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REVIEW ARTICLE

Taxonomical identification of different plant sources of *Vaasa (Adhatoda spp.)*

Teenu Tomy[1] P Y Ansary[2] Sara Moncy Oommen[3] Shincymol V V[4]

[1]PG Scholar Department of Dravyagunavijnanam GAVC, Tripunithura
[2]HOD & Professor Department of Dravyagunavijnanam GAVC, Tripunithura
[3]HOD & Professor Department of Dravyagunavijnanam GAVC, Kannur
[4]Associate Professor Department of Dravyagunavijnanam GAVC, Tripunithura

*Email: teenulishin@gmail.com

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Abstract

Vaasa, is a valuable medicinal plant extensively utilized in Ayurvedic medicine. The increasing demand for *Vaasa* has led to a rise in the availability of both wild and cultivated sources. This study focuses on the taxonomical identification of various plant sources of *Vaasa*(*Adhatoda spp.).* The study involved a comprehensive investigation based on morphological characteristics to differentiate five sources of *Vaasa* (*Adhatoda spp.*), denoted as A1 (*Valiyaadalodakam*), A2 (*Cheriyaadalodakam*), A3 (*Adhatoda spp*. - *Vasika*), A4 (*Adhatoda spp.- Ajagandhi*), and A5 (*Adhatoda beddomei* C B Clarke). The results of the study revealed that sample A1 closely resembled *Adhatoda vasica* Nees, as described in authentic textbooks, indicating its species-level identity. Sample A2, on the other hand, exhibited notable morphological differences from sample A1, suggesting it may represent a distinct "form" of *Adhatoda vasica* Nees. Samples A3 and sample A4 showed variations in various characteristics, indicating that they belong to an infraspecific level, "varieties" within the *Adhatoda spp.* Sample A5 exhibited similar morphological features to *Adhatodabeddomei* C B Clarke, suggesting that it represents a different "species" from Sample A1. In conclusion, the study highlights significant morphological variations among the different *Adhatoda spp.*, confirming the existence of multiple *Vaasa* sources. This underscores the taxonomical diversity within the *Adhatoda spp.* The study's findings contribute to the better understanding and identification of various *Vaasa* sources used in Ayurvedic medicine, whichcan be essential for quality control and research in this field.

Introduction

Vaasa, a highly valued medicinal plant in Ayurvedic medicine, is widely utilized for its therapeutic properties. The Ayurvedic Pharmacopeia of India has officially recognized *Adhatoda vasica* Nees as the main source of *Vaasa* and some experts have also acknowledged *Adhatoda beddomei* C B Clarke as an alternative source. In Kerala, two distinct plants, *Valiyaadalodakam* and *Cheriyaadalodakam*, are locally considered sources of *Vaasa*. *Valiyaadalodakam* is considered as *Adhatoda vasica* Nees. *Cheriyaadalodakam* is morphologically smaller and considered as

Adhatoda beddomei C B Clarke.[1] But it is reported that *Adhatoda beddomei* C B Clarke has been known to be a very rare and endangered species.[2] The wide availability of *Cheriyaadalodakam* across Kerala further complicates the challenge, as it raises doubts about its equivalence to the endangered *Adhatoda beddomei* C B Clarke. Besides cultivated varieties of *Adhatoda spp.* are also used for medicinal preparations due to its wide commercial and medicinal values. By the interaction with experts, it could be known that there have been found morphotypes of *Adhatoda spp.* in Kerala. As the demand for *Vaasa* grows, the ambiguity surrounding the plant's sources has been amplified as both wild and cultivated varieties of *Adhatoda spp.* become more wide spread . Kerala Agricultural University (KAU) released two high-yielding varieties of *Vaasa* named, *Vasika* and *Ajagandhi*, with a vasicine content of 2.5% after comparative yield trials.[3] In the face of these challenges, taxonomy, a branch of biology, plays a crucial role. Taxonomy involves the systematic study of identifying, classifying, and describing organisms, including plants. Morphological features of a species serve as a primary and visually apparent source for recognizing the taxonomic characteristics, enabling precise differentiation and classification. The study involved a comprehensive investigation based on morphological characteristics to differentiate five sources of *Vaasa* (*Adhatoda spp.*), denoted as A1 (*Valiyaadalodakam*), A2 (*Cheriyaadalodakam*), A3 (*Adhatoda spp. - Vasika*), A4 (*Adhatoda spp. - Ajagandhi*), and A5 (*Adhatoda beddomei* C B Clarke).

