SYSTEMATICS AND MOLECULAR PHYLOGENETIC ANALYSIS OF ERECT SPECIES OF CEROPEGIA SECTION BUPRESTIS (APOCYNACEAE: ASCLEPIADOIDEAE), WITH TWO NEW SPECIES FROM INDIA

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SYSTEMATICS AND MOLECULAR PHYLOGENETIC ANALYSIS OF ERECT SPECIES OF *CEROPEGIA* SECTION *BUPRESTIS* (APOCYNACEAE: ASCLEPIADOIDEAE), WITH TWO NEW SPECIES FROM INDIA

SACHIN A. PUNEKAR[1,4], SHUBHADA A. TAMHANKAR[1], P. LAKSHMINARASIMHAN[2*]
K. P. N. KUMARAN[1], AJIT L. RAUT[1] AND S. K. SRIVASTAVA[3]

[1]*Agharkar Research Institute, G. G. Agarkar Road, Pune 411004, Maharashtra*
[2]*Central National Herbarium, Botanical Survey of India, P. O. Botanic Garden, Howrah 711103, West Bengal*
[3]*Northern Regional Centre, Botanical Survey of India, 192 Kaulagarh Road, Dehradun 248195, Uttarakhand*
[4]*Biospheres, Eshwari, 52/403, Lakshmi Nagar, Parvati, Pune 411009, Maharashtra*
** E-mail : lakshminarasimhanp@yahoo.co.in*

ABSTRACT

Erect species of *Ceropegia* section *Buprestis* are revised based on morphology, palynology and molecular study, and a key to all species presented. Two new species, *C. karulensis* and *C. maharashtrensis* are described. The status of the systematically ambiguous *C. lawii is* addressed. In the molecular analysis of erect species using ISSR markers, taxa belonging to section *Buprestis* were found to be distinct from species of section *Indopegia* used as outgroup. The phylogenetic analysis of 20 Indian species of *Ceropegia* representing different sections and their congeners using nuclear ribosomal internal transcribed spacer (ITS) and non-coding chloroplast DNA (cpDNA) sequences shows that the erect species of section *Buprestis* form a separate clade along with section *Indopegia*. This supports Huber's hypothesis (1957) that the section *Buprestis* must have evolved from section *Indopegia*.

Keywords : *Ceropegia* section *Buprestis*, *Ceropegia karulensis*, *Ceropegia maharashtrensis*, India, molecular phylogeny, systematics.

INTRODUCTION

Ceropegia L. of the tribe Ceropegieae Decne. ex Orb. and subtribe Stapeliinae G. Don (Meve & Liede, 2004) comprises c. 200 species (Bruyns, 2003; Surveswaran & al., 2009) distributed in Arabia, warm Africa including Canary Islands to Australia. Ansari (1984) had recognized 44 species in his treatise on Indian *Ceropegia* and later Jagtap & Singh (1999) reported 45 species and 3 varieties from India. Over the years many new taxa from Andaman Islands, Eastern Ghats and Western Ghats were added (Swarupanandan & Mangaly, 1992; Sreekumar & al., 1997; Daniel & Umamaheshwari, 2001; Yadav & al., 2004, 2008; Malpure & al., 2006; Punekar & al., 2006; Yadav & Shendage, 2010; Diwakar & Singh, 2011; Kambale & al., 2012; Kullayiswamy & al., 2012 and Rahangdale & Rahangdale, 2012). Recently Karthikeyan & al., (2009) enumerated 55 species, 2 subspecies and 3 varieties from India. However, as of now, there are 67 taxa (60 species, 2 subspecies and 5 varieties) out of which 44 taxa are endemic to India. Huber (1957) in his treatise on *Ceropegia* classified the genus into 21 sections. Huber's classification is highly artificial as it was solely based on floral morphology, with recent molecular studies confirming this (Meve & Liede, 2007; Surveswaran & al., 2009). It is important to point out artificial nature of Huber's classification. He proposed 19 new sections including *Buprestis* and 22 new series. Under section *Buprestis*, Huber treated 8 taxa (6 species, 1 subspecies and 1 variety) out of which 7 are from western and southern India namely *C. ciliata* Wight, *C. ciliata* subsp. *ensifolia* (Bedd.) H. Huber (presently known as *C. ensifolia* Bedd.), *C. evansii* McCann, *C. evansii* var. *media* H. Huber (presently known as *C. media* (H. Huber) Ansari), *C. lawii* Hook.f. (including *C. panchganiensis* Blatt. & McCann), *C. odorata* Nimmo *ex* Hook.f., *C. omissa* Huber and 1 from the Yunnan province of China namely *C. muliensis* W. W. Sm. Subsequently various workers (Ansari, 1969, 1982b; Hemadri, 1969; Ansari & Kulkarni, 1971; Wadhwa & Ansari, 1969) added many new species to this section namely *C. huberi* Ansari, *C. maccannii* Ansari, *C. rollae* Hemadri, *C. sahyadrica* Ansari & B. G. Kulk. and *C. santapaui* Wadhwa & Ansari. All the species (except *C. lawii)* treated by Huber under this section are twiners, while *C. lawii* is the only erect species. At present, this section comprises 9 twining species and 7 erect species. Section *Buprestis* is characterized in having tuberous

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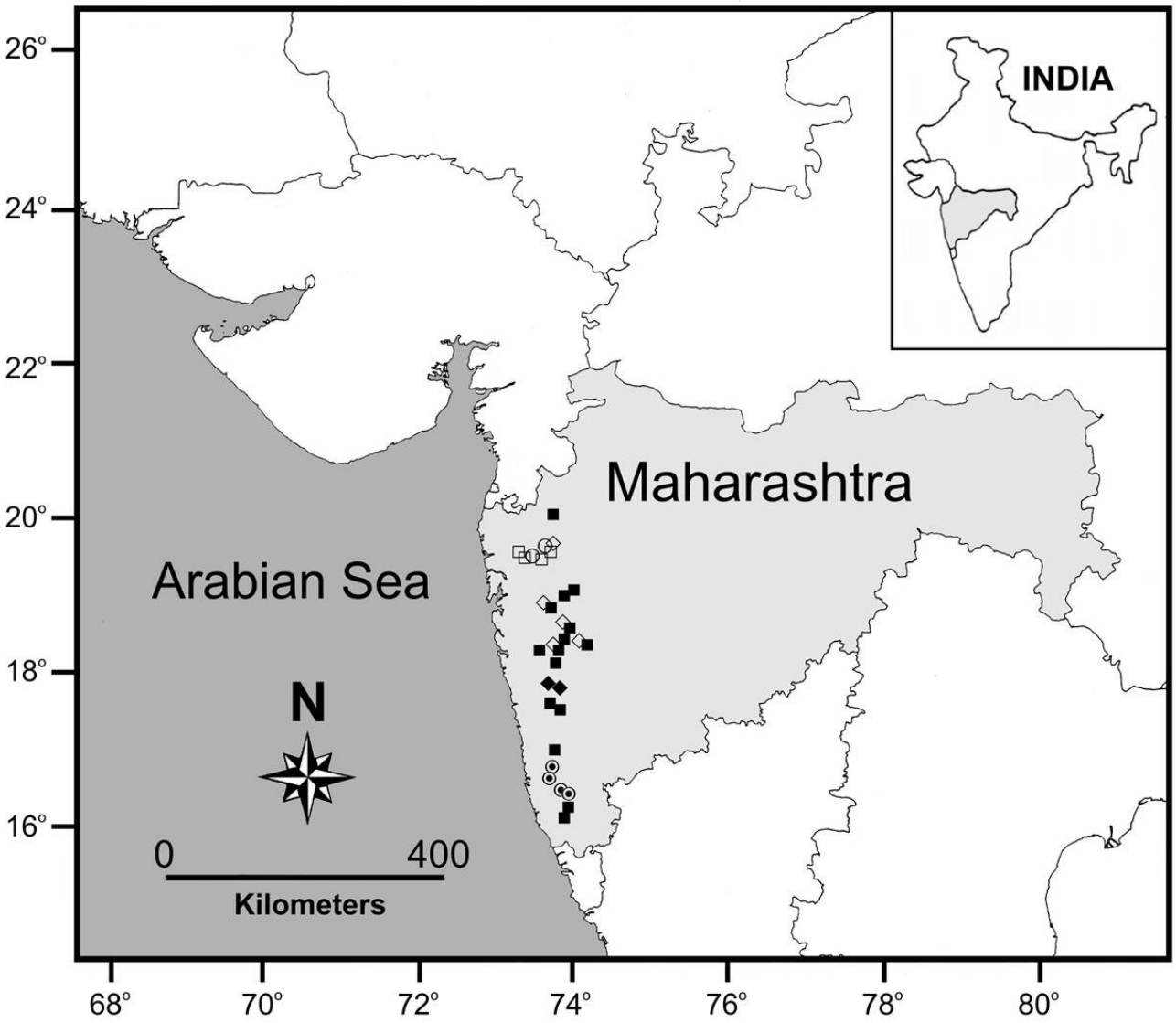

Fig. 1 : Distribution of erect species from *Ceropegia* section *Buprestis* in Maharashtra.

Symbols: ◉ *Ceropegia karulensis;* ◇ *Ceropegia macannii;* ○ *Ceropegia maharashtrensis;* ◆ *Ceropegia panchganiensis;* □ *Ceropegia rollae;* ■ *Ceropegia sahyadrica.*

rootstock; tubers globose or subglobose; stem twining or erect; leaves hairy or glabrous, not fleshy, petiolate; inflorescence generally pedunculate, subumbellate, many-flowered; peduncles patently hirsute, rarely glabrous or pilose in one row; corolla generally glabrous, sometimes pilose inside; tube slightly dilated at base; corolla lobes generally connate at apex; outer corona lobes bifid or entire at apex, sometimes extremely short; gynostegium long or extremely short, pilose or glabrous; inner corona lobes distinctly longer than outer, tip usually erect or sometimes diverted.

Apart from *C. muliensis,* all the species in the section *Buprestis* are endemic to Peninsular India, particularly to the Western Ghats, which is one of the possible loci of origin of *Ceropegia* (Punekar & al., 2006). The erect species of this section namely *C. karulensis*, *C. lawii*, *C. maccannii*, *C. maharashtrensis*, *C. panchganiensis*, *C. rollae* and *C. sahyadrica* are restricted to the high altitudes of north Western Ghats of Maharashtra suggesting that the stock of erect species is probably monophyletic in origin. (Fig. 1)

In the present paper, Indian erect species of *Ceropegia* under section *Buprestis* were studied using morphological, palynological and molecular aspects. Further to these studies, two species were found to be quite distinct from other known species and have been described as new species namely *C. karulensis* and

Fig. 2 : *Ceropegia lawii*. **A**. Holotype deposited at Kew herbarium; **B.** Enlarged view of illustration of corona drawn on the holotype, note the outer cupular corona and inner linear corona; **C.** Photograph of specimen collected from South Concan by Law "25 *Ceropegia*" deposited at Kew herbarium. **© The Board of Trustees of the Royal Botanic Gardens, Kew.** "Reproduced with kind permission of the Director and the Board of Trustees, Royal Botanic Gardens, Kew".

C. maharashtrensis from north Western Ghats based on comparison with herbarium collections at AHMA, BLAT, BM, BSI, CAL, G, K, L and our own field observations. A key to all the species under *Ceropegia* section *Buprestis* is presented. Further, using DNA analysis, phylogenetic relationship among the Indian erect species of *Buprestis* has been addressed.

MATERIALS & METHODS

Morphological & ecological examination : The species were described primarily based on morphological characters, followed by relevant data on flowering and fruiting. The ecological details such as frequency, habitat, microhabitat and associated species were also recorded. The details on specimens studied or collected are provided under materials examined. Special observations and nomenclatural information if any are given under notes. A key to the identification of different species is given to facilitate their identity.

Voucher specimens are deposited at Central National Herbarium, Howrah (CAL) and Agharkar Herbarium of Maharashtra Association, Pune (AHMA). Voucher material for pollen studies is deposited at the repository of Paleobiology Group, Agharkar Research Institute, Pune (MACSG).

Palynological studies : Pollinarium for scanning electron microscopy (SEM) study were collected from fresh flowers and processed using the method described by Juniper & al. (1970) with slight modifications.

Fig. 3 : *Ceropegia lawii* specimen collected from Bombay by Dalzell *Ceropegia* 25 deposited in general Kew herbarium. **© The Board of Trustees of the Royal Botanic Gardens, Kew.** "Reproduced with kind permission of the Director and the Board of trustees, Royal Botanic Gardens, Kew".

Pollinarium were fixed with 2% glutaraldehyde, rinsed in distilled water and then dehydrated through an acetone series. This was followed by critical point drying, gold coating (JFC-1600 Auto Fine Coater), and examination under a JEOL-6360A analytical scanning electron microscope (SEM) in the Department of Physics, University of Pune. For describing pollinarium, terminology of Erdtman (1966) and Kremp (1968) was followed.

