



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(1): 482-487
Received: 05-11-2016
Accepted: 06-12-2016

Dr. Aruna Mehta

Himalayan Research Associate,
Department of Forest Products,
Dr. YS. Parmar University of
Horticulture & Forestry, Nauni,
Solan, Himachal Pradesh, India

Dr. Ravinder Raina

Principal Scientist, Department
of Forest Products, Dr. YS.
Parmar University of
Horticulture & Forestry, Nauni,
Solan, Himachal Pradesh, India

Dr. Romesh Chand Rana

Retired Prof. & Head,
Department of Forest Products,
Dr. YS. Parmar University of
Horticulture & Forestry, Nauni,
Solan, Himachal Pradesh, India

Yash Pal Sharma

Senior Phytochemist,
Department of Forest Products,
University of Horticulture &
Forestry, Nauni, Solan Himachal
Pradesh, India.

Comparative morphological studies of some *Swertia* species

Aruna Mehta, Ravinder Raina, Romesh Chand Rana and Yash Pal Sharma

Abstract

Swertia chirayita (family Gentianaceae), source of important Indian Ayurvedic drug "chirata", is an imperative medicinal plant in Indian system of medicine known for its potent activity against malaria, liver-disorder, fever, gastrointestinal infection and diabetes. However, due to its high demand and scarcity, it is being frequently adulterated with other species of *Swertia* which are more readily available. Presently almost all the similar looking species of *Swertia* are marketed as 'chirata' without any rationale which is affecting the potency of the drug. These substitutes need to be identified through quick test for which a key of morphological characteristics has been prepared. Present studies focused on evaluating *Swertia chirayita* along with its four common adulterants by comparison of their morphological characteristics to distinguish genuine chirata from its adulterants. The study revealed the major distinguishing character amongst all the five *Swertia* species was based on difference in floral features, stem type and leaf shape.

Keywords: *Swertia chirayita*, adulterants, authentication, morphology.

Introduction

Swertia chirayita (Roxb.) H. Karst a member of family Gentianaceae commonly known as "chirata" holds the most prominent position based on its medicinal potential [6]. Beside its uses in different traditional systems of medicine including Ayurveda, Unani and Siddha, its medicinal capabilities have also been described in the Indian pharmaceutical codex, as well as the British and American pharmacopoeias [5]. It is credited with tonic, febrifugal, laxative, stomachic, anthelmintic, anti-inflammatory, anti-diarrhoeal properties [1, 22] and also enjoys a special remedy in Western India for bronchial asthma as well as liver disorders [14]. The plant is native of temperate Himalayas reported to be found at an altitude of 1200-3000m from Kashmir to Bhutan and in Khasi hills in Meghalaya at 1200-1500m [4, 8] and can be grown in sub-temperate regions between 1500m and 2100m altitudes [7, 23]. Existing populations of this species are diminishing due to indiscriminate wild collection and as per International Union for Conservation of Nature and Natural resources (IUCN) criteria, *Swertia chirayita* has been categorised as critically endangered [12, 20, 24]. Natural populations of this species are rare in the wild to sustain its commercial demand leading to deliberate or inadvertent adulteration. This is due to ignorance on the part of the collector or unavailability of the genuine stock. Several other species namely *S. angustifolia*, *S. corymbosa*, *S. decussata*, *S. hookeri*, *S. macrosperma*, *S. petiolata*, *S. lawii*, *S. paniculata*, *S. punctata*, *S. calycina*, *S. purpurascens*, *S. bimaculata*, *S. ciliata*, *S. densifolia*, *S. japonica* and *S. frachetiana* are being used intentionally or unintentionally as its adulterants which is affecting its potency [5, 13, 18, 21]. Besides species belonging to genus *Swertia*, *Swertia chirayita* is also substituted by species like *Andrographis paniculata* (green chirata), *Exacum tetragonum* *E. bicolor*, *E. pedunculatum* and *Slevolia orientalis* [14]. Hence, it was felt to establish distinguishing features to ensure the correct identity of the drug used. Present study was carried to determine morphological profiles of *S. chirayita*, *S. alata*, *S. cordata*, *S. angustifolia* and *S. purpurascens* to establish the authenticity of *S. chirayita* which may help to a great extent for differentiating the genuine drug 'chirata' from its other allied species.