Materials and Methods

1.Collection and Establishment of Plant Sources of *Vaasa* (*Adhatoda spp.*)

1.1 Collection of plant sources of *Vaasa* (*Adhatoda spp.*)

Valiyaadalodakam and *Cheriyaadalodakam* saplings were collected from the campusof Government Ayurveda College, Tripunithura. Saplings of two varieties of *Adhatoda spp.- Vasika* & *Ajagandhi,* released by Agricultural University were collected fromthe Sales centre of Department of Plantation Crops and Spices, Kerala Agricultural University(KAU), Mannuthy, Thrissur. The Centre for Medicinal Plants Research Institute (CMPR) at Kottakkal housed a mother plant of *Adhatoda beddomei* C B Clarke.[2] Saplings of *Adhatoda beddomei* C B Clarke were collected from the Herbal Garden, Centre for Medicinal Plants Research Institute (CMPR), Kottakkal. These five saplings of *Vaasa* were subsequently brought to herbal garden of Department of Dravyagunavijnanam, Government Ayurveda

College, Tripunithura, for establishment. They are named as A1, A2, A3, A4 and A5respectively for descriptive purpose.

Table No. 1 : Sources of *Vaasa* (*Adhatoda spp.*) collected and their collection sites with respective sample codes

Sources of *Vaasa* (*Adhatoda spp.*)	Sample code	Collection site
Valiyaadalodakam	A1	Campus of Government Ayurveda college, Tripunithura
Cheriyaadalodakam	A2	Campus of Government Ayurveda college, Tripunithura
Adhatoda spp. -Vasika variety	A3	Sales Centre of Department of Plantation Crops and Spices, Kerala Agricultural University, Mannuthy, Thrissur
Adhatoda spp.-Ajagandhi variety	A4	Sales centre of Department of Plantation Crops and Spices, Kerala Agricultural University, Mannuthy, Thrissur
Adhatoda beddomei C B Clarke	A5	Herbal garden, Centre forMedic-inal Plants Research Institute (CMPR), Kottakkal

1.2. Establishment of plant sources of *Vaasa* (*Adhatoda spp.*)

A suitable spot was identified within the Herbal Garden of Department of Dravyagunavijnanam, Government Ayurveda College, Tripunithura, considering the specific environmental requirements, as mentioned in the distribution and habitat of *Adhatoda spp.*(well-drained soil in sun or partial shade, with high humidity).[5] For ensuring proper growth, the spots were thoroughly prepared by cleaning the site. With meticulous care and attention, each sapling of *Vaasa* (*Adhatoda spp.*) was transplanted into respective designated spot (Picture No.1) having a pit-size measuring 30 x 20 cm. These pits were then filled with a mixture of soil and organic manure. Another set of

Picture No: 1 Field established samples of *Vaasa* (*Adhatoda spp.*)

saplings were established in earthen pots containing soil and organic manure at Herbal Garden, Department of Dravyagunavijnanam, Tripunithura.

In the present study after one year of establishment, taxonomical identification based on morphological evaluation of each plant was conducted at Herbal Garden, Department of Dravyagunavijnanam, Tripunithura, to assess the habit, stem characters, branching, and leaf characters of *Vaasa* (*Adhatoda spp.*) plants in both the designated spots and the earthen pots. The qualitative and quantitative information about the five samples of *Vaasa* (*Adhatoda spp.*) -A1, 2, A3, A4, and A5 were examined visually.

