

## Leaf architecture characters of *Vachellia tortilis* (Forssk.) Galasso and Banfi along longitudinal gradient in Limpopo Province, South Africa

Características de la arquitectura foliar de *Vachellia tortilis* (Forssk.) Galasso y Banfi a través de un gradiente longitudinal en la Provincia de Limpopo, Sudáfrica

Mashile SP<sup>1,2</sup> & MP Tshisikhawe<sup>1</sup>

**Abstract.** This paper looked at the leaf architecture characteristics of *Vachellia tortilis* to determine if either there is or not an effect of the tropic line on plants. *Vachellia tortilis* leaves were sampled along a national road (N1) in Limpopo province. Sampling points were set 10 km apart away from the Tropic of Capricorn in opposite directions. Leaf morphology revealed that leaves of *V. tortilis* are bipinnately compound with alternate arrangement. The venation pattern of the pinnules was eucamptodromous and brochidodromous with imperfect reticulation. Areoles were imperfect and pentagonal or irregular in shape.

**Keywords:** Pinnules; Eucamptodromous; Brochidodromous.

**Resumen.** Este paper se enfocó en las características de la arquitectura foliar de *Vachellia tortilis* para determinar si hay o no un efecto de la línea del trópico en las plantas. Se muestrearon hojas de *Vachellia tortilis* a lo largo de una ruta nacional (N1) en la provincia Limpopo. Los puntos de muestreo se dispusieron a 10 km de distancia uno de otro desde el trópico de Capricornio en direcciones opuestas. La morfología foliar mostró que las hojas de *V. tortilis* fueron compuestas bipinnadas con disposición alterna. El modelo de las nervaduras de las pínulas fue eucamptodromus y brochidodromous con reticulación imperfecta. Las areolas fueron imperfectas y pentagonales o irregulares en su forma.

**Palabras clave:** Pínulas; Eucamptodromous; Brochidodromous.

<sup>1</sup> Department of Botany, University of Venda, Private Bag X5050, Thohoyandou 0950, South Africa.

<sup>2</sup> South African National Biodiversity Institute, Private Bag X101, Pretoria, 0001, South Africa.

Address Correspondence to: Peter Milingoni Tshisikhawe, e-mail: tshisip@univen.ac.za

Recibido / Received 1.X.2014. Aceptado / Accepted 26.X.2014.

## INTRODUCTION

*Vachellia tortilis* (Forssk.) Galasso and Banfi is one of the dominant leguminous shrub species along the national road (N1) as it stretches from Polokwane City to Makhado Town in Limpopo province of South Africa. It is commonly known as “sweet thorn”, “Haak-en-steek” (Afrikaans), “Mosu” (Northern Sotho), “Nsasani” (Tsonga) or “Muswu” (Venda) in Limpopo province communities. Although the species is common in South Africa and the rest of Africa and South America, its origin has been located to the Caribbean region. This species which is characterized by compound leaves with hook spines belongs to the family Leguminosae. This family is one of the second most economic flowering plant families of the Poaceae (Bouchenak-Khelladi et al., 2010). The genus *Vachellia* has more than 250 members as indicated in the International Plant Names Index (IPNI).

Leaves are the major organs responsible for upward movement of fluids in plants through the xylem (Taiz & Zeiger, 2006). Venation is an important feature of leaves (Teresa & Rekha, 2010); veins provide physical support for the lamina, allowing the leaf to maintain its three-dimensional structure and orientation in space. Also, in all leaves the veins provide a transport system for the movement of water and carbohydrates within the leaf (Roth-Nebelsick et al., 2001). *Vachellia tortilis* was found to be one of the dominant species in Botlokwa along the Tropic of Capricorn.

Morphologically, this species and most other plants found along the Tropic of Capricorn were observed to have a significantly reduced height, but moving to the sub-tropical and tropical regions, plants gradually increased in height. As a result, a ‘U’ shaped format of plants is observed. It was then assumed that most of these plants along the Tropic of Capricorn, including *V. tortilis*, may be influenced by the environmental pattern. Other influencing forces might be the alleged underground force ley lines, energy vortex and portals lines, which often run either under megaliths such as Stonehenge in England or Monoliths in the case of South Africa.



