



Research Article

Seed and seedling morphology of two near threatened Indian species: *Cryptomeria japonica* and *Cupressus cashmeriana* (*Cupressaceae sensu lato*)

Sonali Ray^{1*} and Nanda Dulal Paria²

¹Department of Botany, Surendranath College, 24/2, Mahatma Gandhi Road, Kolkata- 700009., West Bengal, India

²Professor in Botany (retired), Department of Botany, University of Calcutta, 35 Ballygunge Circular Road, Kolkata-700019, West Bengal, India.

Received: 2/23/2018; Revised: 2/28/2018; Accepted: 3/17/2018

Abstract: Seed and Seedling morphology of two species of Cupressaceae – *Cupressus cashmeriana* Royle ex Carrière and *Cryptomeria japonica* (Thunb. Ex L.f.) D. Don have been studied using light microscope (LM) and scanning electron microscope (SEM). Both the species are categorized as Near Threatened (NT) in IUCN Red List Category (2013). For characterization of seed, different parameters like shape, size, base, apex, surface were considered. For the study of seedlings, the parameters like germination pattern, root, hypocotyl, number of paracotyledons, number and nature of first leaf and subsequent leaves have been characterized. The seed and seedling characters as studied in this investigation are important as taxonomic markers for identification purpose.

Keywords: Seedling morphology, identification, *Cupressus cashmeriana* Royle ex Carrière and *Cryptomeria japonica* (Thunb. Ex L.f.) D. Don.

Introduction

Cupressus cashmeriana Royle ex Carrière and *Cryptomeria japonica* (Thunb. Ex L.f.) D. Don belong to family Cupressaceae *sensu lato*. *Cupressus cashmeriana* Royle ex Carrière is an evergreen tree, native to the eastern Himalaya in Bhutan and Arunachal Pradesh in India. It is categorised as Near Threatened species in The IUCN Red List of Threatened Species 2013 (Zhang and Christian, 2013, <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T32311A2813777.en>). It grows at moderately high altitudes ranging from 1250 to 2670 mts elevation. It possesses horizontal main branches and pendulous side branches, with closely appressed, scale-like, opposite decussately arranged leaves (Page, 1998). The male cones are borne terminally, whereas the female cones are axillary on the drooping branches. The male cone is composed of opposite decussately arranged microsporophylls on the cone axis and the female cone is composed of 4 pairs of ovuliferous – bract scale pairs. Both the male and female cones are globose and greenish yellow in colour becoming dark brown when matured. Several reports of medicinal properties of this plant have been made. In vitro anti-inflammatory, antioxidant and antimicrobial activities of essential oils from the leaves and twig parts of this plant have been reported (Yc, S., *et al.*, 2015). Phytochemical studies have reported the presence of a flavanol diglycoside in the leaf extracts of *Cupressus cashmeriana* (Khabir *et al.*, 1987). Several other investigations have been carried out in morphology (Maerki, 2014), cytology (Hair, 1968),

phylogenetic studies (Damon *et al.*, 2006), molecular studies (Rushforth, 2003), anatomy (Román-Jordán *et al.*, 2016) and palynology (Danti *et al.*, 2010) for *Cupressus cashmeriana*.

Cryptomeria japonica (Thunb. Ex L.f.) D. Don, formerly belonging to family Taxodiaceae, now belongs to Cupressaceae. It is regarded as a monotypic genus, endemic to Japan, have been introduced to other countries like India. It is also categorised as Near Threatened (NT) species in The IUCN Red List of Threatened Species 2013 (Thomas, Katsuki and Farjon, 2013, <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39149A2886821.en>), which grows at elevations ranging from 600 mts to 1200 mts. It is a large branched evergreen tree, with fibrous, brown bark that peels off in longitudinal strips, with awl-shaped spirally arranged leaves. They are monoecious with male and female cones usually borne on different branchlets, sometimes on the same branchlet. Male cones form clusters of more than 10 in number. Each male cone bears 15-25 spirally arranged microsporophylls. Female cones are globular, about 20 mm in diameter, pale brown in colour, with 20 – 30 spirally arranged wedge-shaped scales; the bract and ovuliferous scales are fused except at the tip, that ends up in a recurved process. This tree is economically and medicinally very important. Its timber is extremely fragrant, weather and insect resistant, durable and therefore used extensively for furniture and building. This tree

*Corresponding Author:

Sonali Ray,

Assistant Professor, Department of Botany,
Surendranath College, 24/2, Mahatma Gandhi Road,
Kolkata- 700009., West Bengal, India.

E-mail: sonyrr@gmail.com



exudes a resin containing cryptopimaric acid and phenolic acid. The bark also yields 6% tannin. The chemical composition of *Cryptomeria japonica* essential oil (CJE) has revealed excellent antifungal activity (Cheng *et al.*, 2005) and antibacterial activities against acne producing bacteria *Propionibacterium acnes* and *Staphylococcus epidermidis* (Yoon *et al.*, 2009). Mosquito larvicidal activities have been reported in case of extracts from red heartwood-type (Cheng *et al.*, 2008) and the black heartwood-type *Cryptomeria japonica* (Gu *et al.*, 2009). Other than the investigations on the medicinal and economical properties, reports have been made on morphology (Hashimoto, 1990), anatomy (Abe *et al.*, 2003, Tadooka *et al.*, 2005, Kitin *et al.*, 2009), embryology (Lawson, 1904), palynology (Panzani *et al.*, 1986, Uehara *et al.*, 2000, Suárez-Cervera *et al.*, 2003), DNA variation (Kado *et al.*, 2003), AFLP and CAPS linkage maps (Nikaido *et al.*, 2000), tissue culture techniques (Ogita *et al.*, 1999), etc.