Picture No: 2 Plant sample A1 (*Valiyaadalodakam*)

Fig 3: Trunk portion enlarged view of sample A1 (*Valiyaadalodakam*)

Picture No: 4 Fresh leaf of sample A1(*Valiyaadalodakam*)

Picture No: 5 Plant sample A2 (*Cheriyaadalodakam*)

Picture No: 6 Suckers of sampleA2 (*Cheriyaadalodakam*)

Picture No: 7 Fresh leaf of sample A2 (*Cheriyaadalodakam*)

Picture No: 8 Plant sample A3 (*Adhatoda spp.-Vasika*)

Picture No: 9 Trunk portion en larged view of sample A3 (*Adhatoda spp.-Vasika*)

Picture No: 10 Fresh leaf of sample A3 (*Adhatoda spp.-Vasika*)

Picture No: 11 Plant sample A4 (*Adhatoda spp.-Ajagandhi*)

Picture No: 12: Trunk portionenlarged view of sample A4 (*Adhatoda spp.-Ajagandhi*)

Picture No: 13 Fresh leaf of sample A4 (*Adhatoda spp.-Ajagandhi*)

Picture No: 14 Plant sample A5 (*Adhatoda beddomei* C B Clarke)

Picture No: 15 Trunk portionen larged view of sample A5 (*Adhatoda beddomei* C B

Picture No: 16 Fresh leaf of sample A5 (*Adhatoda beddomei* C B Clarke)

Results

The saplings of plant sources of *Vaasa* (*Adhatoda spp.*) planted on the land and in the pot were identified taxonomically after one year of their establishment. The morphological characters of each plant source of *Vaasa* (*Adhatoda spp.*) - A1 A2 A3, A4 and A5 was carried out at this stage. Due to the limited duration of the study, only observable characters related to habit, stem, and leaves were taken into account. The features like root, inflorescence, flower etc were not available as the plant did not gain considerable growth maturity during the period of study. The observations are tabulated below (Table No. 2).

Discussion

Taxonomic identification at the infraspecific level involves identifying differences like subspecies, varieties, and forms as per International Code of Nomenclature in plants (ICBN). Subspecies is used for populations that live in different areas and vary in size, shape, or other physical characteristics (morphology), but that can successfully interbreed. Varieties are oftenthe result of minor genetic differences or adaptations to specific environmental conditions within a species range. They can also be the outcome of human cultivation and selective breeding in plants. This difference will usually be bigger than those of a form; a form will have one or more small differences. Each form is comprised of plants that have minor botanical differences from those in other forms in the species such as the color of flower or shape of theleaves. The officially accepted botanical source of *Vaasa* is *Adhatoda vasica* Nees as per Ayurvedic pharmacopeia of India. Reports indicate the presence of distinct morphotypes with in the *Adhatoda spp.*, exhibiting a wide range of leaf variations (Prabhu Kumar et al.).[6] The term "form" denotes a group with noticeable morphological deviations, as highlighted in book ayurvedic Drugs & their Plant Sources for naturally occurring *Adhatoda spp.* - *Valiyaadalodakam* and *Cheriyaadalodakam* in Kerala.[2] In the present study five different sources of *Adhatoda spp.* were selected and evaluated, after 1 year of establishment of plants. A comparative study on these plants displayed subtle morphological distinctions. Sample A1 (*Valiyaadalodakam*) exhibits similar morphological features of *Adhatoda vasica* Nees is available in the authentic text books. Sample A2 (*Cheriyaadalodakam*) is with noticeable morphological deviations with Sample A1 (*Valiyaadalodakam*) in its habit, stem modification, leaf insertion, length and breadth of lamina, and venation and may be considered as “form” of *Adhatoda vasica* Nees. Sample A3 (*Adhatoda spp.-Vasika*) and sample A4 (*Adhatoda spp.-Ajagandhi*) exhibits differences in the height of plant, leaf insertion, length and breadthof lamina, lamina margin, colour of lamina, and venation with that of sample A1 (*Valiyaadalodakam*) and may be considered as “variety”. Sample A5 exhibits similar morphological features of *Adhatoda beddomei* C B Clarke available in the authentic text booksand it exhibits “species level” variations with that of sample A1 (*Valiyaadalodakam*). These slight morphological differences play a key role in distinguishing these plants. These specific variations are tabulated in table no. 3.