**Fig. 1.** Location map of Limpopo province showing Botlokwa area where the Tropic of Capricorn passes (<https://maps.google.co.za/maps>. Accessed 22/10/2014).

**Fig. 1.** Mapa de la provincia de Limpopo que muestra el área de Botlokwa por donde pasa el Trópico de Capricornio (<https://maps.google.co.za/maps>. Accessed 22/10/2014).

The present investigation was therefore undertaken to study the leaf architecture of *V. tortilis* in five different study sites.

## MATERIALS AND METHODS

**Study area.** This research was conducted at Botlokwa which is situated at about 60 km north of Polokwane, where the N1 route comes to a column making the position of the Tropic of Capricorn at 23° 26' 16" S in the Limpopo Province of South Africa (Fig. 1). It is one of the most significant sites in our country, because it separates sub-tropical from tropical regions in South Africa.

South of the Tropic of Capricorn, Papkuil, Rita, Machaka and Mphakane are in the sub-tropical region. Towards the north of Capricorn, Lalapanzi, Adam's Apple and Louis Trichardt are in the tropical region. Therefore, morpho-anatomical research data were collected from either side of the Tropic of Capricorn, at a distance of 10 to 40 kilometers into the tropical and sub-tropical regions at intervals of 10 kilometers. The 10 to 40 kilometers were used in this study because after 50 km on either side of the Tropic of Capricorn *V. tortilis* tended to disappear and *Acacia karroo* became dominant.

**Procedures.** Fresh leaves of *Vachellia tortilis* were collected from Papkuil, Machaka, Louis Trichardt, Lalapanzi and Tropic of Capricorn. For Papkuil, Machaka, Louis Trichardt and Lalapanzi leaves were cleared with 10% Nitric acid boiling for 2-3 days. Leaves collected from the Tropic of Capricorn were cleared using 30% sodium hypochlorite and sodium hydroxide at 60 °C for 2-3 days. Delafield's haematoxylin was used for staining the cleared leaves. The terminology of Hickey (1973) was followed to describe leaf architecture. An average of 30 readings was taken per study area. After preparation, slides were observed under a light microscope [(40x) Axio-Imager A2 Carl Zeiss microscope] and all observations were supported by micrographs.

## RESULTS

**Qualitative features of leaf morphology.** Leaves of *V. tortilis* were bipinnately compound with alternate arrangement, moderate midrib and entire margins. The leaf shape was not variable, and it was elliptic. In most of the stations, the leaf apex was obtuse, except in Lalapanzi where an acute apex was observed. The leaf base was obtuse. The leaf texture was membranaceous, gland position was laminar and it had a normal petiole.

**Major venation pattern.** The major venation pattern conformed to the Eucamptodromus, festooned, brochidodromous, imperfect, reticulate type. The mid vein was prominent and thicker at the base than at the leaf tip. The secondary veins