Plant material for DNA analysis : Leaf samples from healthy plants of *Ceropegia* species were collected from different localities of north Western Ghats of India and stored in saline NaCl-CTAB solution till their use for DNA extraction (Rogstad, 1992).

ISSR marker analysis : For genomic DNA extraction, the leaves were washed with sterile distilled water to remove the traces of NaCl-CTAB. DNA extractions were carried out following the modified CTAB method as

Table 1. : Source of material examined for DNA analyses and morphological studies and GenBank accession numbers for ITS and trnL sequences.

Taxon & Locality	Voucher	GenBank acc. no. (ITS)	(trnL)
Ceropegia karulensis Punekar & al. India: Maharashtra, Ratnagiri Dt., Karul ghat, 800-900m	*S.A. Punekar* 365	HQ154105	HQ154112
Ceropegia maccannii M. Y. Ansari India: Maharashtra, Pune, Sinhagad, 1200-1400m	*S.A. Punekar & A. Raut* 367	HQ154108	HQ154115
Ceropegia maharashtrensis Punekar & al. India: Maharashtra, Pune, Junnar, Dhakeshwar, 900-1100m	*S.A. Punekar & A. Raut* 357	HQ154104	HQ154111
Ceropegia panchganiensis Blatt. & McCann India: Maharashtra, Satara, Mahabaleshwar, Kate's Point, 1400m	*S.A. Punekar* 355	HQ154107	HQ154114
Ceropegia rollae Hemadri India: Maharashtra, Pune, Junnar, Durgakilla, 800-1000m	*S.A. Punekar & A. Raut* 580	HQ154109	HQ154116
Ceropegia sahyadrica M. Y. Ansari & B. G. Kulk. India: Maharashtra, Sindhudurg, Amboli, 1200-1400m	*S.A. Punekar* 579	HQ154106	HQ154113

Table 2. : Accession numbers of DNA sequences obtained from GenBank/EMBL databases (data of Meve & Liede, 2007 & Surveswaran & al., 2009)

Section	Species	ITS	trnL	Reference
Buprestis	*Ceropegia evansii*	EU106680	EU120003	Surveswaran & al., 2009
	Ceropegia huberii	EU106694	EU120004	Surveswaran & al., 2009
	Ceropegia media	EU106696	EU120009	Surveswaran & al., 2009
	Ceropegia odorata	EU106701	EU119993	Surveswaran & al., 2009
	Ceropegia santapaui	EU106695	EU119991	Surveswaran & al., 2009
Ceropegia	*Ceropegia bulbosa*	EU106687	EU120007	Surveswaran & al., 2009
Chionopegia	*Ceropegia pubescens*	AM493280	AM490379	Meve & Liede, 2007
Indopegia	*Ceropegia fantastica*	EU312083	EU120006	Surveswaran & al., 2009
	C.oculata var. *satpudensis*	HQ154110	HQ154117	Present data
Janthina	*Ceropegia elegans*	EU106677	-	Surveswaran & al., 2009
Lysanthe	*Ceropegia attenuata*	EU106700	EU119992	Surveswaran & al., 2009
Oreopegia	*Ceropegia longifolia*	AM493283	AM491572	Meve & Liede, 2007
Phalaena	*Ceropegia juncea*	EU106685	EU120008	Surveswaran & al., 2009
Outgroup	*Brachystelma edulis*	EU106702	EU120013	Surveswaran & al., 2009

described by Rogers & Bendich (1985). The isolated DNA was processed, quantified by agarose gel electrophoresis and used for PCR amplifications. ISSR-PCR amplifications were performed in reaction volume of 25m l, using selected primers from UBC primer set # 9 (University of British Columbia, Vancouver, Canada). The reaction mixture contained 1.5 mM $MgCl_2$, 0.5 U Taq DNA polymerase, 0.1 mM of each dNTP, 0.4 mM of spermidine, 2% formamide, 0.3m M of primer and 12.5 ng DNA. Thermal cycling was carried out in PTC 200 thermal cycler (MJ Research Inc, www.bio-rad.com) as per the protocol of Nagaoka & Ogihara (1997). The PCR reactions were repeated at least two times for each primer to ensure reproducibility of the band pattern. The

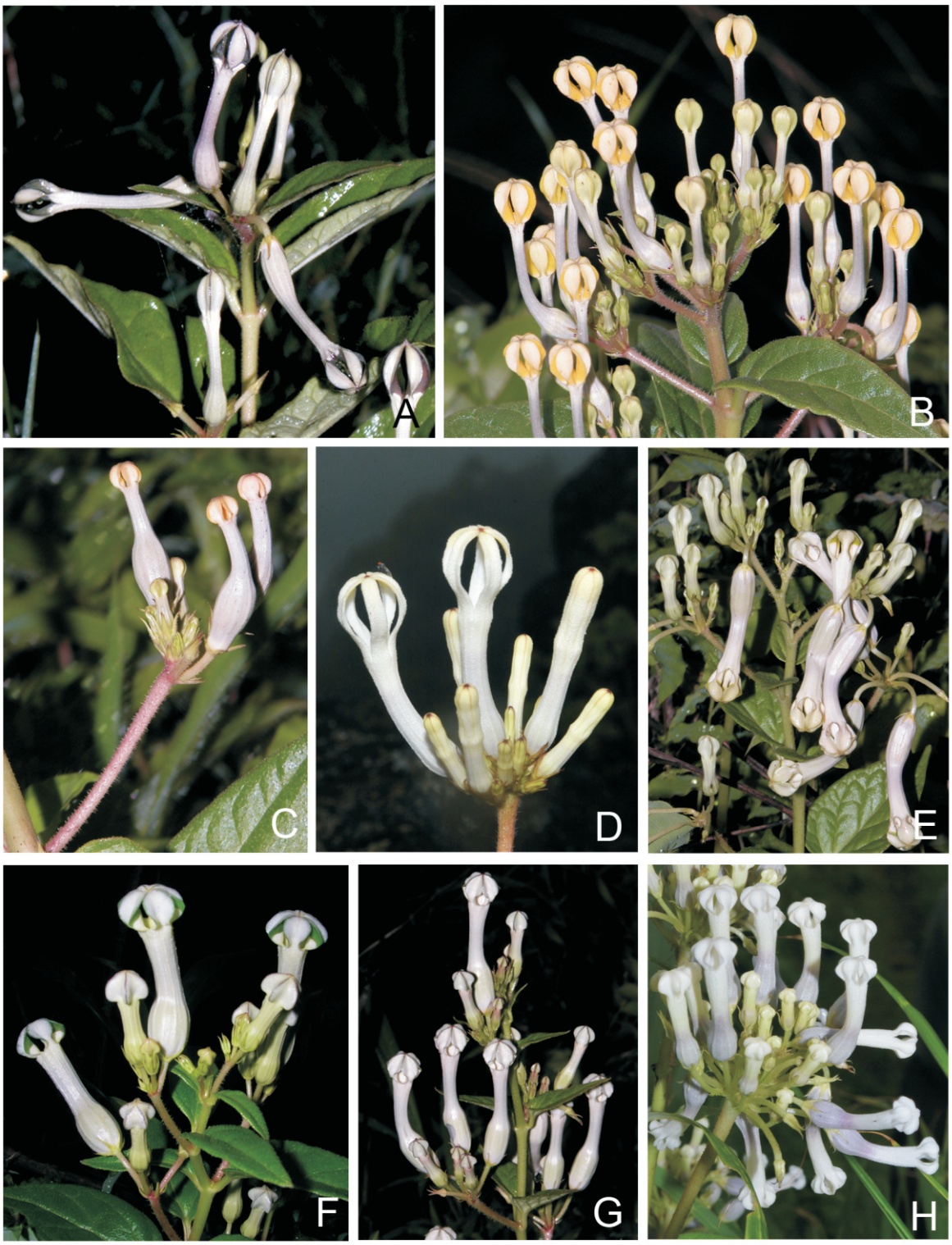

Fig. 4 : Inflorescence. **A.** *Ceropegia maharashtrensis;* **B.** *C. panchganiensis;* **C**. *C. maccannii;* **D**. *C. rollae*; **E.** *C. sahyadrica* - Sinhagadh population; **F.** *C. sahyadrica* - Amboli population; **G.** *C. sahyadrica* - Pabe ghat population; **H**. *C. karulensis*. Photos by Sachin A. Punekar.

amplification products were separated on 1.5% agarose gel in 0.5X Tris-acetic acid-EDTA **(**TAE) buffer. The gels were stained with ethidium bromide and documented using UVP GDS 8000 system.

The bands in amplification profiles were scored as discrete variables, using 1 to indicate presence and 0 for absence. The binary matrix was used to generate pair-wise similarities between the accessions using Dice coefficient. Similarity matrix was subjected to cluster analysis. The dendrogram was derived using UPGMA in SAHN module of NTSYS pc 2.1.

Sequence data analysis : Nuclear ribosomal DNA region containing 18S rRNA gene (partial), 5.8S rRNA gene, 26S rRNA gene (partial) and ITS1 and 2 was amplified with primers ITS4 and ITS5 (White & al., 1990). Chloroplast trnL-intron region were amplified using primer pairs c/d (Taberlet & al., 1991).

PCR DNA amplifications were performed in a 25 µl volume containing 20 ng genomic DNA template, 1 µl (10 pM/µl) of both forward and reverse primers, 0.2 mM of each dNTPs, 0.5 U Taq DNA polymerase, 2.5 mM $MgCl_2$, 10x PCR buffer containing 50 mM of KCl and 10 mM of Tris-HCl. PCR was performed on a Peltier Thermal Cycler (PTC-200, MJ Research, MA, USA) with an initial 3 min at 94^0 C followed by 35 cycles of 94^0C for 30 s, 50^0C for 30 s, 72^0C for 1 min and finally at 72^0C for 5 min. For trnL-intron amplifications the annealing was carried out at 60^0C and the extension time was 1.5 min. The sizes of the amplified products were checked by electrophoresis on 1.5% agarose gels in 0.5x TAE buffer and staining with ethidium bromide. The PCR products were purified by PEG precipitation and sequenced on ABI 3100-Avant Genetic Analyzer. Sequencing reactions were performed with the Big Dye Terminator kit v3.1 (Applied Biosystems, www.invitrogen.com) as per manufacturer's protocol. Both the strands were sequenced for each region.

Phylogenetic and molecular evolutionary analyses of the sequence data were conducted using MEGA version 4 (Tamura & al., 2007). The evolutionary history was inferred using the Neighbor-Joining method. The evolutionary distances were computed using the Jukes-Cantor method (1969) and are in the units of the number of base substitutions per site. All positions containing gaps and missing data were eliminated from the dataset (Complete deletion option). The bootstrap test (1000 replicates) was also conducted.

RESULTS & DISCUSSION

Genetic relationships based on ISSR markers

PCR-based DNA markers provide powerful tools for genetic analysis mainly because of their simplicity and ease of handling. Among various PCR based markers, the inter simple sequence repeat amplification (Zietkiewicz & al., 1994) is a simple, quick and reliable technique used in various species for detecting polymorphism. The ISSR markers have been used extensively for phylogenetic studies, the evaluation of genetic diversity as well as for cultivar identification in a number of plant species (Wolfe, 2005). Six taxa belonging to *Ceropegia* section *Buprestis*, *C. karulensis*, *C. maccannii*, *C. maharashtrensis*, *C. panchganiensis*, *C. rollae* and *C. sahyadrica*, were therefore analyzed using ISSR markers. *Ceropegia oculata* var. *satupudensis* from section *Indopegia* was used as an outgroup. Total 114 bands obtained from 13 primers were scored and the similarity matrix was generated using Dice coefficient. The similarity coefficient ranged from 0.42 to 0.66. In cluster analysis using UPGMA algorithm, *C. oculata* var. *satupudensis* which was used as outgroup species, separated from the rest of the erect species which belong to section *Buprestis*. In this clade, two clusters were observed viz., first cluster consisted of *C. rollae*, *C. sahyadrica* and *C. karulensis* and the second of *C. maharashtrensis*, *C. panchganiensis* and *C. maccannii.* (Fig. 8)

The grouping of the species as observed in the present analysis was compared with the morphological data. Taxa from section *Buprestis* with erect habit formed separate clade and were distinct from outgroup taxon from section *Indopegia* which has twining habit. The two clusters observed in the clade of species with erect habit are also in agreement with the relationships observed based on morphological characters. All the three species in the first cluster viz., *C. maharashtrensis*, *C. panchganiensis* and *C. maccannii* are characterized by a distinctly patterned light windows or windowpanes either in the form of vertical stripes, ring or small circular blotches in the inflated portion of tube or tube in general, cupular outer corona and clavate, subclavate or spathulate inner corona. *C. maharashtrensis* which is separated in this cluster has light windows or windowpanes in inflated

Fig. 5 : L.S. of flower showing windows and corona. **A**. *Ceropegia maharashtrensis;* **B-C.** *C. panchganiensis*; **D.** *C. maccannii;* **E**. *C. rollae*; **F**. *C. sahyadrica* - Sinhagadh population; **G**. *C. sahyadrica* - Amboli population; **H**. *C. sahyadrica* - Pabe ghat population; **I**. *C. karulensis*. Photos by Sachin A. Punekar.