Conclusion

Taxonomical identification of different sources of *Vaasa* (*Adhatoda spp.*) was donein this study after one year of establishment of plants. Sample A1 (*Valiyaadalodakam*) showed similar morphological features with *Adhatoda vasica* Nees. Sample A2 (*Cheriyaadalodakam*), with noticeable morphological deviations with that of sample A1 (*Valiyaadalodakam*) come under the infraspecific level known as forms. Sample A3 (*Adhatoda spp.-Vasika*), and sample A4 (*Adhatoda spp.-Ajagandhi*) are cultivars of

Table No. 2 Morphological characters of different sources of *Vaasa* (*Adhatoda spp.*)

	Sources of *Vaasa* (*Adhatoda spp.*)				
Characters	***Valiyaadalodakam***	***Cheriyaadalodakam***	***Adhatoda spp. - Vasika***	***Adhatoda spp. - Ajagandhi***	***Adhatoda beddomei* C B Clarke**
A. Habit **a**. Type ofplant	Shrubby with bushy appearance	Shrubby	Shrubby	Shrubby	Shrubby
b. Annual/ biennial/ perennial	Perennial	Perennial	Perennial	Perennial	Perennial
c. Height ofPlant **i.** Pottedplant	145cm	36cm	100cm	95cm	96cm
ii. Field established plant	156cm	40cm	88 cm	86 cm	77cm
B. Stem **a**. Nature	Erect, straight, short,and stout trunk	Nil	Erect, straight, long,and stout trunk	Erect, straight, long,and stout trunk	Erect, straight, and long trunk
b. Special modification	Nil	Sucker emerges from the subterranean part of the stem, extending laterally beneath the soil before emerging above ground and producing adventitious roots and shoots completewith leaves, giving rise to novel plant.	Nil	Nil	Nil
c. Branching **i.** Pottedplant	3 equally grown lateral ascending branches aris-en 3.5cmabove the soil by aborting the growth of main trunk.	Nil	3 lateral branches emerged in an ascending manner from the trunk, positioned 3.2cm above the soil and the trunk continues growing with producing new branches.	2 lateral branches emerged in an ascending manner fromthe trunk, positioned 5.6cm above the soil and the trunk continues growing with producingnew branches.	2 lateral ascending branches arisen 43.2 cm above the soil trunk and observed that branching started from almost midpoint of the plant.
ii. Field estab-lished plant	3 equally distributed long lateral ascendingbranch-es arisen 3.1cmabove the soil by aborting the growth oftrunk.	Nil	3 lateral ascending branches arisen 4.3cm above the soiland the trunk continues growing.	3 lateral ascending branch-es arisen 3.8cm above the soil from theprominent nodes of trunk	2 lateral ascending branches arisen 28.6 cm above the soil trunk and observed that branching started from almost midpoint of the plant.
d. Branching angle	Most lateral branches grew horizontally creates an angle rangefrom 55-60 degrees and then tends vertically	Nil	Most lateral branches grew horizontally createsan angle range from55-75 degrees and then tends vertically	Most lateral branches grew horizontally creates an angle range from 55-75 degrees andthen tends vertically	All lateral branches grew horizontally createsan angle 60 degrees and then tends vertically.
g. Shape	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
h. Colour	Young branches –light green Mature branches – Brownish grey	Young branches –light green Mature branches – brownish grey	Young branches –green Mature branches – brownish grey	Young branches –green Mature branches – brownish grey	Young branches – lightgreen Mature branches –greyish cream
e. Texture	Young branches - herbaceous Mature branches -woody in nature	Young branches - herbaceous Mature branches - woody in nature	Young branches –less herbaceous Mature branches - woody in nature	Young branches – less herbaceous Mature branches - woody in nature	Young branches - more herbaceous Mature branches - woodyin nature
f. Type	Solid	Solid	Solid	Solid	Solid