Material and Methods**Collection of Plant Material**

Swertia chirayita was obtained from the Medicinal and Aromatic farm at Shilly (Distt Solan, HP), *S. alata* as well as *S. angustifolia* were collected from Dharon Ki Dhar (Distt, Solan, HP) while *S. purpurascens* and *S. cordata* were collected from Hattu (Distt. Shimla, HP). Qualitative morphological studies were conducted as per standard taxonomic literature [10, 11, 16, 17, 19]. The quantitative characters described were plant height, number of branches, number of prominent veins and leaf dimension etc.

Correspondence**Dr. Aruna Mehta**

Himalayan Research Associate,
Department of Forest Products,
Dr. YS. Parmar University of
Horticulture & Forestry, Nauni,
Solan, Himachal Pradesh, India

Results and Discussion

Medicinal plants have been used in all cultures as a source of medicine in crude form for their curative effects against a variety of mankind's ailments. However, due to some morphological similarities and lack of correct identification, the crude drugs are often adulterated or substituted in trade, which results in the loss of drug efficacy. Correct identification of herbal drug is the foundation of the safe use of plant based products and without proper identification, the safe use of quality products cannot be guaranteed. Therefore, detailed morphological description of medicinal plants is essential step for solving the problem of adulteration thereby ensuring the correct identification of drug used.

In present studies, distinguishing morphological features of *Swertia chirayita* as well as its adulterants species from genus *Swertia* have been studied in detail and presented in Table 1&2. The details are supported by photographs of flowers (figures 1-5) and plants (figures 6-10) (Plate 1). As is clear from table 1 *S. chirayita* is a once flowering herb (pluri-annual) with robust stem containing large pith while other four species i.e. *S. alata*, *S. angustifolia*, *S. cordata*, *S. purpurascens* are annual. Earlier authors have reported *S. chirayita* as annual ^[1, 25], biennial ^[10] or perennial ^[17]. During vegetative phase, *Swertia chirayita* can be distinguished from other species in having large sized radical leaves with purplish under surface arranged in rosette. Stem is distinctly quadrangular in *S. alata*, *S. cordata*, *S. angustifolia* and *S. purpurascens* whereas in case of *S. chirayita* it was round in the lower half but quadrangular in the upper half. The stem is purple colour in *S. angustifolia*, yellowish-brown in *S. alata*, yellowish-reddish purple in *S. cordata* and greenish-yellow in *S. chirayita* and *S. purpurascens* which was in conformity with earlier reports (Karan *et al.* ^[15] and Bhatia *et al.* ^[2]). Leaves are lanceolate in *S. chirayita*, ovate in *S. alata*, linear-lanceolate in *S. angustifolia*, oblong in *S. purpurascens* and ovate-lanceolate in *S. cordata*. These findings are also supported by Karan *et al.* ^[15] and Bhatia *et al.* ^[2].

The most distinguishing features among these species are observed in their flowers (Plate 1 & figures 1-5) which are tetramerous in *S. chirayita*, *S. alata* and *S. angustifolia* with four sepals and four petals. Whereas, *S. cordata* and *S. purpurascens* were pentamerous with five sepals and five petals. These observations are also in conformity with earlier reports ^[2, 3, 8, 9, 15]. The other major difference between *S. chirayita* and other species is the presence of a pair of nectar glands at the base of each petal lobe in the flower whereas in the case of latter, there is only one. Bisht *et al.* ^[3] have also