But seedling morphological studies are not emphasized for these two taxa. The systematic values of seedling of flowering plants have been stressed by different authors abroad (Duke, 1969; Burger, 1972; de Vogel, 1980). Paria and his group reported seedling structures as a key characteristic for systematic as well as phylogenetic studies of angiosperms (1986, 1996, 1999, 2002 and 2014). Studies on seedlings of gymnosperms have been carried out by Lubbock (1892), Hill and Fraire (1914), Philipson and Molloy (1990) and Donald and Joseph (1991). Since seedling morphological characters are genetically stable, they can play an important role in identifying the taxa. The medicinally and economically useful threatened plants may be identified and thereby, conserved at the juvenile stage by using the knowledge of seedling identification. In an attempt towards this, the seedling morphology of two Near Threatened (IUCN, 2013) species of Cupressaceae – *Cupressus cashmeriana* Royle ex Carrière and *Cryptomeria japonica* (Thunb. Ex L.f.) D. Don - is taken up in the present study.

Material and Methods

In the present investigation, seedlings of *Cupressus cashmeriana* Royle ex Carrière and *Cryptomeria japonica* (Thunb. Ex L.f.) D. Don were collected from natural habitats of various areas of Darjeeling district, West Bengal and Pelling, Sikkim. The seedlings of various stages were studied by using light microscope (LM) and scanning electron microscope (SEM). Seeds were also taken from the seed cones collected from identified adult plants and grown in the nursery of temperate climate. The different developmental stages of raised seedlings were considered. Both the raised seedlings from the nursery and those collected from natural habitats were studied and compared. Similar data on seedling morphology were noted in both the cases.

At least ten to fifteen specimens of different growth forms were studied taken from different habitats and the nursery, which revealed the uniform features of seedlings. The specimens showing various stages were documented in the form of herbarium sheets, which have been deposited in the Calcutta University Herbarium (CUH). The description of seeds were prepared in consultation with Martin (1946), Martin and Barkley (1961) and Corner (1976). The description of seeds were prepared in consultation with Bojňanský and Fargašová (2007). The morphology of seedlings was described following the terminology as proposed by Burger (1972), Hickey (1973), Vogel (1980), and Radford (1986). For method of description of seedlings, Lubbock (1892), Vogel (1980), Mukhopadhyay *et al.* (2013) and Paria (2014) were followed. The seedling of both the taxa were placed on glass slide and observed under binocular stereomicroscope (Wild M3). The morphological characters of seeds were noted using different magnifications and documented by taking photographs using Nikon coolpix S7000 digital camera. The scanning electron micrographs were taken at the SEM laboratory, Centre for Research in Nanoscience and Nanotechnology (CRNN), University of Calcutta, Kolkata, West Bengal. Paracotyledons and first leaves were previously desiccated and cleaned with absolute alcohol. The cleaned and dried samples were directly mounted on the adhesive tapes, placed on the stubs and subsequently were palladium gold coated. Surface patterns were studied under different magnifications using CARL ZEISS EVO 18 Special Edition scanning electron microscope. Photographs were taken by selecting the appropriate fields of the specimens.

Results

***Cryptomeria japonica* Thunb. Ex L.f.) D. Don**

Seed Description: *Seed shape* irregular, ellipsoid, trigonous, dorsal side convex, ventral side flattened, with wings. *Dimension* 5-8 x 2-3.2 mm. *Apex* emarginate. *Base* attenuated. *Surface* smooth with raised triradiate ridge on dorsal surface. Colour lustrous dark brown, membranous wings pale. (Fig 1A).

Seedling Description: *Seedlings* epigeal, phanerocotylar. *Tap root* tapering downwards, 1.4 - 6.6 cm, flexuous; unbranched at early stages with 3-7 thin, pointed lateral roots, flexuous; light yellowish in colour. *Hypocotyl* shortly elongating, 1.8 - 2.5 cm, erect, straight, terete, herbaceous to semi-woody, pale green, glabrous, nonpubescent. *Paracotyledons* three, equal, whorled, ascending, fleshy, glabrous, persistent up 45 leaves stage, exstipulate, dark glaucous green, sub-sessile; blade linear (0.9 - 1.2 cm × 0.2 cm), apex acute, base subcuneate, margin entire; presence of a single prominent midrib. *First leaves* simple, cauline, spirally

and closely arranged on the main stem, three per node, smaller than the paracotyledons, exstipulate, deep glossy green on upper surface, paler underneath, glabrous, sessile; blade linear to awl-shaped, triangular in section, flattened or slightly concave above, convex beneath, (0.6 – 2.5 cm x 0.1 – 0.2 cm), apex acute, base sub-cuneate, margin entire, presence of a single prominent midrib. *Subsequent leaves* simple, triangular to awl shaped, all other characters same as first leaves except larger in size, 0.7 – 3.2 cm x 0.2 – 0.3 cm. (Fig. 1B, C, 3A, 4)