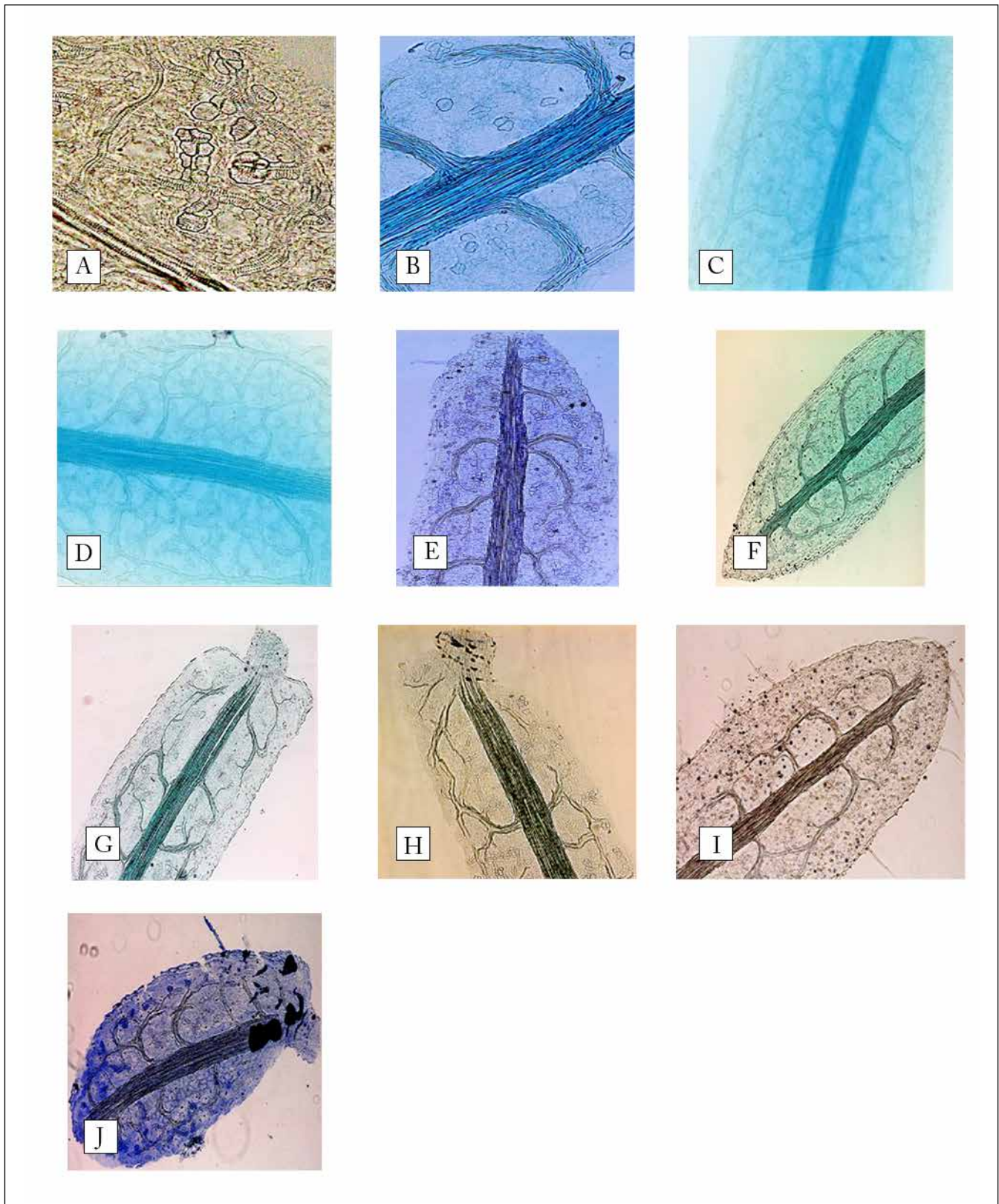


Fig. 2. Leaf architecture of *Vachellia tortilis*.  
Fig. 2. Arquitecatura foliar de *Vachellia tortilis*.

were the next-smallest order of veins arising from the primary veins (Fig. 2E and F). The angle of divergence ranged between the branch and continuation of the source vein at the point of branching ranged from 50° to 100°.

**Minor venation pattern.** Minor veins or the higher order veins constitute the tertiary veins and the next order of finer branches originating from the tertiary veins; these were reticulate (Fig. 2G and H). The finer order of veins originating from the tertiaries, and those of the same size originating from the primary and secondary veins constituted the quaternary veins. In all the locations studied, the highest order of veins was identified up to 5°. The marginal ultimate veins were incomplete.

**Bundle sheath.** In all the studied locations, primary, secondary and tertiary veins had a parenchymatous 'bundle sheath' (Fig. 2H). In some cases, the bundle sheath was observed even in higher-order vein.

**Areolation.** Areoles are the smallest areas of the leaf tissue surrounded by major veins and form a contiguous field over most of the leaf area. In the present study, areoles were imperfect and quadrangular, pentagonal or irregular in shape (Fig. 2C and D). Observations on ultimate veins revealed both simple and branched types of veins. The simple vein endings were either linear or curved (Fig. 2A and B).

**Tracheids.** Tracheids were common at the free vein endings (Fig. 2I). They were unicellular, conical in shape.

---

## DISCUSSION

---

Leaf venation in angiosperms varies both in pattern (Hickey, 1973) and regularity (Hickey & Doyle, 1972). Veins of first, second and third order form major venation patterns, and those of subsequent orders constitute minor venation patterns (Pray, 1954). The venation patterns observed in the present study conform to the eucamptodromous and brochidodromous imperfect and reticulate venation type. Multiple vein order may have evolved to maximize the efficiency of structural support (Niklas, 1999). In addition, reticulation provides redundancy of transport pathways that will minimize the deleterious effect of insects and other sources of damage (i.e. cavitation) on transport pathways. At the same time, it provides a physical barrier which limits the spread of such damage (Salleo et al., 1997).