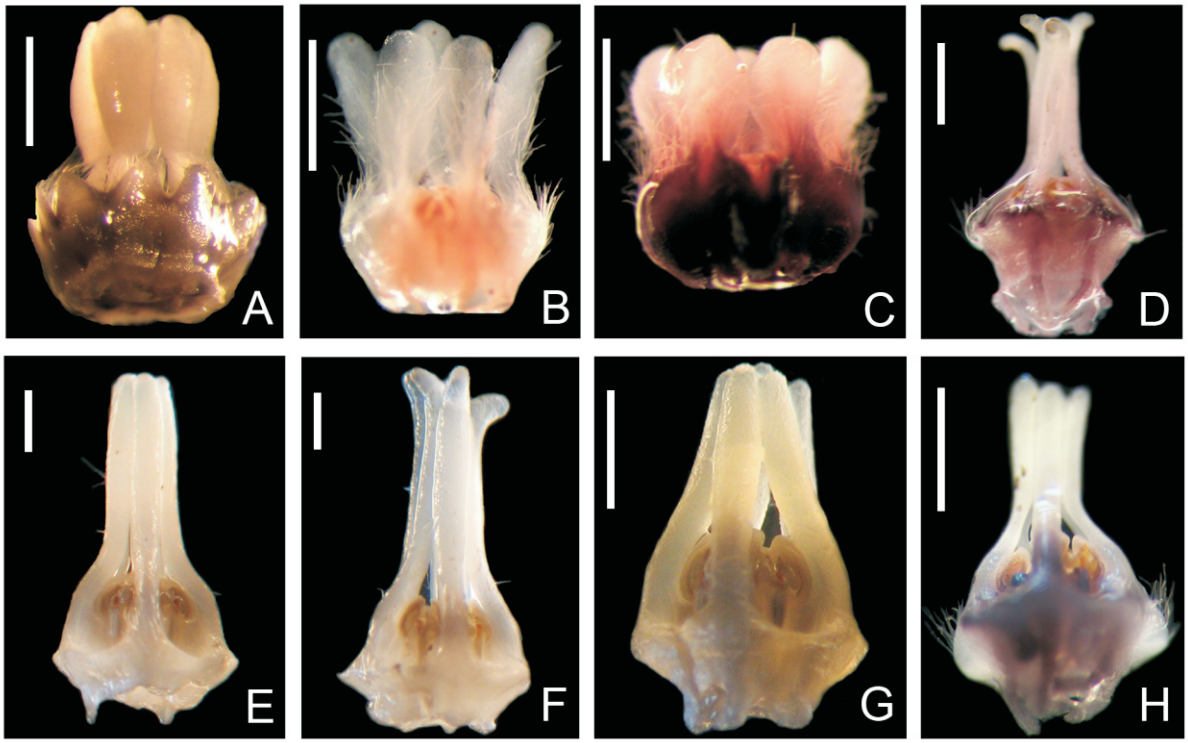

Fig. 6 : Corona. **A**. *Ceropegia maharashtrensis;* **B**. *C. panchganiensis*; **C**. *C. maccannii;* **D**. *C. rollae*; **E**. *C. sahyadrica* - Sinhagadh population; **F**. *C. sahyadrica* - Pabe ghat population; **G**. *C. sahyadrica* - Amboli population; **H**. *C. karulensis*. Scale bar = 1mm. Photos by Sachin A. Punekar.

portion with small circular blotches and inner corona lobes convergent, glabrous or sparsely hairy; while both *C. maccannii* and *C. panchganiensis* which are grouped together have light windows or windowpanes in inflated portion with vertical stripes and densely hairy, divergent inner corona lobes. The species in second cluster viz., *C. rollae*, *C. sahyadrica* and *C. karulensis* are characterized by uniformly dark purple or reddish colouration inside the tube without light windows or windowpanes, saucer-shaped outer corona and linear inner corona. *C. rollae* which is separate in second cluster has oblong corolla lobe and corolla tube slightly inflated at base. Whereas the remaining two taxa grouped together in second cluster viz., *C. sahyadrica* and *C. karulensis* are similar in having distinctly inflated corolla tube at base, oblate to obconic corolla head and corolla lobes broadly ovate. The results show that DNA analysis using molecular markers is efficient and a reliable tool for studying *Ceropegia* species and is complementary to the morphological observations. Morphologically, the erect species belonging to section *Buprestis* have been many times erroneously treated under a certain species; therefore, study of the genetic relationships among them will be very important to resolve such errors.

Sequence data and phylogenetic relationships

Sequence data from nuclear ribosomal DNA and trnL (UAA) intron regions of all the erect species of section *Buprestis* was separately used to derive phylogenetic relationships. The ITS amplification product was ~700 bp in length while chloroplast trnL-intron region was ~550 bp long.

The aligned dataset containing 20 taxa included sequences of erect species of section *Buprestis* studied presently and sequences of other taxa representing the sections within genus *Ceropegia* taken from database (Table 1 & 2). Based on aligned sequence data (627 bp) from ITS region (Fig. 9), all the erect species of section *Buprestis* including two new species (*C. karulensis*, *C. maccannii*, *C. maharashtrensis*, *C. panchganiensis*, *C. rollae* and *C. sahyadrica*) along with 3 twining species (*C. evansii*, *C. fantastica* and *C. oculata* var. *satpudensis*) formed a single clade characterized by broad leaves, which further separated into two. First consisted of 4 species with erect habit while other consisted of 2 species from *Buprestis* with erect habit grouped together along with 3 twining species belong to sections *Indopegia* (*C. fantastica* and *C. oculata* var. *satpudensis*) and *Buprestis* (*C. evansii*). Grouping of *Indopegia* along with erect species of section *Buprestis* suggests close relationship which in turn

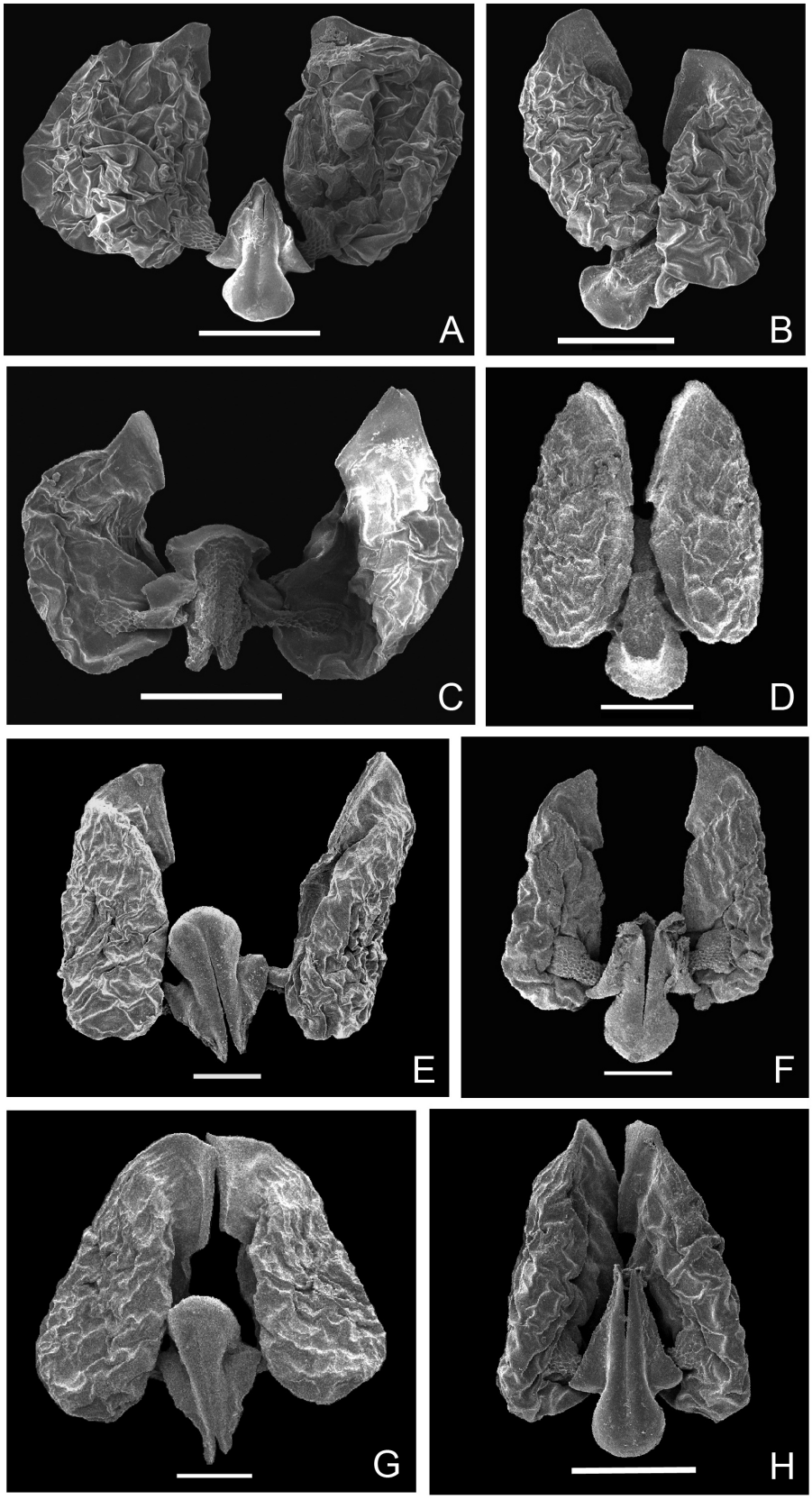

Fig.7 : Pollinarium (Scanning Electron Microscopic photographs). **A.** *Ceropegia maharashtrensis*; **B.** *C. panchganiensis;* **C.** *C. maccannii;* **D.** *C. rollae;* **E.** *C. sahyadrica* - Sinhagadh population; **F.** *C. sahyadrica* - Amboli population; **G.** *C. sahyadrica* - Pabe population; **H.** *C. karulensis.* Scale bar = 100µm.

supports Huber's hypothesis (1957) that the section *Buprestis* must have evolved from section *Indopegia*. *Ceropegia bulbosa* having succulent nature of leaves from section *Ceropegia* was basal taxon in this clade. Four twining and narrow leaved species from *Buprestis* namely *C. odorata*, *C. media*, *C. huberi* and *C. santapaui* along with *C. attenuata* (section *Lysanthe*) and *Brachystelma edulis* (outgroup) were in the other clade which was basal to the above clade. *Ceropegia elegans* (section *Janthina*), another species of Western Ghats is basal to this clade. Non Western Ghats species like *C. pubescens* (section *Chionopegia*) *C. longifolia* (section *Oreopegia*) and *C. juncea* (section *Phalaena*) are further basal to all above Western Ghats species. The observed grouping of *Ceropegia* species is in agreement with the phylogenetic relationships described by Surreswaran & al., (2009).

Based on aligned sequence data (497 bp) from trnL-intron region, two major clades were observed (Fig. 10). All the erect and twining species (except *C. odorata*) from section *Buprestis* and twining species from section *Indopegia* belong to a single clade. The repositioning of *C. evansii*, *C. huberi*, *C. media* and *C. santapaui* in broad leaf clade may be justified in having corolla lobes shorter than tube (except *C. huberi*) and hairy peduncle. Another subclade of succulent *Ceropegia* species like *C. bulbosa* and *C. juncea* is basal to the above clade. In the second clade, non Western Ghats species viz., *C. longifolia* and *C. pubescens* form a subclade. Whereas, *C. odorata* with *C. attenuata* (section *Lysanthe*) and *Brachystelma edulis* (outgroup) form the other subclade. *Ceropegia odorata* incidentally shows corolla lobes equal or slightly longer than tube, a character typical of the section *Lysanthe*.

The present study shows that all the species (except *Ceropegia muliensis*) in the section *Buprestis* are endemic to Peninsular India, particularly to the Western Ghats, which is one of the possible loci of origin of *Ceropegia* and the erect species of this section are restricted to the high altitudes of north Western Ghats of Maharashtra suggesting that the stock of erect species is probably monophyletic in origin. Further it can be concluded that the grouping of divergent species into the same taxonomic group or clade due to convergent evolution in morphological features. Considering the sectional affinity the present data clearly suggests that there is an urgent need of reclassifying and reassigning Indian Ceropegias in respective sections.