SEM Characters: *Paracotyledons*– waxy deposition on both upper and lower surfaces, with unicellular unbranched hairs (8 μ m - 9 μ m) on upper surface (Figs 6 and 7). *First leaf* – amphistomatic, stomata present on the upper surface, are rectangular, dimension 20 μ m – 28 μ m \times 10 μ m – 22 μ m, stomata that are present on the lower surface are arranged in vertical rows, rectangular, dimension 22 μ m – 30 μ m \times 10 μ m – 25 μ m, often stomatal openings have waxy occlusions; few unbranched uniseriate epidermal hairs (14 μ m – 18 μ m) with acute tips and swollen bases present on upper surface with thick epicuticular waxy deposition in form of crystalloids and small tubules. (Figs. 8 and 9).

Cupressus cashmeriana Royle ex Carrière

Seed Description: *Seed shape* irregular, ellipsoidal, compressed lateral, with indistinct wing-like margin. *Dimension* 4-7 x 3-4 mm. *Apex* truncate. *Base* flattened. *Surface* Smooth ventral surface, with slightly raised median ridge on dorsal surface. *Colour* lustrous brown, membranous wings pale. (Fig 2 A)

Seedling Description: *Seedlings* epigeal, phanerocotylar. *Tap root* tapering downwards, 2.3 – 3.9 cm, subflexuous, unbranched at early stages with 1-2 very thin, lateral roots, flexuous; green in colour. *Hypocotyl* shortly elongating, 2.0 – 2.4 cm, erect, straight, terete, herbaceous, dark green at upper half becoming paler at lower half, glabrous, nonpubescent. *Paracotyledons* two, equal, opposite, ascending, fleshy, glabrous, persistent up to 72 leaf stage, exstipulate, dark glaucous green, subsessile; blade linear (0.8 – 1.1 \times 0.1 cm), apex acute, base round, margin entire; presence of a single prominent midrib. *First leaves* simple, two per node, opposite decussately arranged with respect to paracotyledons, smaller than paracotyledons, exstipulate, deep green on upper surface, paler underneath, glabrous, sessile; blade narrowly linear (0.6 – 0.8 \times 0.1 cm), apex acute, base decurrent, margin entire; presence of a single prominent midrib. *Subsequent leaves* simple, four, from each node, whorled, scale-like, with a slight bluish tint, other characters same as first leaves except size 0.6 – 1.0 cm \times 0.1 cm [branching starts at 3rd and 6th node]. (Fig. 2B, C, 3B, 5).

SEM Characters: *Paracotyledons*– heavy waxy deposition on both upper and lower surface, with unbranched hairs on both surfaces (Fig 10A, B). *First leaf* – hypostomatic, stomata on the lower surface are arranged in vertical rows, rectangular, dimension 15 μ m – 22 μ m \times 5 μ m – 9 μ m, often stomatal openings have waxy occlusions; numerous unbranched uniseriate hairs (30 μ m – 34 μ m) with acute tips and swollen bases present on upper as well as lower surface with thick epicuticular waxy deposition in form of small round tubules. (Fig 11 and 12).

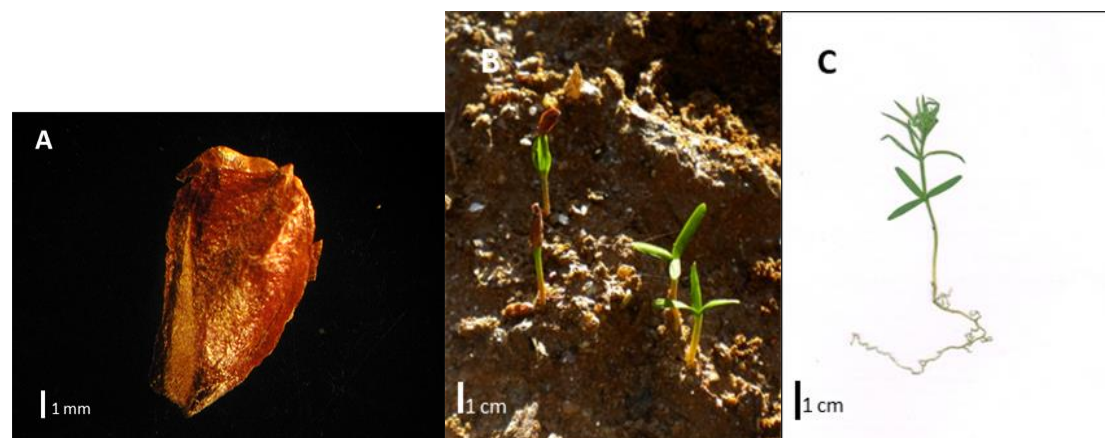


Figure 1. *Cryptomeria japonica* Thunb. Ex L.f. D. Don: **A** - Seed; **B** – Seedlings (7 days old); **C** – Scanned photograph of seedling (28 days old)