reported similar observation in *S. alata* and *S. chirayita*. The gland was in the form of fimbriate pit covered by hairy flap in *S. alata*, naked horse- shoe shaped in *S. purpurascens*, prominent yellow viscid orbicular spot in *S. cordata*, conspicuous fringed boat shaped in *S. angustifolia* and glandular depression in *S. chirayita*. These species also differ on the basis of flower colour. The flowers (Plate 1 & figures 1-5) were observed yellow-greenish in *S. chirayita*, purple-whitish in *S. angustifolia*, purple-dark reddish in *S. purpurascens*, yellowish white in *S. cordata* and lurid-green yellow in *S. alata*. Among these species, *Swertia purpurascens* had particular distinguishing character in having dark purple coloured ring at the base of each corolla lobe. Inflorescence was observed to be leafy panicles in *S. chirayita*, corymbose panicle cyme in *S. angustifolia* and terminal biparous cyme in *S. alata*, *S. purpurascens* & *S. cordata*. Stem was distinctly quadrangular in *S. alata*, *S. cordata*, *S. angustifolia* and *S. purpurascens* whereas in case of *S. chirayita* it was round in the lower half but quadrangular in the upper half. Quantitative morphological description of all five *Swertia* species is given in table 2.

Conclusion

Several species of *Swertia* are exploited as raw material for different traditional medicines. Among them, *S. chirayita* (chirata) which is considered to be superior and actually required by the pharmaceutical industries is difficult to obtain in crude drug market in India. One of the main issues in its trade is adulteration with other species which are considered to be inferior in medicinal quality. Various substitutes of *S. chirayita* sold under the name of "chirata" need to be identified through quick tests for which a key of morphological characteristics has been prepared. The detailed morphological studies revealed that there are marked differences in morphological characters such as flowers (tetramerous in *S. chirayita*, *S. alata* and *S. angustifolia*; whereas, pentamerous in *S. cordata* and *S. purpurascens*) and stem (distinctly quadrangular in *S. alata*, *S. cordata*, *S. angustifolia* and *S. purpurascens*; whereas in case of *S. chirayita* it was round in the lower half but quadrangular in the upper half). *S. chirayita* had a pair of nectar glands at the base of each petal lobe in the flower whereas in other *Swertia* species there is only one. These detailed morphological observations can help in correctly identifying each *Swertia* species which may help to a great extent for differentiating the genuine 'chirata' drug from its other allied species.

Table 1: Qualitative morphological features of *Swertia* species.

