Diversity and Ecology of *Dendrobium*s (Orchidaceae) in Chotanagpur Plateau, India

Pankaj Kumar[(1*)], Gopal Singh Rawat[(1)] and Howard Page Wood[(2)]

1. Department of Habitat Ecology, Wildlife Institute of India, Post Box # 18, Chandrabani, Dehradun – 248001, Uttarakhand, India.
2. 3300 Darby Road, C-802, Haverford, Philadelphia, PA 19041, USA.
** Corresponding author. Email: pankajsahani@rediffmail.com*

(Manuscript received 20 September 2010; accepted 17 November 2010)

ABSTRACT: As part of All India Coordinated Research Project on Taxonomy of orchids (AICOPTAX) Chotanagpur Plateau was surveyed extensively for documentation of orchid species and distribution during 2002 -2006. Sixty three species were collected from the study area with *Dendrobium* as one of the largest group of epiphytic orchids comprising of 11 species, namely, *Dendrobium aphyllum, D. bicameratum, D. cucullatum, D. crepidatum, D. formosum, D. fimbriatum, D. herbaceum, D. moschatum, D. peguanum, D. regium* and *D. transparens*. Most of the species were found in the Sal (*Shorea robusta*) dominated forests. Stratified Random Sampling was used for ecological studies in the forested regions on the plateau. Results show that *D. aphyllum* was the most common amongst 11 species and it was distributed through out the altitudinal gradient, whereas, rest of the orchid species were found to be localised at comparatively higher altitudes. *D. herbaceum* was always found on the upper areas of the plateaus between 900-1000 m asl. *D. crepidatum* was seen in both epiphytic as well as lithophytic conditions, whereas *D. moschatum* were found growing as lithophytes along the streams. Rest of the species were epithytic. The paper also deals with some microhabitat features governing the distribution of these orchids on the plateau along with their key for identification.

KEY WORDS: *Dendrobiums*, diversity, ecology, Chotanagpur Plateau, India.

INTRODUCTION

Orchids have been attracting botanists, naturalists and ecologists since a long time due to their incredible range of floral diversity and high economic value. Among orchids, *Dendrobium* Swartz is one of the largest epiphytic, occasionally lithophytic, genera of beautiful flowers comprising of about 1,100 species (Wood, 2006). The genus occurs in diverse habitats throughout much of south, east and southeast Asia, including Philippines, Borneo, Australia, New Guinea and New Zealand. The name is derived from the Greek '*dendron*' (meaning tree) and '*bios*' (meaning life). In India the genus is represented by 116 species (Misra, 2007). The characteristic features of *Dendrobium* is presence of mentum, a chin made up from the column foot, lip and lateral sepals and the absence of caudicle or viscidia in the polllinia.

An intensive survey was conducted as a part of "All India Coordinated Research Project on Taxonomy", funded by Ministry of Environment and Forests, Government of India, in different parts of Chotanagpur plateau coupled with ecological sampling. The main aim of study was to come up with a comprehensive account of orchids of the area as well as to suggest conservation measures for this group of valuable plants, by understanding their habitat preferences. Sixty three orchid species were recorded for the Plateau, including 11 species of *Dendrobium*s (Kumar et al., 2007).

Orchids are a group of rare plants and apart from being habitat specific (Linder, 1995), they have specialised pollinators (Darwin, 1862; Cozzolino and Widmer, 2005) as well as specific mycorrhizal associations (Taylor and Bruns, 1997; McCormick et al., 2004; Shefferson et al., 2007). Orchid seeds lack endosperm and involvement of fungi in seed germination is well known fact (Bernard 1909), but the specificity in orchid mycorrhizae has been controversial (Harley and Smith, 1983). Some studies shows that orchids are specific (Clements, 1987; Taylor and Bruns, 1997) or some shows they are generalist (Hadley, 1970; Smreciu and Currah, 1989; Masuhara and Katsuya, 1989, 1991; Masuhara et al., 1993; Rasmussen, 1995) in their mycorrhizal symbioses, whereas some states that the specificity is variable among species (Muir, 1989). This phenomenon of specialization make orchids diverse and rare (Gill, 1989; Shefferson et al., 2005; Otero and Flanagan, 2006). This specialization may increase the chance of extinction for those orchids most specialized to endangered or rare habitats (Shefferson et al., 2008). On the other hand mycorrhiza in turn is specific to the host and habitat type. Even host specificity is also very established fact in the epiphytic orchids (Went, 1940; Sanford, 1974). In many places through out the globe host tree specificity has been related to the host suitability of fungi involved in species-specific orchid mycorrhizal associations (Clements, 1987; Barnett and Beattie, 1986; Johansson, 1974; Sanford, 1974; Allen,

1959). The present study deals with the diversity of Dendrobiums in the Chotanagpur plateau along with their ecology, which includes their habitat and host specificity as well as macro habitat preferences.