Key to the species under *Ceropegia* section *Buprestis*

1a. Erect herbs.....*2*

1b. Twining herbs.....*8*

2a. Corolla tube subcylindric (cylindric in *C. lawii*), slightly enlarged at mouth; inner corona linear, 3-4 times longer than outer.....*3*

2b. Corolla tube narrow, cylindric, not enlarged at mouth; inner corona clavate, subclavate or spathulate, as long as or twice longer than outer.....*6*

3a. Corolla lobes linear-oblong.....*C. rollae*

3b. Corolla lobes ovate, obovate or elliptic.....*4*

4a. Corolla tube narrow, cylindric, with slightly inflated base; outer corona tubular.....*C. lawii*

4b. Corolla tube broad, subcylindric, with largely inflated base; outer corona saucer shaped.....*5*

5a. Corolla 3.5 - 5.5cm long; head obovate or obconic; lobes pale orange to olive green inside at apex; peduncle densely hairy, hairs with bulbous base; pedicels hairy; inner corona 5.0 - 6.0mm long, slightly hairy near the base.....*C. sahyadrica*

5b. Corolla up to 2.0cm long; head spheroidal to subspheroidal; lobes pure white throughout; peduncle sparsely hairy, hairs without bulbous base; pedicels glabrous or glabrescent; inner corona up to 2.5mm long, glabrous..... *C. karulensis*

6a. Corolla less than 2.2cm long; lobes 2.0 - 3.0mm long; tube largely inflated in lower ⅔ to ½ part; inner corona lobes spathulate..... *C. maccannii*

6b. Corolla more than 2.8cm long; lobes 6.0 - 7.0mm long; tube slightly inflated in lower ⅓ to ¼ part; inner corona lobes clavate to subclavate.....*7*

7a. Leaves densely hairy, hairs bulbous based; corolla lobes obovate, glabrous, yellow inside, tips incurved forming a subglobose head; inner corona densely hairy..... *C. panchganiensis*

7b. Leaves sparsely hairy, hairs without bulbous base; corolla lobes elliptic, minutely stiff hairy, olive green inside, tips beaked forming a spheroidal head; inner corona glabrous or sparsely hairy.....*C. maharashtrensis*

8a. Corolla lobes equal or slightly longer than tube.....*9*

8b. Corolla lobes shorter than tube.....*11*

9a. Corolla less than 1.5cm long; lobes broadly ovate-cordate.....*C. huberi*

9b. Corolla more than 3.0cm long; lobes linear to oblong.....*10*

10a. Corolla tube glabrous inside; outer corona ciliate..... *C. ensifolia*

10b. Corolla tube hairy inside; outer corona glabrous..... *C. odorata*

11a. Peduncles glabrous.....*C. omissa*

11b. Peduncles hairy.....*12*

12a. Rootstock often a cluster of fusiform roots.....*C. muliensis*

12b. Rootstock a subglobose tuber.....*13*

13a. Corolla lobes broadly ovate or orbicular.....*14*

13b. Corolla lobes lanceolate or broadly oblong.....*15*

14a. Corolla less than 2.0cm long; lobes orbicular, glabrous inside; corona uniseriate, inner hairy.....*C. santapaui*

14b. Corolla 2.5 - 4.0cm long; lobes broadly ovate, pubescent inside; corona biseriate, inner glabrous.....*C. evansii*

15a. Stem hairy; flowers green; inner corona lobes spathulate, erect-divergent or recurved at apex.....*C. ciliata*

15b. Stem glabrous; flower white or pale pinkish-white; inner corona lobes linear, not recurved at apex.....*C. media*

Ceropegia karulensis Punekar, Tamhankar, Lakshmin., Kumaran, A. Raut, S.K. Srivast. & Kavade, **sp. nov.** *Ceropegia lawii sensu* D. K. Mishra & N. P. Singh, Indian J. Forest. Addit. Ser. 9: 21. 2000, p.p. & Endem. & Threat. Fl. Pl. Maharashtra 136. 2001, p.p.; S. R. Yadav & Sardesai, Fl. Kolhapur Distr. 285. 2002; Ingalhalikar, Furth. Flow. Sahyadri. 365, fig. 2007; Surveswaran & al., Plant Syst. Evol. 281: 53, 60, fig. 4 d. 2009, *non* Hook.f., 1883.

Ceropegia karulensis sp. nov. *C. sahyadricae* atque *C. rollae* similis. A *C. sahyadrica* apicibus foliorum caudato-acuminatis vel abrupte acuminatis (non acutis), floribus fragrantissimis (non inodoris), cymis plerumque terminalibus subumbellatis (non lateralibus), pedicellis glabris vel glabrescentibus (non hirsutis), corolla breviore minus quam 2cm (non 3.5 - 5.5cm) longa, lobis corollae utrinque candidis (non extus cinereis neque intus pallidis aurantiis neque olivaceis) et lobis interioribus coronae glabris (non ad basin hirsutis) brevibus usque 2.5mm tantum (non 5 - 6mm) longis differt. A *C. rollae* foliis elliptico-ovatis vel lanceolatis (non late ovatis), tubo corollae ad basin multo inflato (non aegre inflato) et lobis corollae orbicularibus vel late ellipticis (non lineari-oblongis) differt.

Type : India, Maharashtra State, Kolhapur District, Gaganbawada, Karul ghat, 25 August 2005, *S.A. Punekar* 365 (Holo : CAL; Iso : AHMA). (**Figs.** 1, 4H, 5I, 6H, 7H).

A tuberous erect or suberect herb. Tuber 1.5 - 3.0cm across, depressed globose. Stem unbranched, 27 - 77cm high, 4.0 - 6.0mm across, slender, sparingly hairy. Leaves opposite; petioles up to 2.3cm long, slender, deeply channeled above, hairy; lamina 3.0 - 12.5cm long, 1.5 - 6.5cm across, basal bigger compared to upper, elliptic-ovate or lanceolate, base subcordate, rounded or rarely oblique, apex caudate-acuminate or abruptly acuminate, sparsely hairy above and along margin, glabrous below except midrib and nerves; secondary nerves up to 5 pairs, curving upwards, looping along the margin, emerging from leaf base. Flowers highly fragrant, in subumbellate cymes, axillary and/or terminal on same plant; peduncles up to 6.5cm long, sparsely hairy; pedicels up to 8mm long, terete, glabrous or glabrescent. Calyx 5-partite; lobes subulate, up to 3.2mm long, broader at base, glabrous, 1-nerved. Corolla up to 2.0cm long, slightly curved or not, wither early; tube subcylindric, up to 1.5cm long, up to 3.0mm across, slightly wide at apex, whitish and minutely stiff hairy throughout outside, distinctly striated, dark reddish to purple inside in lower ⅔ part, distinctly dilated at base, dilated portion up to 6.0mm long, up to 4.0mm across, ovoid, with hairs at base of inflated part; corolla lobes orbicular or broadly elliptic, up to 5.2mm long, up to 3.5mm across, apex acuminate-caudate, pure white inside and outside, glabrous, connate at

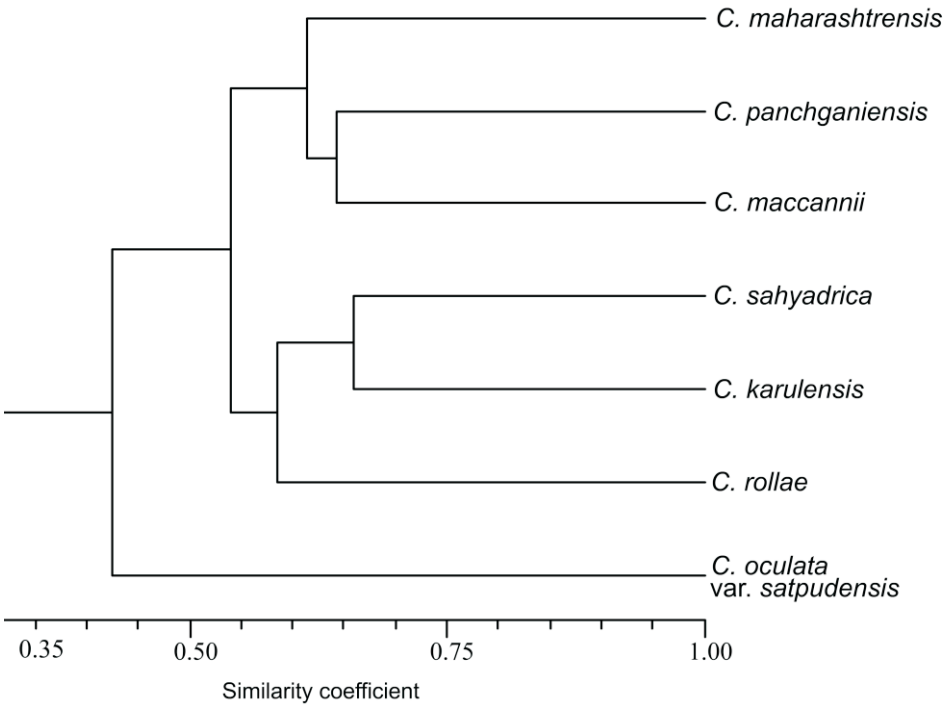

Fig. 8 : Genetic relationships among the erect species of section *Buprestis* using ISSR markers.

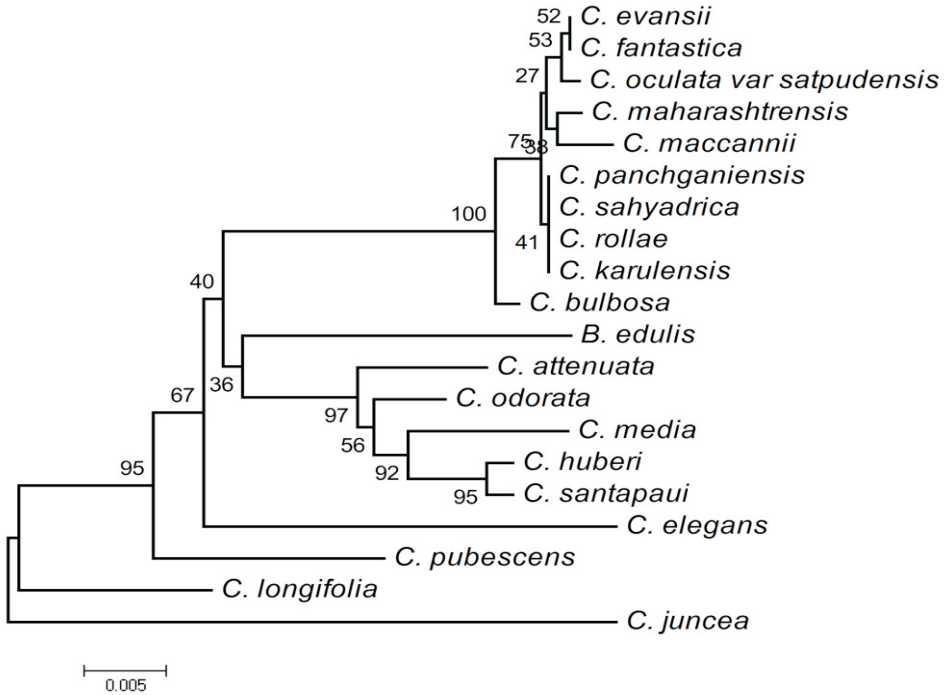

Fig. 9 : Phylogenetic tree based on ITS data obtained using the Neighbor-Joining method. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) is shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree.