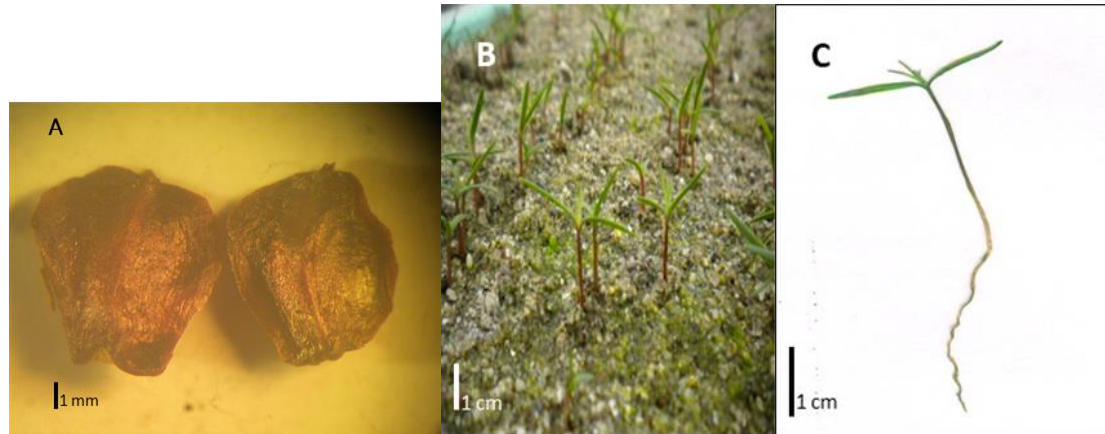


Figure 2. *Cupressus cashmeriana* Royle ex Carrière: **A** - Seed; **B** - Seedlings (10 days old); **C** - Scanned photograph of seedling (15 days old)



Figure 3. Developmental stages of seedlings: **A** - *Cryptomeria japonica* Thunb. Ex L.f.) D. Don **B** - *Cupressus cashmeriana* Royle ex Carrière

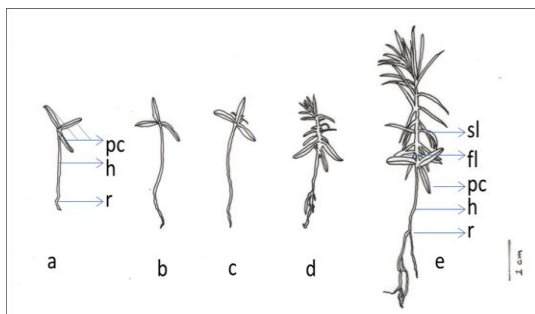


Figure 4. *Cryptomeria japonica* Thunb. Ex L.f.) D. Don (fl- first leaves, h- hypocotyl, pc- paracotyledons, r- root, sl- subsequent leaves)

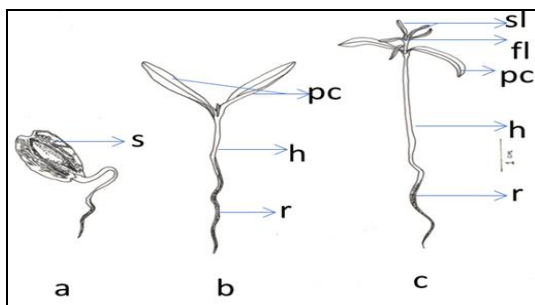


Figure 5. *Cupressus cashmeriana* Royle ex Carrière (fl- first leaves, h- hypocotyl, pc- paracotyledons, r- root, s- seed, sl- subsequent leaves)

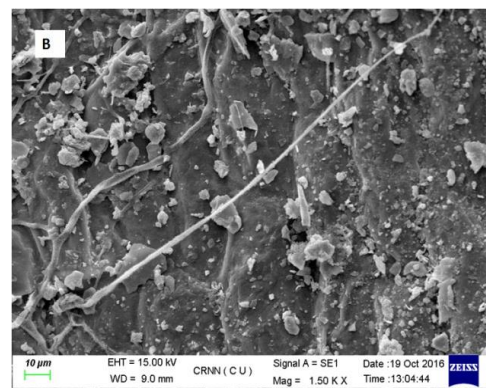
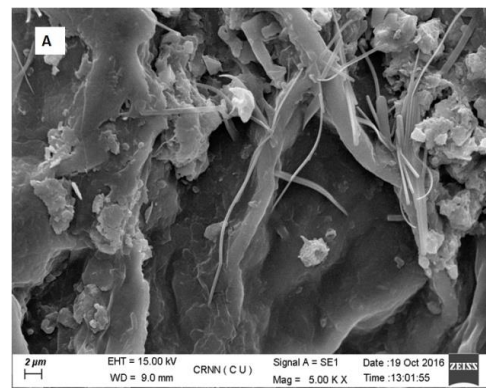


Figure 6. SEM micrographs: *Cryptomeria japonica*. **A, B**: Paracotyledon upper surface with waxy deposition & very few hair.