Parameters	Tetramerous species			Pentamerous species	
	<i>S. chirayita</i>	<i>S. alata</i>	<i>S. angustifolia</i>	<i>S. purpurascens</i>	<i>S. cordata</i>
Habit	Robust, branched, pluri-annual	Annual herb	Annual herb	Annual herb	Annual herb
Stem	Robust, single stemmed Bearing several lateral branches. Lower half circular becoming quadrangular above.	Single stemmed, branched, winged, quadrangular, greenish-brown.	Single stemmed, branched, and narrowly winged, quadrangular, purplish at base greenish above.	Branched, quadrangular, spreading, brownish yellow.	Branched, quadrangular, winged, yellowish to purple in mature parts, green in tender.
Leaves	Broadly lanceolate, subsessile, 5 or 7 nerved. Radical leaves large, conspicuous forming a dense rosette at base. Cauline leaves opposite and decussate gradually diminishing in size above.	Simple, opposite, ovate, sessile, acute, decussate, 5-nerved, green.	Simple, opposite, linear-lanceolate, acute, decussate, 3-nerved, green.	Simple, opposite, sessile, glabrous, oblong, lanceolate, acute, 3-nerved, reticulate, multicostate, convergent, green.	Opposite, sessile, decussate, sessile, ovate-lanceolate, acute, 5 or 7 nerved, reticulate, multicostate, convergent, green.
Inflorescence	Leafy panicles bearing solitary axillary, axillary or terminal clusters of 3-5 flowers. Peduncle quadrangular.	Terminal cymes (biparous).	Cymes in corymbose panicles.	Terminal cymes (biparous).	Terminal cymes (biparous).
Flower	Bracteate, pedicellate, complete bisexual, actinomorphic, hypogynous, lurid green, coloured (outside) purplish inside.	Ebracteate, pedicellate, complete, bisexual, actinomorphic, hypogynous, yellowish-green, streaked purple.	Ebracteate, pedicellate, complete, bisexual, actinomorphic, hypogynous, pale yellow or whitish, dark purple dotted.	Complete, ebracteate, pedicellate, actinomorphic, bisexual, hypogynous, pale red purple.	Complete, ebracteate, pedicellate, actinomorphic, bisexual, hypogynous, yellowish-white.
Calyx	Sepals four, gamosepalous, lanceolate, smaller than corolla, elongated at capsule maturation stage, sepal tip acute, green.	Sepals four, gamosepalous, in two pairs of short and large sepals, lanceolate, green.	Sepals four, gamosepalous, oblong-linear, green.	Sepals five, gamosepalous, oblong, slightly smaller than corolla, valvate aestivation, green, inferior.	Sepals five, gamosepalous, ovate-lanceolate, often larger than petals, green, inferior.
Corolla	Petals four, gamopetalous, ovate, greenish yellow tinged with purple at the margins. Two nectar glands at the base of each lobe, fringed with hairs, hairs extending upto half the length of corolla lobe.	Petals four, gamopetalous, ovate, blue or lurid green-yellow, darker dotted petals tinged with purple above the half of each corolla lobe, one green, fringed gland on base of each corolla lobe.	Petals four, gamopetalous, oblong, pale blue or white, darker purple dotted above the half of each corolla lobe, one yellowish-green, conspicuous fringed gland on each corolla lobe.	Petals five, gamopetalous, ovate, pale red purple, purple ring at the base of corolla lobes, one horse shoe shaped gland on each corolla lobe.	Petals five, gamopetalous, ovate-lanceolate, yellow-white, margins marked with pale-purple streaks, one yellowish gland on the base of each lobe, lobes oblong.
Androecium	Stamens four, epipetalous, alternipetalous, polyandrous, bitheous, inferior.	Stamens four, epipetalous, alternipetalous, polyandrous, bitheous, inferior.	Stamens four, epipetalous, alternipetalous, polyandrous, bitheous, inferior.	Stamens five, epipetalous, alternipetalous, polyandrous, bitheous, inferior.	Stamens five, epipetalous, alternipetalous, polyandrous, bitheous, inferior.
Gynoecium	Bicarpellary, syncarpous, unilocular, parietal placentation. Stigma bifid, style slender, superior.	Bicarpellary, syncarpous, unilocular, parietal placentation, stigma bifid, superior.	Bicarpellary, syncarpous, unilocular, parietal placentation, stigma bifid, superior.	Bicarpellary, syncarpous, unilocular, parietal placentation, style elongated, stigma linear, superior.	Bicarpellary, syncarpous, unilocular, parietal placentation, bifid stigma, superior.

Table 2: Quantitative morphological features of *Swertia* species.