i. External characters	Smooth and thin bark which was easily scrapable found in the mature stem. Lenticels present- raised, elongated, or round shaped, arranged longitudinally. More visible at older branches but not muchvisible in younger branches.	Smooth and thin bark which was easily scrapable found in the maturestem. Lenticels present- raised, elongated, or round shaped, arranged longitudinally. More visible at older branches but not much visible in younger branches.	Smooth and thin bark which was easily scrapable found in the maturestem. Lenticels present- raised, elongated, or round shaped, arranged longitudinally. More visible at older branches but not much visible in younger branches.	Smooth and thin bark which was easily scrapable found in themature stem. Lenticels present- raised, elongated, or round shaped, arranged longitudinally. More visible at older branches but not much visible in younger branches.	Smooth and thin barkwhich was easily scrapable found in themature stem. Lenticels present- raised, elongated, or round shaped, arranged longitudinally. More visible at older branches but not much visible in younger branches.
C. Leaf					
a. Insertion	Cauline	Ramal	Ramal and cauline	Ramal and cauline	Ramal and cauline
b. Arrangement	Opposite decussate	Opposite decussate	Opposite decussate	Opposite decussate	Opposite decussate
c. Presence of petiole	Petiolate, semiterate and short	Petiolate, semiterate and short	Petiolate, semiterate and short	Petiolate, semiterate and short	Petiolate, semiterate andshort
i. Length of petiole	1.5 - 3 cm	1.4-2 cm	1-1.2 cm	0.9-1 cm	1.5-2.3 cm
ii. Diameterof petiole	0.3-0.6cm	0.2-0.3cm	0.2-0.3 cm	0.2-0.3 cm	0.3-04 cm
d. Presenceof stipule	Exstipulate	Exstipulate	Exstipulate	Exstipulate	Exstipulate
e. Leaf base	Attenuate	Attenuate	Attenuate	Attenuate	Attenuate
f. Leaf kind	Simple	Simple	Simple	Simple	Simple
g. Form oflamina	Marginal attachment	Marginal attachment	Marginal attachment	Marginal attachment	Marginal attachment
i. Laminalength (l)	26.5 -32.5cm long	16.5- 17 cm long	9-15.5 cm long	11.5cm - 14 cm long	19-21.5 cm
ii. Lamina breadth (w)	7.8-8.5cm	5-5.3 cm	2-3.7 cm	3.2-3.5 cm	5.7-6.2cm
iii. l/w ratio	3.39 -3.8	3.3-3.20	4.5- 4.18	3.59 - 4	3.33-3.46
h. Shape	Ovate - elliptic	Ovate - elliptic	Ovate/lanceolate	Ovate/lanceolate	Ovate - elliptic
i. Margin of lamina	Entire up to 5-6 cm from base and markedcrenulations that appear from the midpoint of lamina towards the apex, seems wavy toward smargin	Entire up to 4-4.5cm from base and marked crenulations that appear from the midpoint of lamina towards the apex, seems wavy towardsthe margin	Minute crenulations	Minute crenulations	Entire up to 5-6 cm from base, then crenations appear from the midpointof lamina towards the apex, seems wavy towards margin
j. Leaf apex	Acuminate	Acuminate	Acuminate	Acuminate	Acuminate
k. Surface	Minutely pubescent /puberulous when young, but smoothwhen mature	Minutely pubescent /puberulous when young, but smooth when mature	Minutely pubescent /puberulous when young, but smooth when mature	Minutely pubescent /puberulous when young, but smoothwhen mature	Smooth and firm
l. Colour	Younger leaves- bright green above and pale green below Older leaves - dark green above and pale Below	Younger leaves- bright green above and pale green below Older leaves - dark green above and pale below	Both younger andolder leaves - darkgreen above and paler beneath	Both younger and older leaves - dark green above and paler beneath	Younger leaves- strongbright green above and pale green below Older leaves- dark greenabove and pale below
m. Venation	Distantly spaced minutely puberulous secondary nerves reticulate with 15-18 pairs of prominent secondary nerves arising at an angle of 55-60 degree, running parallel to each other	Distantly spaced minutely puberulous secondary nerves reticulate with 10-11 pairs of prominent secondary nerves, arising at an angle of 45-60 degree, running parallel to each other	Distantly spaced minutely puberulous secondary nerves reticulate with 10-11pairs of prominent secondary nerves, arising at an angle of35-50 degree, running parallel to each other	Distantly spaced minutely puberulous secondary nerves reticulate with 9-10 pairs of prominent secondary nerves, arising at an angle of 35-50 degree, runningparallel to each other	Distantly spaced minutely puberulous secondary nerves reticulate with 9-10 pairsof prominent secondary nerves, arising at an angle of 40-50 degree, running parallel to each other
n. Texture	Medium	Medium	Medium	Medium	Smooth and firm