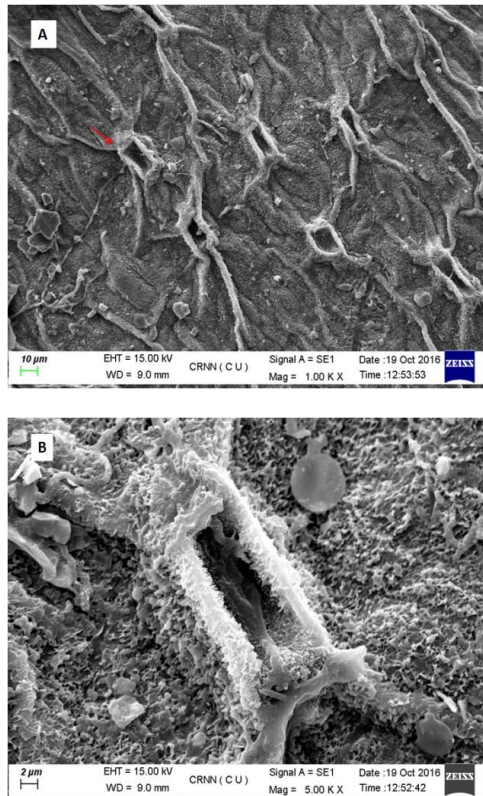


Figure 7. SEM micrographs: *Cryptomeria japonica*. A, B: Paracotyledon showing stomata on undersurface, marked by arrow.

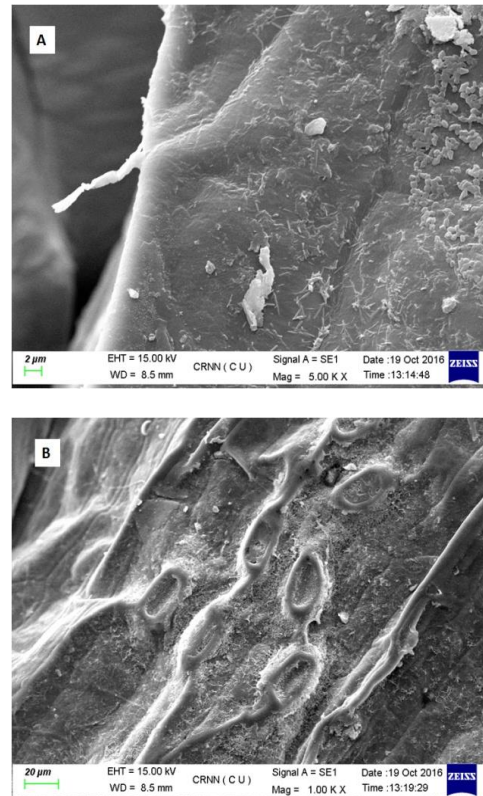


Figure 9. SEM micrographs: *Cryptomeria japonica*. A, B: Lower surface of first leaf showing hair with waxy deposits and stomata.

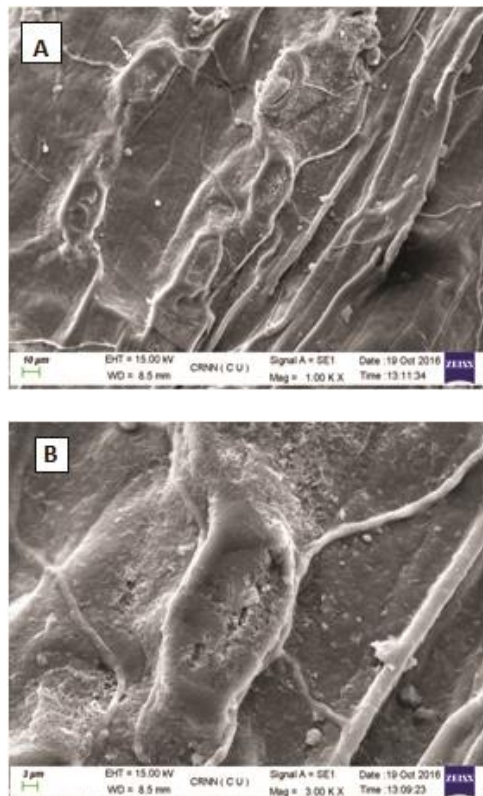


Figure 8. SEM micrographs: *Cryptomeria japonica*. A, B: Upper surface of first leaf showing waxy deposition in some stomata, along with hair.

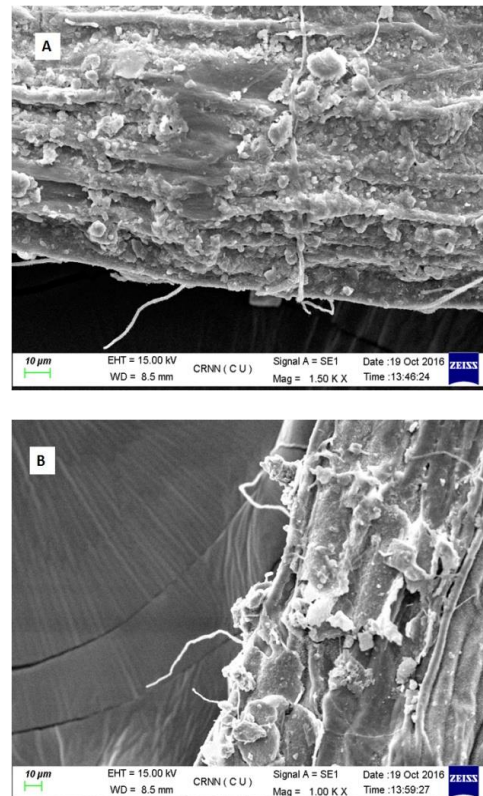


Figure 10. SEM micrographs: *Cupressus cashmeriana*. A, B: Paracotyledon with heavy waxy deposition and hairs on upper & lower surface.