Parameters	Tetramerous species			Pentamerous species	
	<i>S. chirayita</i>	<i>S. alata</i>	<i>S. angustifolia</i>	<i>S. purpurascens</i>	<i>S. cordata</i>
Plant height	94-124cm (108.4± 9.87cm)	39.5-75cm (55.9 ± 5.390cm)	24.6 - 51.5cm (40.1 ± 0.79cm)	28.5- 65cm (45.25 ±1.20cm)	21- 70cm (38.08 ± 3.87)
No. of branches	15-34 (20 ± 2.15)	8-20 (13 ± 1.27)	2- 9 (5.4 ± 0.20)	10-25 (15.1 ± 00.55)	8- 25 (13.8 ± 1.41)
Basal Leaves					
Length	6.40-17.50 cm (9.97 ± 0.33cm)	2.30- 5.50cm (3.44 ± 0.11cm)	1.70- 5.00cm (2.97 ± 0.31cm)	27- 6.10cm (3.72 ± 0.03cm)	1.6- 4.4cm (3.04 ± 0.10cm)
Breadth	2.50-6.60cm (4.37 ± 0.17cm)	1.00- 2.90cm (1.94 ± 0.06cm)	0.30-1.30cm (0.59 ± 0.008cm)	0.70- 2.10cm (1.12 ± 0.01cm)	0.6- 3.6cm (2.20 ± 0.07cm)
No. of veins	7 (7 ± 0)	5 (5 ± 0.16)	3 (3 ± 0)	3 (3 ± 0)	5 or 7 (5.46 ± 0.181)
Middle Leaves					
Length	4.00- 19.70cm (8.98 ± 0.30cm)	3.10- 5.90cm (4.52 ± 0.14cm)	3.00- 6.10cm (4.21 ± 0.03cm)	3.10- 2.60cm (4.22 ± 0.03cm)	1.6- 6.0cm (3.53 ± 0.12cm)
Breadth	2.30- 4.60cm (3.47 ± 0.11cm)	1.30- 3.20cm (2.40 ± 0.08cm)	0.10-0.90cm (0.60 ± 0.00cm)	0.70- 2.00cm (1.12 ± 0.01cm)	0.60- 4.50cm (2.43 ± 0.08cm)
No. of veins	5 (5± 0)	5 (5 ± 0)	3 (3 ± 0)	3 (3 ± 0)	5 or 7 (5.40 ± 0.181)
Top leaves					
Length	2.50-7.40cm (4.33 ± 0.11cm)	1.20- 4.10cm (2.63 ± 0.09cm)	1.40- 4.80cm (3.09 ± 0.03cm)	1.40- 3.70cm (2.54 ± 0.02cm)	1.50- 4.50cm (2.31 ± 0.08cm)
Breadth	1.00-3.00cm (3.47 ± 0.14cm)	0.30- 2.50cm (1.10 ± 0.03 cm)	0.15-0.90cm (0.48 ± 0.007cm)	0.10- 0.90cm (0.54 ± 0.006cm)	0.50- 2.50cm (1.60 ± 0.05cm)
No. of veins	5 or 7 (6 ± 0.20)	3 or 5 (4.6 ± 0.16)	1 or 3 (2.33 ± 0.031cm)	3 (3 ± 0)	5 or 7 (5.06 ± 0.16)
Flower					
Diameter	9.2- 11.5mm (10.3± 0.5mm)	10.5-14.0mm (12.8± 0.3mm)	9.0- 12.0mm (10.5± 0.3mm)	8.1- 9.6mm (8.8 ± 0.4mm)	3.5- 9.5mm (7.1 ± 0.4mm)