Table No. 3 Variations in the morphological characters of different sources of *Vaasa* (*Adhatoda spp.*)

Characters	Sources of *Vaasa* (*Adhatoda spp.*)				
	Valiyaadalodakam	***Cheriyaadalodakam***	***Adhatoda spp.- Vasika***	***Adhatoda spp.- Ajagandhi***	***Adhatoda beddomei* C B Clarke**
A. Habit **a**. Type ofplant	Shrubby with bushyappearance	Shrubby	Shrubby	Shrubby	Shrubby
b. Height of Plant	Potted -145 cm Field established- 156cm	Potted -36 cm Field established-40cm	Potted -100 cm Field established-88cm	Potted -95 cm Field established-86cm	Potted -96 cm Field established-77cm
B. Stem a. Special modification	Nil	Sucker	Nil	Nil	Nil
b. Branching	3 equally grown lateral ascending branches arisen 3.5cmabove the soil by aborting the growth ofmain trunk.	Nil	3 lateral branches emerged in an ascendingmanner from the trunk, positioned 3.2cm above the soil and the trunk continues growingthe with producing new branches.	2 lateral branches emerged in an ascendingmanner from the trunk, positioned 5.6cm above the soil and the trunk continues growing with producing new branches.	2 lateral ascending branches arisen 43.2 cm above the soil trunk and observed that branching startedfrom almost midpointof the plant.
C. Leaf **a.** Insertion	Cauline	Ramal	Ramal and cauline	Ramal and cauline	Ramal and cauline
i**.** Length x diameter of petiole	1.5 - 3 cm x0.3-0.6cm	1.4-2 cm x 0.2-0.3cm	1-1.2 cm x0.2-0.3 cm	0.9-1 cm x0.2-0.3 cm	1.5-2.3 cm x0.3-04 cm
ii. Laminalength (l)	26.5 -32.5cm long	16.5- 17 cm long	9-15.5 cm long	11.5cm - 14 cm long	19-21.5 cm
iii. Lamina breadth (w)	7.8-8.5cm	5-5.3 cm	2-3.7 cm	3.2-3.5 cm	5.7-6.2cm
iv. l/w ratio	3.39 -3.8	3.3-3.20	4.5- 4.18	3.59 - 4	3.33-3.46
b. Margin of lamina	Entire up to 5-6 cm from base and marked crenulations that appear from the midpoint of lamina towards the apex, seems wavy towards margin	Entire up to 4- 4.5cm from base and marked crenulations that appear from the midpoint of lamina towards the apex, seems wavy towards the margin	Minute crenulations	Minute crenulations	Entire up to 5-6 cm from base, then crenations appear from the midpoint oflamina towards the apex, seems wavy towards margin
c. Colour	Younger leaves- bright green above and pale green below Older leaves - dark green above and palebelow	Younger leaves- bright green above and pale green below Older leaves - dark green aboveand pale below	Both younger and older leaves were dark green above and paler beneath	Both younger and older leaves were dark green above and paler beneath	Younger leaves- strong bright green above and pale greenbelow Older leaves- dark green above and palebelow
d. Venation	15-18 pairs	10-11 pairs	10-11 pairs	9-10 pairs	9-10 pairs
e. Texture	Medium	Medium	Medium	Medium	Smooth and firm

Adhatoda spp. and these plants come under the infraspecific level known as variety. Sample A5 showed morphological similarity with *Adhatoda beddomei* C B Clarke. The present study revealed significant variations in the morphological features of these *Adhatoda spp.*, confirming the existence of multiple *Vaasa* sources. These differences highlighting the taxonomical diversity within the *Adhatoda spp.*. Acknowledging the diversity within the plant is crucial for ensuring the accurate identification and utilization of *Vaasa* in Ayurvedic medicine and other therapeutic applications. This knowledge can aid in the development of strategies for sustainable cultivation, conservation, and quality control of Vaasa-based products, ultimately benefiting both traditional medicine and modern herbal medicine practices.

Conflict of interest: Nil

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