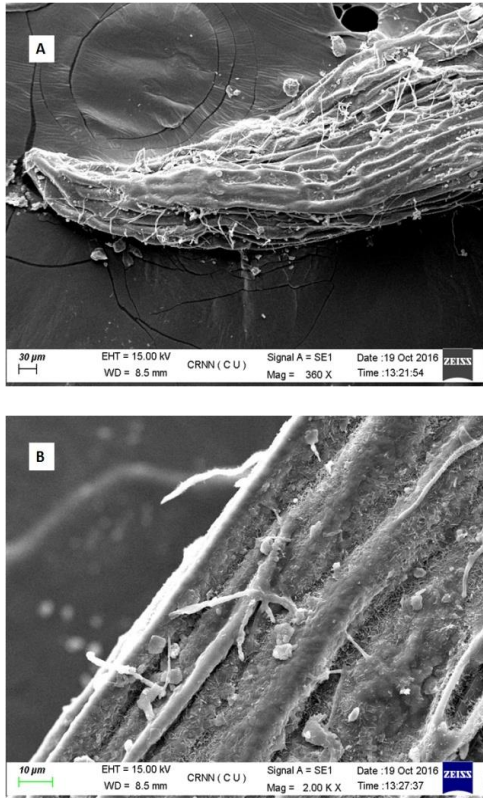


Figure 11. SEM micrographs: *Cupressus cashmeriana*. A, B: Upper surface of first leaf with many hairs and waxy deposits.

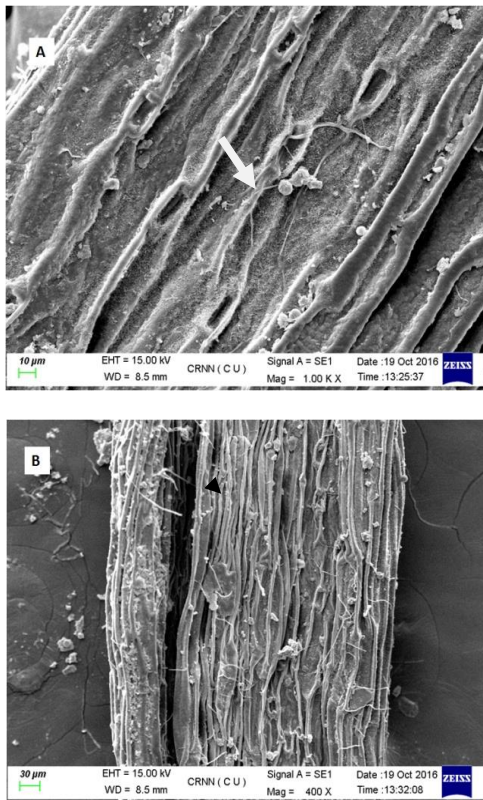


Figure 12. SEM micrographs: *Cupressus cashmeriana*. A, B: Under surface of first leaf with hairs, waxy deposits and stomata (marked by arrow).

Table 1. Comparative account of characters studied for two taxa:

Characters	<i>Cryptomeria japonica</i>	<i>Cupressus cashmeriana</i>
Paracotyledon	Number	Three
	Phyllotaxy	Whorled
First leaves	Number	Two
	Phyllotaxy	Opposite
Subsequent Leaves	Number	Three per node
	Phyllotaxy	Two per node
First leaves	Phyllotaxy	Opposite decussate
	Shape	wrtparacotyledons
Subsequent Leaves	Shape	Linear to awl-shaped
	Base	Narrowly linear
Subsequent Leaves	Apex	Subcuneate
	Apex	Decurrent
Subsequent Leaves	Shape	Acute
	Shape	Triangular to awl-shaped
Subsequent Leaves	Shape	Scale-like

Discussion

The study of the two taxa revealed some important characteristics of seed and seedling morphology which are potential for serving as taxonomic markers for identification. Both the taxa belonging to Cupressaceae *sensu lato* are characterized by phanerocotylar, epigeal pattern of germination. Since these two taxa are identified as Near Threatened (NT) by IUCN Red List, their identification at an early stage of seedling will assist to protect this plant in nature in the midst of unfavourable environmental and biotic factors. From the table 1, it is observed that the seedling characters, such as, the number of paracotyledons is remarkably differentiating for the two taxa. *Cryptomeria japonica* is characterised having three, linear, paracotyledons with whorled phyllotaxy while two, linear, oppositely arranged paracotyledons is observed in *Cupressus cashmeriana*. Three first leaves in whorled phyllotaxy in *Cryptomeria japonica* is in contrast with the presence of two opposite decussately arranged first leaves in *Cupressus cashmeriana*. These characters would be remarkable markers for taxonomic identification of the two economically important species. The identification at the seedling stage would be an aid in protecting the two Near Threatened species of Cupressaceae *sensu lato* from further depletion from natural habitats due to over exploitation.