Length	8.0- 9.3mm (8.6 ± 0.3mm)	6.5- 10.0 mm (8.2± 0.3mm)	6.0- 7.2mm (6.6 ± 0.4mm)	3.5- 7.5mm (6.1 ± 0.5mm)	7.0- 10mm (8.5± 0.5mm)
Pedicel length	4.9-5.7mm (5.3± 0.3mm)	4.5- 8.5mm (7.5± 0.4mm)	5.0- 7.0mm (6.5 ± 0.2mm)	6.5- 8.7mm (7.6 ± 0.4mm)	8.0- 7.0mm (7.7± 0.3mm)
Sepals					
Number	4	4	4	5	5
Length	5.3- 6.1mm (5.2± 0.10mm)	6.0- 14. mm (10.2 ± 0.27mm)	7.0- 8.2mm (7.5± 0.19mm)	5.0- 6.8mm (5.8± 0.2mm)	8.0- 12.0mm (10.6 ± 0.2mm)
Breadth	1.0-2.0mm (1.6± 0.07 mm)	1.0- 2.0mm (1.8 ± 0.05 mm)	1.0- 2.0mm (1.8± 0.04mm)	1.3- 2.5mm (1.8 ± 0.04mm)	2.0- 3.0mm (2.5 ± 0.06mm)
Petals					
Number	4	4	4	5	5
Length	6.2- 7. mm (6.8± 0.20 mm)	5.0- 10mm (7.6 ± 0.19mm)	7.0- 8.0mm (7.4± 0.19mm)	5.7- 7.0mm (6.2± 0.2mm)	6.0- 9.0mm (7.7 ± 0.2mm)
Breadth	2.7- 3.2mm (2.9± 0.04mm)	1.0- 3.0mm (2.4 ± 0.06 mm)	2.0- 3.0mm (2.4± 0.07mm)	2.0- 3.0mm (2.5 ± 0.06mm)	2.0- 3.0mm (2.4± 0.06mm)
Androecium					
No. of stamens	4	4	4	5	5
Filament length	3.8- 4.2mm (4.0± 0.10mm)	3.0- 4.0mm (3.4± 0.09mm)	2.0- 3.6mm (3.2± 0.08mm)	4.0- 4.8mm (4.4± 0.09mm)	3.5- 5.0mm (4.2 ± 0.10mm)
Anther length	1.0- 1.4mm (1.1± 0.02mm)	1.1-2.3mm (1.7± 0.14mm)	1.0- 2.2mm (1.6± 0.03mm)	1.0- 1.5mm (1.3± 0.04mm)	1.0- 1.12mm (1.0 ± 0.02mm)
Stamens length	4.9- 5.7mm (5.2± 0.10mm)	4.2- 6.3mm (5.1 ± 0.20mm)	3.0- 5.8 mm (4.6± 0.10mm)	5.2- 6.3mm (5.7 ± 0.12mm)	4.5- 6.1mm (5.2 ± 0.13mm)
Gynoecium					
No. of carpels	2	2	2	2	2
Style length	1.2- 2.0mm (1.5 ± 0.0.7mm)	2.0- 3.0mm (2.3 ± 0.06mm)	2.1- 3.2mm (2.7± 0.09mm)	2.2- 2.6mm (2.4 ± 0.11 mm)	2.0-2.5mm (2.3 ± 0.08mm)
Ovary length	2.6- 3.0mm (2.7± 0.07mm)	1.0-2.5mm (1.9 ± 0.05 mm)	1.1-2.2mm (1.52± 0.04 mm)	1.0- 2.2mm (2.4± 0.06mm)	2.5-3.1mm (2.3 ± 0.06mm)
Pistil length	3.8- 5.0mm (4.2± 0.10mm)	3.0-5.4mm (4.3 ± 0.11 mm)	3.2- 5.4mm (4.4± 0.13mm)	3.2- 4.8mm (4.1± 0.17mm)	4.5- 5.6 mm (5.1 ± 0.14mm)