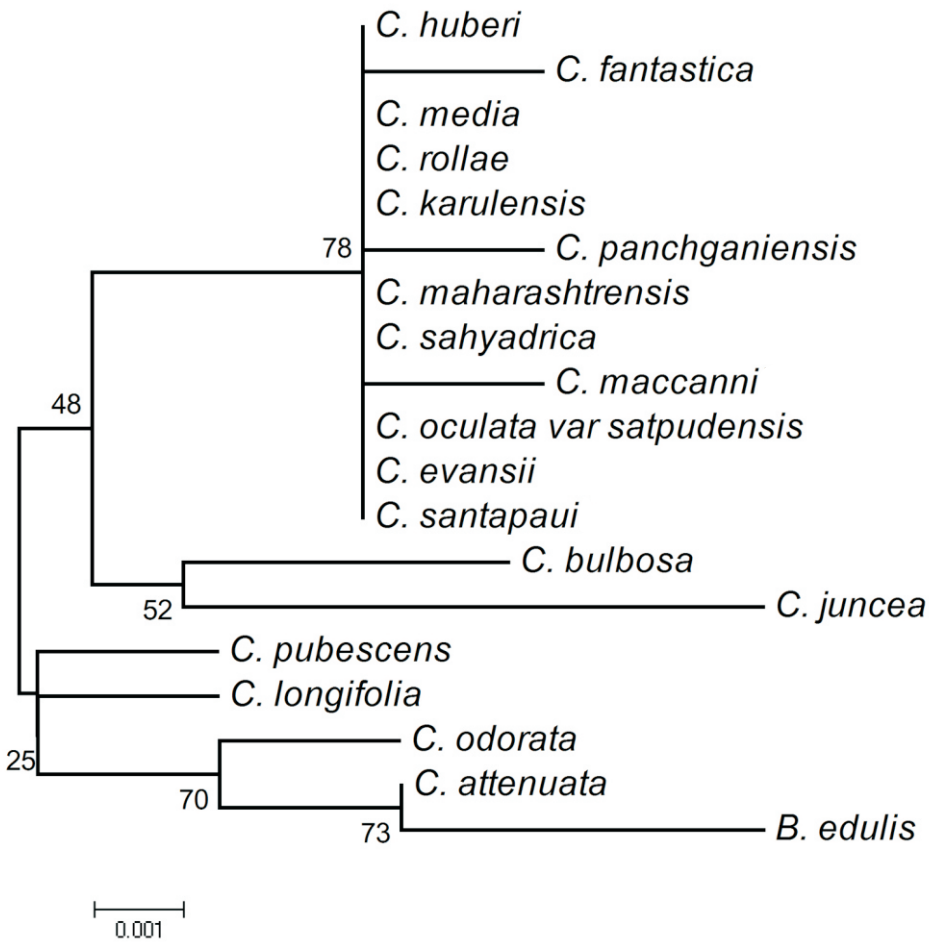

Fig. 10 : Phylogenetic tree based on chloroplast trnL- intron data obtained by the Neighbor-Joining method. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) is shown next to the branches.

tips, forming a spheroidal to subspheroidal head up to 6.0mm across in the broadest part. Corona biseriate, 2.75-3.0mm long; outer (gynostegial) corona lobes saucer shaped, broadly or obtusely 5-lobed, up to 0.5mm high, purplish, densely pilose inside, glabrous outside, obtuse or rounded at apex, yellow; inner (staminal) corona lobes 5, linear, erect, glabrous, densely papillate, white, up to 2.5mm long. Pollinarium erect, waxy with pellucid layer. Corpuscle 132 - 173µm long; head 50 - 64µm long, 67 - 71µm across, usually rounded at apex, rarely truncate; stalk 74 - 108µm long, up to 36µm across. Caudicle up to 60µm long, up to 20µm across. Pollinia 266-297µm long, 93 - 111µm across, lanceolate or narrowly ovate.

Etymology : The present species is being named after the type locality Karul ghat of Maharashtra, India.

Distribution and habitat : India: Maharashtra - Kolhapur District (Bhuibawda ghat, Karul ghat, Radhanagari) and Ratnagiri District (Anuskura ghat, Machal hills). Grows in the tuft of grasses on the stiff hill slopes and also as undergrowth in the *Strobilanthes callosa* strand at an elevation ranging from 400 - 900m.

Remarks : This species is an intermediate between *Ceropegia sahyadrica* and *C. rollae*. The allied taxa also show a saucer shaped outer corona, linear, erect inner corona, and corolla tube uniformly dark purple or reddish in lower half. Recent collections from Anuskura ghat, Karul ghat, Machal hills and Radhanagari have shown that this taxon forms a large population that can be distinguished morphologically, ecologically and geographically. *Ceropegia karulenis* is undoubtedly analogous to *C. sahyadrica,* however it differs from *C. sahyadrica* by the caudate-acuminate or abruptly acuminate leaf apices (vs. acute), highly fragrant flowers (vs. non fragrant), usually in terminal subumbellate cymes (vs. lateral), shorter corolla, less than 2.0cm long (vs. longer corolla, 3.5 - 5.5cm long), pedicels glabrous or glabrescent (vs. hairy), corolla lobes pure white inside and outside

(vs. ash-grey coloured outside and pale orange to olive green inside) and inner corona lobes glabrous (vs. slightly hairy near the base), short, up to 2.5mm long (vs. long, 5.0 - 6.0mm long). *Ceropegia karulenis* differs from *C. rollae* by the elliptic-ovate or lanceolate leaves (vs. broadly ovate), corolla tube largely inflated at base (vs. slightly inflated at base), corolla lobes orbicular or broadly elliptic (vs. linear-oblong). All the three species have generally been found at 800 - 1400m, of which *C. sahyadrica* has comparatively wider distribution in Maharashtra, which grows in two different habitats; in the boulder crevices on the high altitude lateritic plateaus and other among the grasses on gentle hill slopes. *C. rollae* has a narrow ecological amplitude and grows in the crevices of basaltic boulder outcrops on the open top of the Dhak Killa. However, *C. karulensis* grows on well exposed steep hill slopes in the tuft of grasses and also as undergrowth in the *Strobilanthes callosa* Nees tuft. The flowering phenology of *C. karulensis* and *C. sahyadrica* overlap from mid July to late August, whereas *C. rollae* flowers in mid August to late September-October. At this time, the former two species are almost in a fruiting stage. Geographically, *C. karulensis* occurs quite away from the distribution range of *C. rollae*, whereas there is some overlap in Karul ghat with *C. sahyadrica* which grows on the eastern slopes in high altitudes and *C. karulensis* growing only a few kilometers away on the western slopes of the same mountain.

Additional specimens examined : India, Maharashtra State, Kolhapur District, Gaganbawada, Karul ghat, 25 August 1997, *D.K. Mishra* 176855; Bhuibawda ghat, 26 August 1997, *D.K. Mishra* 176858 (All in BSI); Gaganbawada, Karul ghat, 17August 2008, *S.A. Punekar* 697 (MACSG); Ratnagiri District, Anuskura ghat, 2 August 2010, *S.P. Kavade* 698 (MACSG); Machal hills, 8 August 2010, *S.A. Punekar* & *S.P. Kavade* 699 (MACSG).

Ceropegia lawii Hook.f., Fl. Brit. India 4: 67. 1883; T. Cooke, Fl. Bombay 2: 240. 1967 (Repr.), p.p.; Santapau & Irani, Bull. Bot. Soc. Bengal 12: 8. 1958, p.p.; Ansari, Fasc. Fl. India 16: 19. 1984, p.p.; A.P. Jagtap & N. P. Singh, Fasc. Fl. India 24: 228. 1999, p.p.; D. K. Mishra & N. P. Singh, Indian J. Forest. Addit. Ser. 9: 21. 2000, p.p. *et* Endem. & Threat. Fl. Pl. Maharashtra 136. 2001, p.p.

Type : India, Maharashtra, Concan (Konkan), *Law & Stocks Ceropegia* n. 25. [Holo : K, (Kew bar code K000357607)]. **(Figs. 2, 3)**

A tuberous erect herb. Tuber 3.0 - 5.0cm across. Stems branched or unbranched, 39 - 45cm long, sparingly hairy. Leaves opposite; petiole up to 2.5cm long, channeled or deeply ribbed, sparsely to densely hairy; lamina up to 9.0cm long and 4.0cm across, ovate, ovate-oblong to ovate-lanceolate, base rounded or subcordate, apex acuminate or caudate-acuminate, acumen curved, sparsely hairy throughout on the upper surface and along margin, prominent on the nerves, nearly glabrous beneath; secondary nerves 4 to 5 pairs, emerging almost from the base of the lamina. Flowers in subumbellate cymes, axillary; peduncles densely hairy, up to 3.5cm long, hairy; pedicel 3.0 - 4.0mm long, hirsute. Calyx 5-partite; lobes subulate, 3.5 - 4.0mm long, stiff hairy outside below the half. Corolla up to 2.8cm long; tube cylindric, narrow, slightly enlarging at apex, up to 2.5cm long, 2.0 - 2.2mm across, gradually dilated at base, dilated portion up to 7mm long, 2.5 - 3.0mm across, with a ring of hairs inside; corolla lobes elliptic, 5.0 - 6.5mm long, up to 3.5mm across, forming a ovoid or ellipsoidal head. Corona biseriate, up to 5mm long; outer (gynostegial) corona lobes cupular, consisting of 5 deeply bifid lobes as if they look like 10 separate lobes, each lobe deltoid, densely hairy inside, glabrous or sparingly hairy outside, obtuse at apex; inner (staminal) corona lobes 5, linear, erect, free, 3-4 times longer than outer.

Distribution and habitat : India: Maharashtra State - Conkan (Konkan), Bombay. Habitat data is not known as this species is only known from the type collection.

Remarks : Hooker (1883) had described this species based on the collection made by Law & Stock from Concan (Konkan). The old collections deposited in Kew and other foreign herbaria under *C. lawii* contain different species which have been subsequently published as new species namely *C. maccannii*, *C. panchganiensis*, *C. rollae* and *C. sahyadrica*. Blatter and McCann (1933) described *Ceropegia panchganiensis* (the only other erect species with broad leaves known then from Western India) from Panchgani, Maharashtra and compared with *C. lawii*. Later McCann (1945) merged *C. panchganiensis* under *C. lawii* without any note. Since then, *C. panchganiensis* was treated as synonym by subsequent workers like Huber (1957), Santapau & Irani (1958) and others. Huber (1957) in his treatise on *Ceropegia* provided a description of

C. lawii and cited collections from many parts of Maharashtra deposited in various herbaria such as BM, FI, G, GH, K, L, P and W which actually contains many other species which have been subsequently described as new. Ansari (1984), does not give detailed distribution of *C. lawii* but mentioned that a specimen collected by *Wadhwa* 127731 (BSI) from Harishchandragad on 29 September 1970 agrees well with the protologue and the type photo of *C. lawii*. However, the illustration of corona given by Ansari, *l.c.* for *C. lawii* does not match with the illustration of the corona on the holotype of *C. lawii*. Further Ansari and Kulkarni (1971) and Ansari (1982a, 1982b, 1984) have confused about the identity of true *C. lawii*. Ansari and Kulkarni (1971) while describing *C. sahyadrica* compared this to *C. rollae* and *C. lawii*, where they have mentioned that *C. lawii* is characterized by having cupular outer corona and clavate inner corona, about double the length of outer ones. Ansari (1982a) compared *C. panchganiensis* to *C. lawii*, where he mentioned that *C. lawii* has saucer shaped outer corona, of 10 obtuse lobes and inner corona erect, slender, 4-5 times longer than outer, while comparing *C. maccannii* with *C. lawii*, Ansari (1982b) has mentioned the same characters for *C. lawii*. Ansari and Kulkarni (1971) probably described *C. lawii* based on Wadhwa's collection from Harishchandragad. However, the description matches well with *C. maharashtrensis* sp. nov. described in this paper. The detailed comparison of *C. maharashtrensis* with its allied species viz., *C. lawii*, *C. maccannii* and *C. panchganiensis* is also provided. Even according to Almeida (2001) the decision taken by Ansari to treat the material from Harishchandagad as the *C. lawii* did not seem to be logical. In addition, Almeida (2001) synonymised *C. sahyadrica* under *C. lawii* and treating the allied species namely *C. maccannii* and *C. panchganiensis* as varieties of *C. lawii* which added further confusion to the identity of real *C. lawii* and makes the taxonomic status of these species dubious. Mishra and Singh (2000, 2001) also provided the detailed assessment and distribution of *C. lawii* by erroneously studying complex of many species namely *C. karulensis*, *C. maharashtrensis* and *C. sahyadrica* which leads to further ambiguity in the identity of true *C. lawii*. The reason for such erroneous descriptions or merging, as it can be judged now, lies in almost total absence of true *C. lawii* in Indian herbaria and its imperfect knowledge. Even earlier workers have inappropriately studied the true *C. lawii* in Kew and other foreign herbaria. There is an urgent need to recollect this species from Bombay, Concan, India as it is so far represented only by the type collections at Kew.

After thoroughly studying the types of *Ceropegia lawii* deposited at Kew, the authors are of the opinion that this species is more akin to *Ceropegia maharashtrensis* and *C. panchganiensis*. It differs from *Ceropegia maharashtrensis* in having various characters mentioned under *C. maharashtrensis*. *Ceropegia lawii* differs from *C. panchganiensis* in having leaves sparsely hairy, hairs without bulbous base (vs. leaves densely hairy, hairs bulbous based), corolla lobes elliptic (vs. corolla lobes obovate), corolla tube slightly inflated at base (vs. largely inflated) and inner corona lobes linear, 3 - 4 times longer than outer (vs. clavate or subclavate, as long as or twice longer than outer). Interestingly *C. lawii* is having tubular outer corona and linear inner corona, which seems to be a linkage between the species having saucer shaped outer corona with linear inner corona and species with tubular outer corona with clavate, subclavate or spathulate inner corona.