Acknowledgements

We sincerely are grateful to Centre for Research in Nanoscience and Nanotechnology (CRNN), University of Calcutta for the SEM micrographs included in this study.

References


1. Abe H, Nakai T, Utsumi Y and Kagawa A. Temporal water deficit and wood formation in *Cryptomeria japonica*. *Tree phys.* 23. 12. (2003): 859-863. Print.
2. Ahammed, J and Paria, ND. Systematic value of seedling morphology in some Indian Asteraceae, *Acta Bot. Indica.* 24. (1996): 49-55. Print.

3. Bojňanský V and Fargašová A. Atlas of Seeds and Fruits of Central and East-European Flora: The Carpathian Mountains Region. Springer, 2007, xxxiii – xxxvii. Print.
4. Burger HD. Seedlings of some tropical trees and shrubs, mainly of South-East Asia. Centre for Agricultural Publishing and Documentation (PUDOC), Wageningen. (1972).
5. Cheng SS, Lin HY and Chang ST. Chemical Composition and Antifungal Activity of Essential Oils from Different Tissues of Japanese Cedar (*Cryptomeria japonica*). *J of Agricul and Food Chem.* 53.3. (2005): 614-619. Print.
6. Cheng SS, Huang CG and Chen WJ. Larvicidal activity of tectoquinone isolated from red heartwood-type *Cryptomeria japonica* against two mosquito species. *Bioresource tech.* 99.9. (2008): 3617-3622. Print.
7. Corner E J H. The Seeds of Dicotyledons. Cambridge University Press, Cambridge, U.K. (1976): 311.
8. Danti R, Della Rocca G, Mori B, Torraca G, Calamassi R and Mariotti Lippi M. Old world and new world *Cupressus* pollen: morphological and cytological remarks. *Plant syst and evol.* 287.3. (2010): 167-177. Print.
9. Damon PL. Evolution and circumscription of the true *Cupressus* (Cupressaceae: *Cupressus*). *Syst Botany.* 31.3. (2006): 461-180. Print.
10. Das DC and Paria ND. Seedling morphology of some Indian species of *Bauhinia* L. (Leguminosae) *Feddes Rep.* 110. (1999): 375-379. Print
11. Deb DK and Paria ND. Seedling morphology of some economic trees. *Indian Agric.* 30. 2. (1986): 133-142. Print
12. Donald B and Joseph A. Growth and development of natural seedlings of *Abies* and *Tsuga* in old growth forest. *Jour of Ecology, British Ecological Society.* 79. (1991): 985-998. Print.
13. Duke JA. On tropical tree seedlings I. Seeds, seedlings, systems and systematics. *Ann. Missouri Bot. Gard.* 56. (1969): 125-161. Print.
14. Gu HJ, Cheng SS, Huang CG, Chen WJ and Chang ST. Mosquito larvicidal activities of extractives from black heartwood- type *Cryptomeria japonica*. *Parasitol Res.* 105. (2009):1455. Print.
15. Hair JB. The chromosomes of Cupressaceae. *New Zealand J of Bot.* (1968).
16. Hashimoto R. Analysis of the morphology and structure of crowns in a young sugi (*Cryptomeria japonica*) stand. *Tree Physiol.* 6.2. (1990): 119-134. Print.
17. Hickey L.J. Classification of architecture of dicotyledonous leaves. *Amer J of Bot.* 60. (1973):18 – 33. Print.
18. Hill TG and Fraine E.de. On the classification of seed-leaves. *Ann of Bot I.* (1914): 696-706.
19. Kado T, Yoshimaru H, Tsumura Y and Tachida H. DNA variation in a conifer, *Cryptomeria japonica* (Cupressaceae *sensu lato*). *Genetics.* 164. 4. (2003): 1547-1559. Print.
20. Khabir M, Khatoon F and Ansari WH. Flavanoids of *Cupressus sempervirens* and *Cupressus cashmeriana*. *J of Nat Products.* 50. 3. (1987): 511-512.
21. Kitin P, Fujii T, Abe H and Takata K. Anatomical features that facilitate radial flow across growth rings and from xylem to cambium in *Cryptomeria japonica*. *Ann of Bot.* 103.7. (2009): 1145-1157. Print.
22. Lawson AA. The gametophytes, fertilization and embryo of *Cryptomeria japonica*. *Ann. of Bot.* 18. 71. (1904): 417- 444. Print.
23. Lubbock J. A contribution to our knowledge of seedlings Vol. 1 & 2, Kegan Paul, Trench, Trubner& Co, London. (1892).
24. Maerki D. Two distinct Himalayan Cypress species *Cupressus tortulosa* and *Cupressus cashmeriana* with additional comparison to *Cupressus torulosa*. *Bull. CCP.* 3. 3. (2014): 99-115. (12.2014). Print.
25. Martin AC. The comparative internal morphology of seeds. *Amer. Midl. Naturalist.* 36. (1946):513-660.
26. Martin A and Barkley W. Seed Identification Manual. Berkley, California: University of California Press. (1961): 221.
27. Mukhopadhyay S, Bose A and Paria ND. Systematic value of seedling morphology of some members of the tribe Spermaceae of Rubiaceae. *Pleione.* 7. 2. (2013): 357-365. Print.
28. Nikaido AM, Ujino T, Iwata H, YoshimuraK, Yoshimura H, Suyama Y, Murai M, Nagasaka K and Tsumura Y. AFLP and CAPS linkage maps of *Cryptomeria japonica*. *Theor and Appl Genetics.* 100. 6. (2000): 825-831. Print.
29. Ogita S, Sasamoto H and Kubo T. Selection and microculture of single embryogenic cell clusters in Japanese conifers: *Picea jezoensis*, *Larix leptolepis* and *Cryptomeria japonica*. *In Vitro Cellular and Developmental Bio-Plant.* 35. 5. (1999): 428-431. Print.
30. Page CN. Cupressaceae In: The Families and Genera of Vascular Plants IV. K. Kubitzki, ed. Springer-Verlag Berlin Heidelberg. (1998): 302-316.
31. Panzani R, Yasueda H, Shimizu T and Shida T. Cross-reactivity between the pollens of *Cupressus sempervirens* (Common cypress) and *Cryptomeria japonica* (Japanese cedar). *Ann of allergy.* 57.1. (1986): 26-30. Print.