Values in parentheses are Mean ± S.E

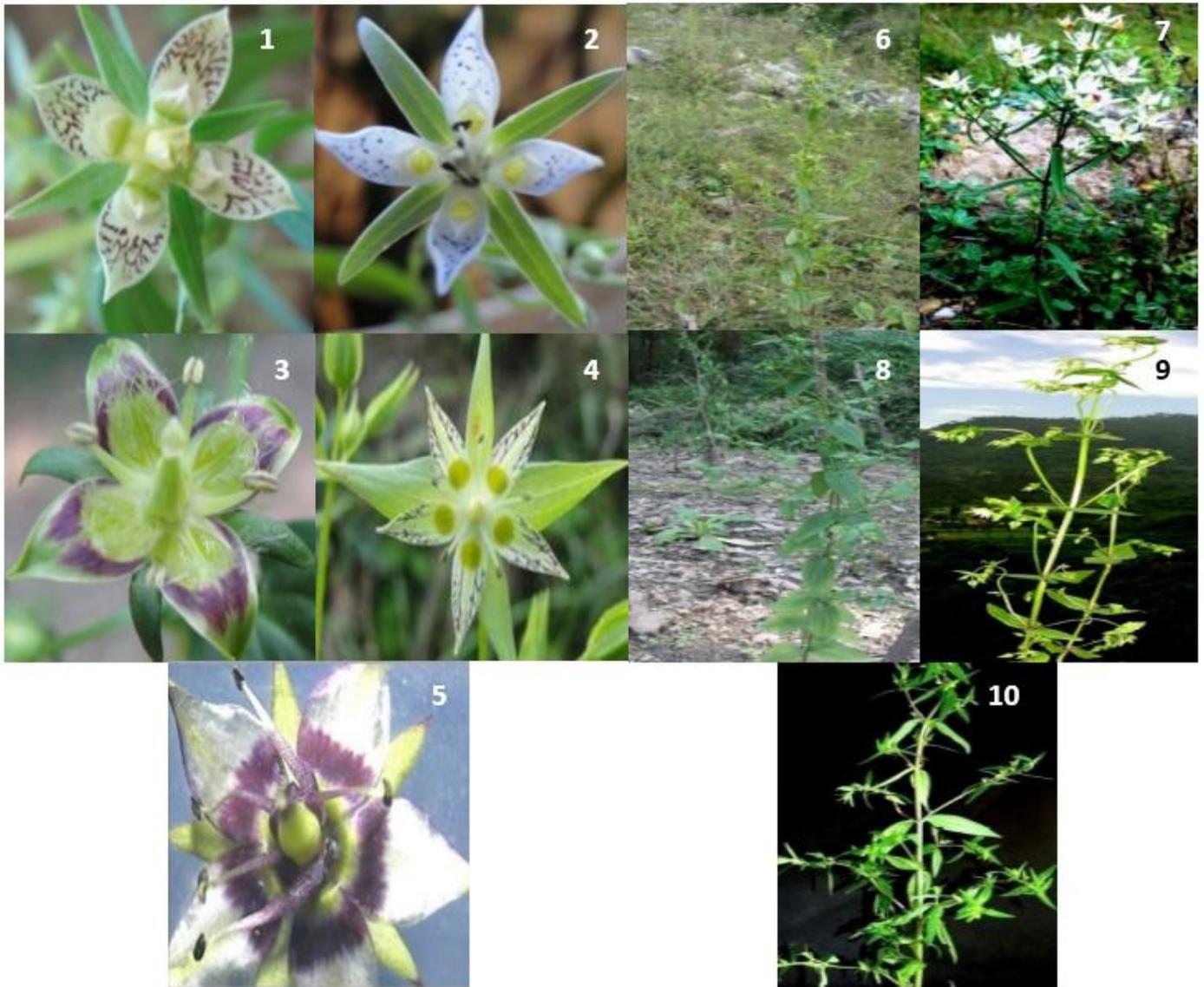


Fig 1-5: Flowers of *S. alata* (1) *S. angustifolia* (2) *S. chirayita* (3) *S. cordata* (4) *S. purpurascens* (5).
Fig 6-10: Plants of *S. alata* (6) *S. angustifolia* (7) *S. chirayita* (8) *S. cordata* (9) *S. purpurascens* (10).