Additional specimens examined : India, Maharashtra, South Concan, *Law* 25 *Ceropegia* (K) [Kew negative no. 9254, bar code no. K000357608], 1st from the right side of the sheet; Concan, *Law & Stocks Ceropegia* 24 (K), 3rd specimen from the left side of the sheet (Kew bar code no. K000357813); Concan, *Law & Stocks Ceropegia* 24 (P); Bombay, *Dalzell Ceropegia* 25 (K) [bar code no. K000357815].

Ceropegia maccannii Ansari, Bull. Bot. Surv. India 22: 227. 1982 (1980) *et* Fasc. Fl. India 16: 22, t. 3, fig. 16. 1984; A.P. Jagtap & N. P. Singh, Fasc. Fl. India 24: 230. 1999; D. K. Mishra & N. P. Singh, Indian J. Forest. Addit. Ser. 9: 22. 2000 *et* Endem. & Threat. Fl. Pl. Maharashtra 138. 2001. *C. lawii sensu* T. Cooke, Fl. Bombay 2: 175. 1904 [2: 240. 1967 (Repr.)], p.p.; Huber, Mem. Soc. Broter. 12: 67, t. 3, fig. 35. 1957, p.p.; Venkata Reddi, Willdenowia 5 (1): 32, t. 1-2. 1968; Hemadri, Bull. Bot. Surv. India 10: 125, t. 1, fig. 3-3A.1969 (1968); Ansari & B. G. Kulk., Indian Forester 97: 689, t. 2, fig. B3. 1971, non Hook.f., 1883. *Ceropegia lawii* var. *maccannii* (Ansari) M. R. Almeida, Fl. Maharashtra 3A: 234. 2001, **syn. nov.**

Type : India, Maharashtra, Pune District, Sinhagadh hill, 7 August 1964, *M. Y. Ansari* 97574 A (Holo : CAL; Iso, 97574 B-C in BSI, D in CAL, E in K; F in BLAT). (**Figs.** 1, 4C, 5D, 6C, 7C).

A tuberous erect herb. Stems firm, terete, pubescent above, 30 - 100cm high. Leaves opposite; petiole 1.0 - 2.0cm long, hairy and grooved above; lamina ovate to lanceolate, 9.0 - 12cm long, 4.0 - 6.0cm across, base

usually acute, sometimes rounded, apex acute or acuminate, hairy above, glabrous beneath except nerves. Flowers in subumbellate cymes, axillary and lateral; peduncles up to 3.5cm long, hirsute; pedicels 0.6 - 1.0cm long, hairy. Calyx 5-partite; lobes 4.0 - 5.0mm long, hairy on dorsal side. Corolla 1.7 - 2.2cm long, curved; tube 1.5 - 2.0cm long, cylindric, largely inflated in lower ⅔ to ½ part base, inflated portion 0.8 - 1.0cm long, 6.0 - 7.0mm across, purplish-grey or yellowish-grey outside, dark purple with conspicuous white vertical streaks inside, glabrous inside except for a ring of white hairs at bottom of inflated base only; corolla lobes obovate, 2.0 - 3.0mm long, up to 2.0mm across, apex acute, creamy white outside, yellowish-orange inside, glabrous, connate at tips forming a minute obovate or obconic head, 2.0 - 3.0mm across. Corona biseriate; outer (gynostegial) corona lobes cupular, consisting of 5 shortly bifid lobes, hairy along the margins and inside, lobes up to 1.0mm long; inner (staminal) corona lobes 5, spathulate, lobes up to 1.0mm long, fleshy, hairy, as long as outer. Pollinarium erect, waxy with pellucid layer. Corpuscle up to 104µm long; head 30 - 36µm long, up to 75µm across, broader than long, rounded at apex, apical portion is slightly elevated; stalk up to 67µm long, up to 31µm across. Caudicle up to 64µm long, up to 10µm across. Pollinia up to 189µm long, up to 101µm across, ellipsoid or ovoid. Follicles in pair, up to 15cm long, up to 0.5cm across, glabrous. Seeds small, comose.

Distribution and habitat : India: Maharashtra - Ahmednagar (Harishchandragad), Pune (Dongarwadi, Purandhar, Sinhagadh, Torna fort). Endemic to the northern part of North Western Ghats. Growing in open areas on hill tops and crevices of moist rocks along steep hill slopes at an elevation ranging from 800 - 1300m.

Remarks : The earliest collection of this species happens to be two specimens collected by Law and Stocks from Concan and mounted along with one specimen of true *Ceropegia lawii* (1st from right side of the sheet) on the sheet (of Hooker Herbarium at Kew), labelled *"Ceropegia* (25)" and identified as *C. lawii.* Being erect and broad-leaved this species was mistaken for *C. lawii* by Huber (1957), Venkata Reddi (1968) and Hemadri (1969). It was Ansari (1982b) who recognized this species as distinct from other erect, broad-leaved species of Western India. According to him among the Indian species of *Ceropegia, C. maccannii* has the smallest corolla lobes (2.0 - 3.0mm long). This species is undoubtedly allied to *C. maharashtrensis* and *C. panchganiensis* in having narrow, cylindric corolla tube, cupular outer corona and thick (spathulate) inner corona. *C. maccannii* differs from *Ceropegia maharashtrensis* in having various characters mentioned under *C. maharashtrensis* sp. nov. It differs from *C. panchganiensis* in having shorter corolla, less than 2.2cm long (vs. 3.0 - 4.0cm long), tube largely inflated in lower ⅔ to ½ part (vs. inflated in lower ⅓ to ¼ part), corolla lobes 2.0 - 3.0mm long (vs. 6.0 - 7.0mm) and inner corona lobes spathulate (vs. clavate). *Ceropegia maccannii* is an Endangered species (Mishra and Singh, 2001), distributed in northern part of north Western Ghats (Ahmednagar, Mulshi, Sinhagadh, Purandhar, Torna fort), which grows on hill tops in well drained soil and also on grassy hill slopes especially near waterfalls having narrow ecological amplitude. This species flowers from July to August. The population is severely fragmented and there is decline in the number of mature individuals due to frequent collections by the botanists from the same localities, harvesting tubers by the local cowherds and the natural pests like caterpillars of Plain and Striped Tiger butterflies.

Additional specimens examined : India, Maharashtra, Concan, *Law* & *Stocks* 25 *Ceropegia* (K) [Kew negative no. 9254, bar code no. K000357608], 1st two specimens from the left side of the sheet; Concan, *Law* & *Stocks Ceropegia* 25 (P); Maharashtra, Pune District, Purandhar, August 1891, without collector *s.n.* (Acc. No. 296606) (CAL); Sinhagad, 13 July 1951, *B.A. Razi* 5334 (AHMA); Purandhar, 31 August 1955, *Santapau* 7125 & 7127-7128 (BLAT); Sinhagad, along the slopes in shade, 1200m, 27 August 1955, *V.D. Vartak* 921 (AHMA); Sinhagad, near the base of the fort, 1200m, 28 August 1956, *V.D. Vartak* 5570 (AHMA); Bhor hill, 1200m, 17 July 1957, *V.D. Vartak* 9582 (AHMA); Sinhagadh, 29 August 1963, *M.Y. Ansari* 87804 (BSI); Grown in BSI, Poona from tubers brought from Sinhagad, Poona district, July 1965, *B.V. Reddy* 101207 (CAL); Sinhagad, 17 August 1996, *D.K. Mishra* 175429 (BSI); Sinhagadh 27 August 2004, *S.A. Punekar* & *A. Raut* 367 (MACSG); Sinhagadh, 27 August 2004, *S.A. Punekar* 552 (MACSG).

Ceropegia maharashtrensis Punekar, Tamhankar, Lakshmin, Kumaran, A. Raut & S.K. Srivast., **sp. nov.** *Ceropegia lawii sensu* Ansari, Indian Forester 97: 689. 1971 & Fasc. Fl. India 16: 19. 1984, p.p.; D. K. Mishra &

N. P. Singh, Indian J. Forest. Addit. Ser. 9: 21. 2000, p.p. *et* Endem. & Threat. Fl. Pl. Maharashtra 136. 2001, p.p., *non* Hook.f., 1883. *Ceropegia lawii* var. *wadhwae* M. R. Almeida, Fl. Maharashtra 3A: 234. 2001 *nom. inval.* (without latin descr. or type; published as a nom. nov. based on misapplied name).

Ceropegia maharashtrensis sp. nov. *C. panchganiensi*, *C. maccannii* atque *C. lawii* similis. A *C. panchganiensi* foliis sparsim (non dense) hirsutis, pilis ad basin non bulbosis, lobis corollae ellipticis minute rigidis hirsutis, intus olivaceis (non obovatis glabris intus luteis), parte inflata fenestras maculis parvis circularibus ornatas ferenti et lobis coronae interioribus convergentibus glabris vel sparsim hirsutis (non divergentibus dense hirsutis) differt. A *C. maccannii* corolla usque 2.8cm (non minus quam 2.2cm) longa, lobis corollae usque 6.5mm (non 2 - 3mm) longis, tubo in parte tertia infima aegre inflato (non in dimidio neque ⅔ partibus multo inflato) fenestras maculis parvis circularibus (non striis verticalibus) ornatas ferenti *et* lobis interioribus coronae clavatis vel subclavatis (non spathulatis) differt. A *C. lawii* petiolo brevi minus quam 1.7cm (non usque 2.5cm) longo, acumine folii recto (non manifeste curvato), capitulo corollae sphaeroideo (non ellipsoideo) *et* corona interiori clavata vel subclavata (non lineari) coronam exteriorem aequanti vel quam ea duplo (non 3-4 plo) longiore differt.

Type : India, Maharashtra State, Pune District, Junnar Taluka, Dhak killa (Dhakeshwar), 1100 m, N 19° 18'-19° 40' and E 73° 66'-73° 85', 30 August 2005, *S.A. Punekar* & *A. Raut* 357 *(*Holo : CAL; Iso : AHMA). (**Figs.** 1, 4A, 5A, 6A, 7A).

A tuberous erect herb. Tuber 2.0 - 4.0cm across, depressed globose. Stem usually branched, rarely unbranched, 30 - 90cm high, 0.5 - 1.0cm across, sparingly hairy. Leaves opposite; petioles up to 1.7cm long, stout, deeply channeled above, hairy; lamina ovate, ovate-oblong, ovate-lanceolate, up to 10.5cm long and up to 4.5cm across, base rounded or subcordate or cordate, apex bluntly acuminate or caudate, sparsely hairy above and along margin, glabrous below except midrib and nerves; secondary nerves 5 to 6 pairs, curving upwards, looping along margin, second pair of secondary nerves emerging above from leaf base. Flowers in subumbellate cymes, axillary; peduncles densely hairy, 1.0 - 2.0cm long; pedicels terete, up to 5.0mm long, densely hirsute. Calyx 5-partite; lobes subulate, broader at base, 3.7 - 4.0mm long, stiff hairy outside below half on midnerve, glabrous inside, hairy at apex, 5 to 6-nerved. Corolla up to 2.8cm long, slightly curved, minutely stiff hairy throughout outside, striated, whitish outside; tube subcylindric, up to 1.2cm long, up to 2.5mm across, minutely wide at apex, faint pink-whitish at apex and steadily becoming purple downwards up to corolla base, tube gradually slightly dilated at base, dilated portion 9.0 - 11mm long, 4.0 - 5.0mm across with a ring of hairs and white mottling or dots inside; corolla lobes elliptic, up to 6.5mm long, up to 3.2mm across, apex acuminate-caudate, olive green inside, whitish outside, connate at tips, forming a spheroidal head with short beak, minute stiff hairy outside, glabrous or rarely minute stiff hairy inside. Corona biseriate, up to 3.5mm long; outer (gynostegial) corona lobes cupular, consisting of 5 deeply bifid lobes as if they look as 10 separate lobes, each lobe deltoid, up to 1.2mm long, densely hairy inside, glabrous or sparingly hairy outside, acute or acuminate at apex, yellow, bordered with purple; inner (staminal) corona lobes 5, clavate or subclavate, erect, sparsely hairy or glabrous, white, up to 2.0mm long, free. Pollinarium erect, waxy with pellucid layer. Corpuscle up to 131µm long; head 34 - 83µm long, 69 - 100µm across, broader than long, rounded at apex, apical portion is slightly elevated; stalk up to 78µm long, up to 28µm across. Caudicle up to 69µm long, up to 19µm across. Pollinia 234 - 397µm long, 156 - 180µm across, broadly ovate or ovoid. Follicles in pair, up to 9.0cm long, up to 0.5cm across, straight, tapering to fine point, erect. Seeds up to 6.0mm long, up to 2.2mm across, oblong-elliptic, brown; coma up to 2.5cm long.

Etymology : The species is named after the Maharashtra State of India.

Distribution and habitat : India: Maharashtra - Ahmednagar District (Harishchandragadh), Pune District, Junnar Taluka (Dhakeshwar hill-Dhak Killa, Malshej Ghat). Found at 1200 - 1400m in the tuft of *Euphorbia neriifolia* L. along the banks of seasonal streams or in rocky crevices on hill slopes.