Sehgal and Paliwal (1974) concluded that size of the areole is not of much ecological significant value on the basis of their study of venation pattern of 150 species of *Euphorbia*. This was because areole size overlapped considerably in several species of that genus. In the present study, areoles were imperfect with a quadrangular, pentagonal or irregular shape.

The average areole size was more or less the same in all the locations ranging from 0.35 to 0.48 mm<sup>2</sup>. Inamdar and Shenoy (1980) reported that since diversity of opinions exist regarding the size of the areole and the number of vein endings, statistical data should not be of much use. The number of vein endings is not connected in any way to the size of the areole, as the nearby areoles, even though more or less equal in size, vary in their number of vein endings.

During the present study, simple and branched vein endings were observed. Tracheids present at the tips of the vein endings were non-glandular. Marginal ultimate venation was generally incomplete. Inamdar and Shenoy (1980) reasoned that tracheids at the vein endings mostly increase the cell diameter and are extraordinarily variable in size, shape and orientation. Leaf area of *V. tortilis* was very small; Pyykko (1966) reported that both desert and Mediterranean plants have small leaves.

Because minor characters, such as areole, tracheids and vein endings showed no difference within the locations, they can be used as taxonomic criteria in this species. This study also indicated that geographical condition had no impact on the structure of leaf architecture.

---

## CONCLUSION

---

The venation pattern observed might have an important function in transpiration and water distribution in the leaf. No changes were detected in leaf architecture. These anatomical characters can be considered of great taxonomic importance.

---

## ACKNOWLEDGEMENTS

---

We acknowledge the mentorship of Prof. RB Bhat throughout the research. The National Research Foundation (NRF) is acknowledged for their financial support. We also thank the University of Venda for providing us the opportunity to use their infrastructure and equipment.

---

## REFERENCES

---

- Bouchenak-Khelladi, Y., O. Maurin, J. Hurter & M. van der Bank (2010). The evolutionary history and biogeography of Mimosoideae (Leguminosae): An emphasis on African acacias. *Molecular Phylogenetics and Evolution* 57: 495-508.
- Hickey, L.J. (1973). Classification of the architecture of dicotyledonous leaves. *American Journal of Botany* 60: 17-33.
- Hickey, L.J. & J.A. Doyle (1972). Fossil evidence on the evolution of angiosperm leaf venation. *American Journal of Botany* 59: 661. <https://maps.google.co.za/maps>. Accessed 22/10/2014.
- Inamdar, J.A. & K.N. Shenoy (1980). Leaf Architecture in some Convolvulaceae. *Phyton* 21: 115-124.
- Niklas, K. (1999). A mechanical perspective of foliage leaf form and function. *New Phytologist* 143: 19-31.
- Pray, T.R. (1954). Foliar venation of Angiosperms. I. Mature venation of *Liriodendron*. *American Journal of Botany* 41: 663-670.

- Pyykko, M. (1966). Leaf anatomy of East Patagonian xeromorphic plants. *Annales Botanici Fennici* 3: 453-622.
- Roth-Nebelsick, A., D. Uhl, V. Mosbrugger & H. Kerp (2001). Evolution and function of leaf architecture: a review. *Annals of Botany* 87: 533-566.
- Salleo, S., A. Nardini & M. Lo Gullo (1997). Is sclerophylly of Mediterranean evergreens and adaptation to drought? *New Phytologist* 135: 603-612.
- Sehgal, L. & G.S. Paliwal (1973). Studies on the leaf anatomy of Euphorbia II Venation pattern. *Botanical Journal of the Linnean Society* 68: 173-208.
- Taiz, L. & D. Zeiger (2006). Plant physiology. 4<sup>th</sup> edition. Sinauer Sunderland, Massachusetts, USA.
- Teresa, M.V.M. & K. Rekha (2010). Studies on leaf architecture of Polygala Linn. *Plant Archives* 10: 551-553.