References

- Anonymous. The wealth of India, Vol. X: sp-W (Raw material) CSIR Publication, New Delhi. 1976; 77-81.
- Bhatia K, Karan M, Vasisht M. Morphological and chemotypic comparison of certain Indian species of *Swertia*. *Journal of Medicinal and Aromatic Plant Sciences* 2003; 25:336-343.
- Bisht D, Gupta M, Srivastava S, Datt B, Rawat AKS. Comparative pharmacognostic evaluation of three species of *Swertia* L. (Gentianaceae). *2011 Pharmacognosy Journal*; 3(19):7-12.
- Blatter E. Beautiful flowers of Kashmir. Vol II, International Book Distributors, Dehradun, 1984; 45-49.
- Brahmchari G, Mondal S, Gangopadhya A, Gorai DS. (Gentianaceae): Chemical and pharmacological aspects. *Chemistry and Biodiversity* 2004; 1:1627-1651.
- Chakraborty S, Mukherjee D, Dasgupta T. Cytological study on chromosome behaviour and new report on nature of mode of pollination of *Swertia chirayita*, a high value endangered medicinal plant of North Eastern Himalayan region. *Caryologia*; 2009; 62:43-52.
- Chopra RN, Nayar SL, Chopra IC. Glossary of Indian Medicinal Plants, CSIR, New Delhi, 1956; 237.
- Clarke CB. The Flora of British India, Vol.- IV, Hooker, J.D. (ed.) L. Reene and Co. London. 1885, 780.
- Collett H. Flora Similensis. A handbook of flowering plants of Simla and the neighborhood, 2nd edn., Thacker, Spink and Co., London. 1921; 322-327.
- Garg S. Gentianaceae of the North West Himalaya (a revision). International Bioscience Monograph 17: Today and Tomorrow's Publication Co. New Delhi, 1987.
- Hooker JD. The Flora of British India. Vol. V, L. Reeve and Co. Ltd, London. 78-79.
- IUCN SSC. The IUCN Red List of Threatened species, 1994-2007 version. Switzerland, 2008.
- Joshi K. *Swertia* Gentianaceae in Nepal: Ethnobotany agenda for sustainable management. *Ethnobotanical Leaflets* 2008; 12:1-6.
- Joshi P, Dhawan V. *Swertia Chirayita*-an overview. *Current Science*. 2005; 89: 635-640.
- Karan M, Vasisht K, Handa SS. Morphological and chromatographic comparison of certain Indian species of *Swertia*. *Journal of Medicinal and Aromatic Plant Sciences*. 1997; 19:955-963.
- Kaufman PB, Carlson TF, Dayanandan P, Evans ML, Fisher JB, Parks O *et al*. Plants their biology and importance. New York: Hopper and Raw Publishers, 1989; 532: 714-730.

17. Kirtikar KR, Basu BD. Indian Medicinal Plants vol. III, 2nd edn, M/S Bishen Singh Mahendra Pal Singh, Dehradun, 1935; 1663-1668.
18. Latif A, Rehman R. Standardization of a herbal medicine- *Swertia chirayita*. Pharmacophore. 2014; 92(12):1733-1738.
19. Lawrence GHM. Taxonomy of vascular plants. New York: The McMillan Company. 1951; 670-672.
20. Nayar MP, Shastri ARK. Red data book of Indian Plants Vol. I, II, III, Botanical Survey of India (BSI) Calcutta, 1990.
21. Negi JS, Singh P, Rawat B. Chemical constituents and biological importance of *Swertia*: a review. Current Research in Chemistry. 2011; 3(1):1-15.
22. Pant M, Bisht P and Gusain MP. De novo shoot organogenesis from cultured root explants of *Swertia chirata* Buch.-Ham.ex Wall.:an endangered medicinal plant. Natural sciences 2010; 8, 244-252.
23. Rastogi S, Khatoon S, Pandey MM, Rathi A, Rawat AKM, Mehrotra S. Evaluation of Ayurvedic compound formulation 2- Palas abijadi churna. Indian Journal of traditional Knowledge 2008; 7: 384-388.
24. Semwal DP, Saradhi PP, Nautiyal BP, Bhatt AB. Current status, distribution and conservation of rare and endangered medicinal plants of Kedarnath wildlife sanctuary, Central Himalayas, India. Current Science 2007; 1733-1738.
25. Srivastava GN, Hasan SA, Bagchi GD, Kumar S. Indian traditional veterinary medicinal plants, CIMAP, Lucknow, 2000; 466-469.