Remarks : This species was erroneously treated as *Ceropegia lawii* by Ansari and Kulkarni (1971) and Ansari (1984) based on the specimen [*Wadhwa* 127731 (BSI)] collected from Harishchandragad, which is not traceable at present in BSI herbarium. According to Ansari (1984), this specimen agrees well with the protologue

and the type photo of *C. lawii*. According to Almeida (2001), the decision taken by Ansari to treat the material from Harishchandagad as the *C. lawii* seems illogical. Almeida (2001) provided a new name instead of describing the novelty for Wadhwa's collection as *Ceropegia lawii* var. *wadhwae* M.R. Almeida (Fl. Maharashtra 3A: 234. 2001) without Latin diagnosis or type based on misapplied name and hence becomes an invalid name. *Ceropegia maharashtrensis* is undoubtedly an intermediate between *C. maccannii* and *C. panchganiensis*. These allied taxa show a cupular shaped outer corona, clavate, subclavate or spathulate inner corona and corolla tube inside in a dilated portion with light windows or windowpanes either in the form of vertical stripes, ring or small circular blotches. A recent collection from Dhakeshwar hills (Dhak Killa) has shown that this taxon forms a small population that can be distinguished morphologically, ecologically and geographically. *Ceropegia maharashtrensis* is undoubtedly analogous to *C. panchganiensis. Ceropegia maharashtrensis* differs from *C. panchganiensis* by the bluntly acuminate or caudate leaf apices (vs. acute or acuminate), non fragrant flowers (vs. highly fragrant flowers), leaves sparsely hairy, hairs without bulbous base (vs. leaves densely hairy, hairs bulbous based), corolla lobes elliptic, minute stiff hairy, olive green inside (vs. corolla lobes obovate, glabrous, yellow inside), light windows or windowpanes in inflated portion with small circular blotches (vs. base with vertical stripes and a white ring at the mouth of inflated portion) and inner corona lobes convergent, glabrous or sparsely hairy (vs. divergent, inner corona densely hairy). *Ceropegia maharashtrensis* differs from *C. maccannii* by the corolla up to 2.8cm long (vs. less than 2.2cm long), corolla lobes up to 6.5mm long (vs. 2.0 - 3.0mm long), tube slightly inflated at base in lower ⅓ part (vs. largely inflated in lower ⅔ to ½ part), light windows or windowpanes in inflated portion with small circular blotches (vs. with vertical stripes) and inner corona lobes clavate or subclavate (vs. spathulate). *Ceropegia maharashtrensis* is also somewhat similar to *C. lawii* but differs from it in having short petiole, less than 1.7cm long (vs. long petiole, up to 2.5cm long), leaf acumen straight (vs. acumen distinctly curved), corolla head spheroidal (vs. ellipsoidal), inner corona clavate or subclavate, as long as or twice longer than outer (vs. linear, 3-4 times longer than outer). All the three species namely *C. maccannii*, *C. maharashtrensis* and *C. panchganiensis* have been found at 600 - 1450m, of which *C. maccannii* is distributed in northern part of north Western Ghats (Ahmednagar, Mulshi, Purandhar, Sinhagad, Torna), which grows on hill tops in well drained soil and also on grassy hill slopes especially near waterfalls whereas *C. panchganiensis* is distributed in the central part of north Western Ghats (Lingmala, Mahabaleshwar) having narrow ecological amplitude and grows on the edge of the cliffs. However, *C. maharashtrensis* is distributed in northern part of north Western Ghats (Harishchandragad, Dhakeshwar hills, Malshej ghat), which grows in the tuft of *Euphorbia neriifolia* L. along the banks of seasonal streams or in the rock crevices on hill slopes. Hemadri (1969) has described *C. rollae* from Dhak Killa from the top of the hill whereas the present species though found on the same hill grows at comparatively low altitude and different habitat. The flowering phenology of *C. maharashtrensis* and *C. maccannii* overlaps from the mid July to August end, whereas *C. panchganiensis* flowers early in June-July when the former two species just start sprouting. Geographically, *C. maharashtrensis* occurs quite away from the distribution range of *C. panchganiensis*, whereas there is some overlap on Harishchandragad, with *C. maccannii* growing in tufts of grass on hill slopes at low altitude (c. 600 m) and *C. maharashtrensis* growing along the banks of seasonal streams or in the rock crevices of the same mountain at a higher altitude (1200 - 1400m).

Additional specimens examined : India, Maharashtra, Ahmednagar, Harishchandragad, 12 September 1998, *D.K. Mishra* 177614 (BSI); Junnar, Dhak Killa, 25 August 2006, *S.A. Punekar* 571, same locality 19 August 2010, *S.A. Punekar* 700 (both in MACSG).

Ceropegia panchganiensis Blatt. & McCann, J. Bombay Nat. Hist. Soc. 36: 534. 1933; Ansari, Bull. Bot. Surv. India 22: 199, **figs.** 1-4. 1982 (1980) *et* Fasc. Fl. India 16: 27, 21, fig. 16 & opp. p. 27, t. 4, fig. 22. 1984; A.P. Jagtap & N. P. Singh, Fasc. Fl. India 24: 235. 1999; D. K. Mishra & N. P. Singh, Indian J. Forest. Addit. Ser. 9: 24. 2000 *et* Endem. & Threat. Fl. Pl. Maharashtra 146. 2001. *Ceropegia lawii* var. *panchganiensis* (Blatt. & McCann) M. R. Almeida, Fl. Maharashtra 3A: 234. 2001, **syn. nov.**

Type : India, Maharashtra, Satara District, Lingmala near Mahabaleshwar, 20 June1968, *M.Y. Ansari* 105090 A (Neo : CAL). (**Figs.** 1, 4B, 5B-C, 6B, 7B).

A tuberous erect herb. Stem branched or unbranched, pubescent above, 45 - 50cm high. Leaves opposite; petiole 2.3 - 2.5cm long, rigid, deeply channeled, glabrous; lamina ovate, ovate-oblong to ovate-lanceolate, 6.0 - 9.0cm long, 3.0 - 6.0cm across, base rounded or subcordate, apex acute or acuminate, hairy above, hairs bulbous based. Flowers in subumbellate cymes, arising from between petioles, and axillary; peduncles 0.5 - 1.5cm long, hairy; pedicels 0.8 - 1.5cm long, hairy. Calyx 5-partite; lobes subulate, broader at base, 3.0 - 7.0mm long, hairy or glabrous. Corolla 3.0 - 4.0cm long, usually curved, greyish outside, striated; tube distinctly inflated at base in lower ⅓to ¼ part, uniformly cylindric above, narrowing at apex, 2.2 - 2.8cm long, inflated portion outside at base with minute purple blotches or guiding spots, inside with a ring of hairs at bottom and with distinct longitudinal purple lines and a dull white ring at mouth separating narrow elongated dark purple parts above, white ring visible outside also; lobes obovate-acute, yellow inside, 6.0 - 7.0mm long, up to 4mm across, glabrous, tips incurved, connate, forming a subglobose head. Corona biseriate, up to 1mm long; outer (gynostegial) corona lobes cupular, consisting of 5 shortly bifid or truncate lobes, with a long bristly hairs; inner (staminal) corona lobes 5, clavate or subclavate, erect, divergent, up to 2mm long, long hairy. Pollinarium erect, waxy with pellucid layer. Corpuscle 94 - 98µm long; head up to 35µm long, up to 65µm across, broader than long, rounded at apex, apical portion subretuse; stalk up to 58µm long, up to 25µm across. Caudicle 48 - 50µm long, up to 16µm across. Pollinia oblong, up to 204µm long, up to 94µm across.

Distribution and habitat : India: Maharashtra; Satara District, Mahabaleshwar surroundings (Lingmala, Hunter's point, Kate's point). It grows in the outskirts of semi-evergreen forests on the edges of Cliffs at 1390 & 1400m.

Remarks : This species was erroneously treated many times as a synonym of *Ceropegia lawii* by the earlier workers namely McCann (1945), Huber (1957), Santapau and Irani (1958) and others until Venkata Reddi (1968) tried to resurrect it to its original specific status based on his collections from Ambavane-Sakharpathar area in Pune District, Maharashtra, which were found to be misidentified and later described new as *C. sahyadrica* by Ansari and Kulkarni (1971). It was Ansari (1982a) who scrutinized the specimens available at BLAT and subsequently rediscovered the true *C. panchganiensis* from Lingmala, near Mahabaleshwar. According to Ansari (1982a), the specimen collected from Lingamala (*Ansari* 105090) represents the first authentic and mature specimen of *C. panchganiensis* which he later designated as a Neotype. However, the specimen *Howard* 7408 (K) of May 1920, from Mahabaleshwar under the name *C. lawii* was the first authentic and mature specimen of *C. panchganiensis*. Almeida (2001) treated *C. panchganiensis* as a variety of *C. lawii* which seems illogical. Recently Kamble and Yadav (2004), in their paper on Asclepiadaceae of Maharashtra inadvertently treated specimens from Harsishchandragadh as *C. panchganiensis*, which is actually *C. maharashtrensis* sp. nov. described in this paper. *Ceropegia panchganiensis* is allied to *C. maccannii* and *C. maharashtrensis* and differs from them in having various characters provided under the remarks of *C. maccannii* and *C. maharashtrensis. Ceropegia panchganiensis* is a Critically Endangered species (Mishra and Singh, 2001) having very narrow ecological amplitude distributed in the central part of north Western Ghats (Mahabaleshwar surroundings), which grows in the outskirts of semi-evergreen forests on the edges of cliffs at 1390 - 1400m. This species flowers from June to July (rarely in May). Restricted distribution, narrow range of tolerance and habitat destruction are the major threats of this species. This species requires immediate conservation considering the above threats.

Additional specimens examined : India, Mahabaleshwar, 4500ft., rainfall 250inch., May 1920, *W.H.K. Howard* 7408 (K) [Kew barcode number K000357816]; Satara, Mahabaleshwar, June 1956, *Irani* 2005 & 2007 (BLAT); *D.K. Mishra* 175412, 14 July 1996 (BSI); Kate's point, 12 June 2004, *S.A. Punekar* 355 & Hunter's point, 12 June 2003, 368, & 17 July 2006, 652 (All in MACSG).

Ceropegia rollae Hemadri, Bull. Bot. Surv. India 10: 123. 1969 (1968); Ansari & B. G. Kulk., Indian Forester 97: 689, t. 2. fig. B2. 1971; Ansari, Fasc. Fl. India 16: 29, opp. p. 27, t. 4, fig. 23. 1984; A.P. Jagtap & N. P. Singh, Fasc. Fl. India 24: 237. 1999; D. K. Mishra & N. P. Singh, Indian J. Forest. Addit. Ser. 9: 25. 2000 *et* Endem. & Threat. Fl. Pl. Maharashtra 148. 2001.

Type : India, Maharashtra, Dhak khilla, about 27 km west of Junnar, Poona District, 29 September 1965, *K. Hemadri* 107472 A (Holo : CAL; Iso : 107472 B-C in BSI, 107472 D in K, 107472 E in L, 107472 F in CAL; paratypes, Durga Khilla, about 30 km west of Junnar, Poona District, 1 October 1965, *K. Hemadri* 107547 C in CAL, 1077547 D in K). (**Figs.** 1, 4D, 5E, 6D, 7D).

A tuberous erect herb. Stem 30 - 100cm high, unbranched, fleshy, clothed with short coarse bulbous hairs. Leaves opposite, occasionally 3 at each node; petioles up to 1.5cm long; lamina broadly ovate, 2.5 - 6.0cm long, 2.0 - 4.0cm across, bulbous hairy above and along margins, glabrous below, base rounded, apex acute or shortly acuminate. Flowers in subumbellate cymes, axillary and terminal; peduncles hirsute, 1.0 - 2.0cm long; pedicels terete, 0.4 - 1cm long, hirsute. Calyx 5-partite; lobes linear-lanceolate, sparsely hairy, 3.0 - 5.0mm long. Corolla white, 2.3 - 2.5cm long; tube 1.5 - 2.5cm long, 3.0 - 4.0mm across at narrowest portion, glabrous and white outside, slightly inflated at base, inflated portion 5.0 - 8.0mm long, 4.0 - 6.0mm across, tube inside glabrous except for a conspicuous hyaline pubescence at its bottom, rest glabrous, dark purple in lower half; lobes linear-oblong, glabrous, 0.8 - 1.3cm long, 0.25cm across, connate at apex forming a ovoid or subglobose head. Corona bi-seriate, outer (gynostegial) corona saucer-shaped, up to 3mm across of 5 short, entire or notched lobes, ciliate; inner (staminal) corona 5, up to 3mm long, erect, linear with slightly recurved apices. Pollinarium erect, waxy with pellucid layer. Corpuscle up to 179µm long; head 59-72µm long, 86 - 90µm across, rounded at apex, uniformly wavy or not; stalk up to 134µm long, up to 24µm across. Caudicle up to 79µm long, up to 24µm across. Pollinia up to 293µm long, up to 124µm across, oblong-lanceolate. Follicles in pair, linear, terete, tapering at the ends, 4.5 - 6.0cm long, 0.2 - 0.3cm across. Seeds ovoid, comose.

