiolate	Sessile (0); Petiolate (1)
48.	Terminating Leaflets Symmetrical	Asymmetrical (0); Symmetrical (1)
49.	Lateral Leaflets Oblique	No (0); Yes (1)
50.	Arrangement of Leaves	Opposite (0); Alternating (1)
51.	Veins From Midrib Swollen	No (0); Yes (1)
52.	Inflorescence stalk elongated	No (0); Yes (1)
53.	Leaf/ Leaflet Margins pronounced	No (0); Yes (1)
54.	Leaves Opposite Tendrils	No (0); Yes (1)
55.	Terminating Leaflets Sessile or Petiolate	Sessile (0); Petiolate (1)
56.	Lateral Leaflets Sessile or Petiolate	Sessile (0); Petiolate (1)
57.	Terminating Leaflets	Odd (0); Even (1); Simple (2)
58.	Plants The Specimen Live Among	Grasses (0); Shrubs (1); Trees (2)
59.	Number Of Leaflets On The Specimen	One (0); Three (1); Five (2)