32. Paria ND and Das DC. Seedling morphology in the tribe Viciae (Leguminosae) with reference to taxonomy. In: Advances in Legume Research in India. R.R. Rao, and L.B. Chaudhary, eds. Bishen Singh Mahendra Pal Singh. (2002):145 – 156. Print.
33. Paria ND. Botanical Research in India in the domain of Seedling Morphology in relation to Taxonomy. *Science and Culture*. 80. 9.10. (2014): 262–270. Print.
34. Philipson WR and Molloy BPJ. Seedling, shoot and adult morphology of New Zealand conifers genera *Dacrycarpus*, *Podocarpus*, *Dacrydium* and *Prumnopitys*. *New Zeal J of Bot*. 28.1. (1990): 73-84. Print.
35. Radford EA, Fundamentals of Plant Systematics, New York, Harper & Row publishers. (1986): 1-498.
36. Romàn-Jordàn E, Esteban L, Palacios P and Fernández F, Wood anatomy of *Cupressus* and its relation to geographical distribution. *LAWA Journal*. 37.1. (2016): 48-68. Print.
37. Rushforth K, Adams RP, Zhang M and Pandey RN. Variation among *Cupressus* species from the eastern hemisphere based on Random Amplified Polymorphic DNAs (RAPDs). *Biochem. Syst and Ecol*. 31.1. (2003): 17-24. Print.
38. Suarez-Cervera M, Takahashi Y, Vega-Maray A and Seoane-Camba JA. Immunocytochemical localization of Cry j 1, the major allergen of *Cryptomeria japonica* (Taxodiaceae) in *Cupressus arizona* and *Cupressus sempervirens* (Cupressaceae) pollen grains. *Sexual Pl Reprod*. 16.1. (2003): 9-15. Print.
39. Su YC, Hsu KP, Hua KF and Ho CL. Composition, *in vitro* anti-inflammatory, antioxidant and antimicrobial activities of essential oils from leaf and twig parts of *Cupressus cashmeriana*. *Nat Prod Comm*. 10. 8. (2015): 1461- 1464.
40. Tadooka N, Koizum A and Zhu J. [Sapporo (Japan)]. The variations in anatomical characteristics and mechanical properties among the stem of Japanese cedar (*Cryptomeria japonica*). *Res. Bull of the Hokkaido Univ*. (2005). Print.
41. Thomas P, Katsuki T and Farjon A. *Cryptomeria japonica*. The IUCN Red List of Threatened Species 2013: e. T39149A2886821.
42. Uehara K and Sahashi N. Pollen wall development in *Cryptomeria japonica*. *Grana*. 39.6. (2000): 267-274. Print.
43. Vogel EF.de. Seedling of Dicotyledons, Centre for Agricultural Publishing and Documentation (PUDOC), Wageningen. (1980).
44. Yoon WJ, Kim SS, Oh TH, Lee NH and Hyun CG. *Cryptomeria japonica* essential oil inhibits the growth of drug-resistant skin pathogens and LPS-induced nitric oxide and Pro-Inflammatory Cytokine production, *Pol. J. of Microbio*. 58.1. (2009): 61-68. Print.
45. Zhang D, Christian T, *Cupressus cashmeriana*. The IUCN Red List of Threatened Species 2013: e. T32311A2813777.

Cite this article as:

Sonali Ray and Nanda Dulal Paria. Seed and seedling morphology of two near threatened Indian species: *Cryptomeria japonica* and *Cupressus cashmeriana* (Cupressaceae *sensu lato*). *Annals of Plant Sciences* 7.4 (2018) pp. 2179-2186.

 <http://dx.doi.org/10.21746/aps.2018.7.4.3>

Source of support: Centre for Research in Nanoscience and Nanotechnology (CRNN),
University of Calcutta
Conflict of interest: Nil