Distribution and habitat : India: Maharashtra, Ahmednagar District (Harishchandragadh); Pune District (Dhak Killa, Durga Killa near Durga wadi, Malshej ghat). It is found in crevices of big basaltic boulders on exposed hilltops from 1200 - 1350m.

Remarks : This species is distributed in a small pocket in the borderline areas of Ahmednagar and Pune Districts growing in the crevices of big basaltic boulders on exposed hill tops. The altitude varies from 1200 - 1350m. It is quite interesting to note that the flowering of this species can extend up to late in September or early Octoberober. At that time most of the erect species of section *Buprestis* are in fruiting stage or perished. According to Huber the position of this species is slightly more intricate. Its erect stem and shape of the corolla designed it to belong to section *Buprestis* but when keyed out, this species seems to belong rather to section *Indopegia* Huber because of the rather conspicuous hyaline pubescence within the inflated part of the corolla tube. This apparently links to two sections together, a fact not particularly unexpected because section *Buprestis* has most likely evolved from section *Indopegia* (Hemadri, 1969). *Ceropegia rollae* is undoubtedly allied to *C. karulensis* and *C. sahyadrica* in having corolla white outside, tube purple in lower half inside, saucer-shaped outer corona and linear inner corona. *Ceropegia rollae* diifers from *C. sahyadrica* in having usually in terminal subumbellate cymes (vs. lateral), shorter corolla, 2.3 - 3.5cm long (vs. longer corolla, 3.5 - 5.5cm long), corolla lobes pure white inside and outside (vs. ash-grey coloured outside and pale orange to olive green inside), corolla tube slightly inflated at base (vs. largely inflated at base) and corolla lobes linear-oblong (vs. broadly ovate to obovate). *Ceropegia rollae* differs from *C. karulenis* in having many characters mentioned under *C. karulensis* in the remarks. This species is Critically Endangered having severely fragmented population. It needs immediate protection to avoid its total annihilation.

Additional specimens examined : India, Malabar Concan Regio, *Stocks* & *Law*, 24 *Ceropegia* (G); Maharashtra, Pune, Malshej ghat near Junnar, 3 September 1996, *D.K. Mishra* 175500 (BSI); Durga Killa, 4 October 2005, *S.A. Punekar* & *A. Raut* 580, same location, 19 August 2010, *S.A. Punekar* 701 (both in MACSG).

Ceropegia sahyadrica Ansari & B. G. Kulk., Indian Forester 97: 688, figs. 1-4. 1971; Ansari, Fasc. Fl. India 16: 29, opp. p. 27, t. 4, fig. 24. 1984, p.p.; A.P. Jagtap & N. P. Singh in Fasc. Fl. India 24: 238. 1999, p.p.; D. K. Mishra & N. P. Singh, Indian J. Forset. Addit. Ser. 9: 26. 2000 *et* Endem. & Threat. Fl. Pl. Maharashtra 149. 2001. *Ceropegia lawii* Hook. f., Fl. Brit. India 4: 67. 1883, p.p.; *sensu* T. Cooke, Fl. Pres. Bombay 2: 240. 1904 [2: 175. 1967 (Repr.)], p.p.; Santapau & Irani, Bull. Bot. Soc. Bengal 12: 8. 1958, p.p., *non* Hook. f., 1883. *C. panchganiensis sensu* Venkata Reddi, Willdenowia 5: 32. 1968; Hemadri, Bull. Bot. Surv. India 10: 125. 1969

(1968); M.R. Almeida, Fl. Maharashtra 3A: 233. 2001, p.p.; D. K. Mishra & N. P. Singh, *l.c.* 136, p.p., *non* Blatt. & McCann, 1933.

Type : India, Maharashtra, Ratnagiri, Ambolighat (presently in Sindhudurg District.), 30 August 1967, *B.G. Kulkarni* 108643A (Holo : CAL; Iso : 108643 B-C in BSI, 108643 D in CAL, 108643 E in K; para 106321 A-B in BSI, 102141 A-B in BSI). (**Figs.** 1, 4E-G, 5F-H, 6E-G, 7E-G).

A tuberous erect herb. Stem generally 1, occasionally 1-5 from same tuber, generally unbranched, rarely branched, 30 - 100cm high, pubescent. Leaves opposite; petioles 2.0 - 3.0cm long; lamina variable, lower broadly ovate, upper ovate-lanceolate, base rounded or cordate, apex acute, 4.0 - 11cm long, 2.0 - 8.0cm across, hispidulous on top, glabrous beneath; secondary nerves 4-5 pairs. Flowers in subumbellate cymes, axillary; peduncles densely hairy, 1.0 - 5.5cm long; pedicels terete, up to 2cm long, hairy. Calyx 5-partite; lobes 5.0 - 7.0mm long, glabrous, rarely hairy on midnerve. Corolla 3.5 - 5.5cm long; tube up to 4.4cm long, ash-coloured to white, straited externally, inside dark purple in lower ⅔part, minutely hairy at base of inflated part and white or ashy-grey in upper ⅓ part, glabrous, broadening upward to funnel shape; lobes up to 1.1cm long, up to 0.8cm across, internally pale-orange to olive-green in upper ¼ part only, the rest ash-grey coloured, ovate-cordate in shape, completely glabrous, connate at tips, forming an obovate or obconic head up to 1.7cm across in broadest part. Corona biseriate; outer (gynostegial) corona saucer-shaped, 1.5 - 1.75mm high, up to 3mm across, broadly or obtusely 5-lobed, creamy-yellow, hairy along the margins; inner (staminal) corona of 5 erect, linear, terete, yellow processes, 5.0 - 6.0mm long, slightly hairy near base, usually straight at apex, rarely recurved. Pollinarium erect, waxy with pellucid layer. Corpuscle 233 - 243µm long; head 91 - 109µm long, 100 - 109µm across, as long as broad or slightly broader than long, obtuse to rounded at apex; stalk 126 - 146µm long, 51 - 64µm across. Caudicle 104 - 113µm long, 23 - 39µm across. Pollinia 366 - 450µm long, 121 - 155µm across, linear-lanceolate or oblong. Follicles in pairs, up to 15cm long, 0.5cm across, terete, tapering at both ends. Seeds many, comose.

Distribution and habitat : India: Maharashtra - Nashik District (Anjaneri hills), Pune District (Ambavane-Sakharpathar, Khandala, Lonavala, Pabe ghat, Purandhar fort, Raireshwar, Rajgadh, Rajmachi killa, Sinhagadh, Torna fort), Ratnagiri District (Gothne plateau), Satara District (Rede ghat, Vasota fort), Sindhudurg District (Amboli ghat, Mahadevgad). It grows from 700 - 1450m among grasses on gentle hill slopes and also in the rock and boulder crevices on bouldered lateritic plateaus.

Remarks : The earliest known collection of this species happens to be in the form of fragment (2nd from the left side of the sheet) of specimen collected by Law & Stocks from Concan and mounted along with 3 other specimens of *Ceropegia* sp. on the sheet (of Hooker Herbarium at Kew), labelled "*Ceropegia* (24)" and identified as *C. lawii*. There is one more sheet at Kew collected by Stocks labelled "24 *Ceropegia*" and identified as *C. lawii*. The 1st specimen from the right side of the sheet is happens to be *C. sahyadrica*. It was Ansari and Kulkarni (1971) who have first identified this species as new often misconceived as *C. lawii* and *C. panchganiensis*. Recently, Almeida (2001) interpreted incorrectly the material from Amboli in Konkan as *C. lawii* and synonymised *C. sahyadrica* under the same. *Ceropegia sahyadrica* is allied to *C. karulensis* and *C. rollae* in having saucer-shaped outer corona and linear inner corona. For differences among these species refer to the remarks under *C. karulensis* and *C. rollae*. This species is having wider ecological amplitude (Nashik to Sindhudurg District) as compared to other erect species of section *Buprestis*. *Ceropegia sahyadrica* shows lot of variation especially in the shape of corolla, corolla head and corona structure. This polymorphic nature may be due to the habitat diversity and associated pollinators. The population of central and southern north Western Ghats (Satara, Ratnagiri and Sindhudurg Districts) differs from the population from northern area of north Western Ghats (Pune and Nashik District) in having ovate-lanceolate or elliptic leaves (vs. broadly ovate), corolla head more depressed (vs. obovate or obconic), smaller corona size, 3.5mm long (vs. 5mm long) and corona more or less ovate (vs. more or less elongate). Furthermore the inner corona hooked (Pabe ghat) or not hooked at tips (rest of the localities) shows that *C. sahyadrica* is still evolving. Flowering starts from late July to August. Although it shows profuse flowering, fruit setting is rare. Landslides and destruction of tubers by local cowherds are two major threats to the species which at present place this species in a Vulnerable category

(Mishra and Singh, 2001). Similarly failure of seed setting (probably failure of pollination in absence of pollinators) seems to be major reason for its rarity.

Additional specimens examined : India, Concan, *Law & Stocks Ceropegia* 24 (K) [Kew bar code no. K000357813], 2nd specimens from the left side of the sheet; Concan, *Stocks* 24 *Ceropegia* (K) [Kew bar code no. K000357814], 1st specimens from the right side of the sheet; India, Maharashtra, Sinhagadh ('Singhar'), 30 July 1902, *Garade* 57 A-C (BSI); Khandala, July 1919, *Blatter* & al., 27424 (BLAT); Ambavane-Sakharpathar, *Venkata Reddi* 98655, 98660, 98678, 99212 A (all in BSI); Raireshwar, 25 August 1957, *V.D. Vartak* 11084 (AHMA); Ambavane, Poona district, 10 September 1964, *Venkata Reddi* 99165 (BSI); Ratnagiri, without date, *Mistry* 1191 (BLAT); Nasik, Denache Deval, Anjaneri hill top, 27 July 1983, *P.L. Narasimhan* 162112 (BSI, K); Pune, Sinhagadh, 10 August 1997, *D.K. Mishra* 176975 (BSI); Sindhudurg, Amboli, Mahadevgad, 4 September 1997, *D.K. Mishra* 176912 (BSI); Pune District, Sinhagadh, 26 July 2004, *S.A. Punekar* 350 (MACSG); Pabe ghat, 28 July 2004, *S.A. Punekar* 352 (MACSG); Ratnagiri District, Gothane plateau, 1300m, 24 August 2005, *S.A. Punekar* 579 (MACSG).

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आकारिकी पेलिनोलॉजी तथा आणविक अध्ययन के आधार पर पुनरीक्षित सेरोपिजिआ की उध्व जातियाँ

सचिन ए पुनेकर, सुभादे ए तमहाकर, पी लक्ष्मीनरसिंह, के पी एन कुमारन, अजित एल राउत एवं एस के श्रीवास्तव

सारांश

आकारिकी पेलिनोलॉजी तथा आणविक अध्ययन के आधार पर पुनरीक्षित सेरोपिजिआ की उध्व जातियों के सार-संक्षेप (key) दिये गये हैं। दो नयी जातियां *सेरोपिजिआ केरुलेंसिस* एवं *सेरोपिजिया महाराष्ट्रोंसिस* के वर्णन किये गये हैं। क्रमबद्ध रूप से संदग्धि *सेरापिजिआ लाँवी* की स्थिति का समाधान किया गया हैं। आइ एस एस आर (ISSR) मार्करस के प्रयोग से उध्व जातियों के आणविक विश्लेषण में सेक्शन बुप्रेस्टिस के टेक्सा आउटग्रुप के रूप में प्रयुक्त सेक्शन *इंडोपेजिआ* की जातियों से भिन्न पाई गई। विभिन्न सेक्शन का प्रतिनिधित्व करने वाली सेरोपिजिआ के 20 भारतीय जातियों एवं उनके समवंशी के फायलोजेनेटिक विश्लेषण में परमाणुविक रायबोसोमल इंटर्नल ट्रांसक्राइब्ड स्पेसर (ITS) तथा ननकोडिंग क्लोरेप्लास्ट डी एन ए (cp DNA) सिक्वेंस सेक्शन इंडोपिजिआ के साथ सेक्शन बुप्रोस्टिस की उध्व जातियां एक पृथक क्लेड बनाती हुई दर्शाती है। यह सेक्शन बुप्रेस्टिस के सेक्शन इंडोपेजिआ से विकसित होने की हुबर की परिकल्पना (1975) का अनुसरण करता है।