STUDY AREA

Chotanagpur lies in Deccan province in the Indian Region of Paleotropic Kingdom (Takhtajan, 1978). It covers the administrative boundary of the state of Jharkhand. It occupies 2.4 % of India's geographic area, situated between 22º01' – 25º30' N latitudes and 83º30' – 87º52' E longitudes, with a total area of 79,714 km^2 of which 29.61 % is under forest cover (FSI 2005). Chotanagpur plateau being one of the oldest landmass on earth is phytogeographically very important region of Indian subcontinent. The Chotanagpur Plateau also has a flora and fauna that are distinct from the adjacent areas (Rodgers and Panwar, 1988), with several pockets of rare and endemic plants. In the geological past, this plateau formed a link between Satpura Hill Ranges and eastern Himalaya that allowed species exchanges between these ranges (Hora, 1949). Clarke (1898) and Haines (1921-24) have suggested that the higher hills of this region, *i.e.*, the Parasnath Hills (Giridih district) might have served in the past as stepping stone for the passage of plant species between the hills of Peninsular India and Eastern Himalaya. There are 3 major vegetation types reported from area, namely, Tropical Moist Deciduous Forests, Tropical Dry Deciduous Forests and Montane Subtropical Forests (Champion and Seth, 1968). No comprehensive study on Orchids has been done in this area in the past hence the current effort of Orchid survey is highly justified. (Fig. 1).

METHODOLOGY

Field Survey

Field surveys were conducted throughout the forested regions of the state, which were traversed on foot from 2002-2006 in different seasons. Effort was made to study plants in their flowering condition so as to identify them properly. Standard methods for collection and preservation were used following Jain and Rao (1977). Voucher specimens are deposited at WII. Flowers were preserved in alcohol and they were mounted on card sheets to study the morphological details. Herbariums and libraries at CAL, BHAG, DD, BSD, WII, RENZ and K were consulted for identification along with experts on orchids as well as the available local floristic works.

Ecology

Stratified Random Sampling was done in the forested habitats of the plateau (especially in the Sal forests) following Muller-Dombois and Ellenberg (1974) and various macro-habitat and micro-habitat features were recorded. Habitat types were categorised using Important Value Index (IVI) values (Curtis and McIntosh, 1951) of the tree species and the distribution of *Dendrobium* species were recorded in these habitats. Flowering phenology was studied on the basis of observations of their flowering period. Box plots of altitude and %canopy cover were used to study the habitat heterogeneity across habitats (Tukey, 1989). Canonical Correspondence Analysis (Ludwig and Reynolds, 1988; Ter Braak, 1986, 1987) was used to study the effects of microhabitat features on the distribution of the *Dendrobium* species.

RESULTS

Taxonomic studies

Dendrobium Swartz belongs to, subfamily: Epidendroideae; tribe: Dendrobieae and subtribe: Dendrobiinae. Eleven species of *Dendrobium* were recorded from the Chotanagpur plateau, namely, *Dendrobium aphyllum* (Roxb.) C.E.C.Fisch., *D. bicameratum* Lindl., *D. crepidatum* Lindl. *et* Paxton, *D. cucullatum* R. Br., *D. fimbriatum* Hook., *D. formosum* Roxb. *ex* Lindl., *D. herbaceum* Lindl., *D. moschatum* (Buch.-Ham.) Sw., *D. peguanum* Lindl., *D. regium* Prain and *D. transparens* Wall. *ex* Lindl.. Out of these, 6 species, namely, *D. cucullatum*, *D. fimbriatum*, *D. moschatum*, *D. peguanum* and *D. transparens* are new record for Chotanagpur Plateau. Earlier records of these 5 species were from the areas adjacent to the plateau. *D. bicameratum* and *D. regium* were included on the authority of *Biswas 2180*, Parasnath Hills, Jharkhand (CAL) and *Cardon sine no.* (*CAL 451396*, probably from West Singhbhum district), respectively. Most of the species were found in epiphytic condition, except *D. moschatum* which were lithophytic and *D. herbaceum* and *D. crepidatum* were occasionally found in lithophytic condition. (Figs. 2-7)

Key to the identification of species of *Dendrobium*s in Chotanagpur Plateau:

1a. Inflorescence terminal or sub terminal ……..... 2
1b. Inflorescence terminal ……...…… 6
2a. Stem short and ovoid ….....…. *D. peguanum* (DPEG)
2b. Stem elongated ……..…. 3
3a. Stem branched ……... *D. herbaceum* (DHER)
3b. Stem unbranched ……..…… 4
4a. Stem pubescent with brown-black hairs …… *D. formosum* (DFOR)
4b. Stem glabrous ……..…….. 5
5a. Leaves with pointed apex ……..….. *D. fimbriatum* (DFIM)
5b. Leaves with rounded apex …..…….....*D. moschatum* (DMOS)
6a. Mentum urceolate ……..… *D. bicameratum* (DBIC)
6b. Mentum conic …… 7
7a. Petals lanceolate, as narrow as sepals …… 8
7b. Petals broad ……..….. 9

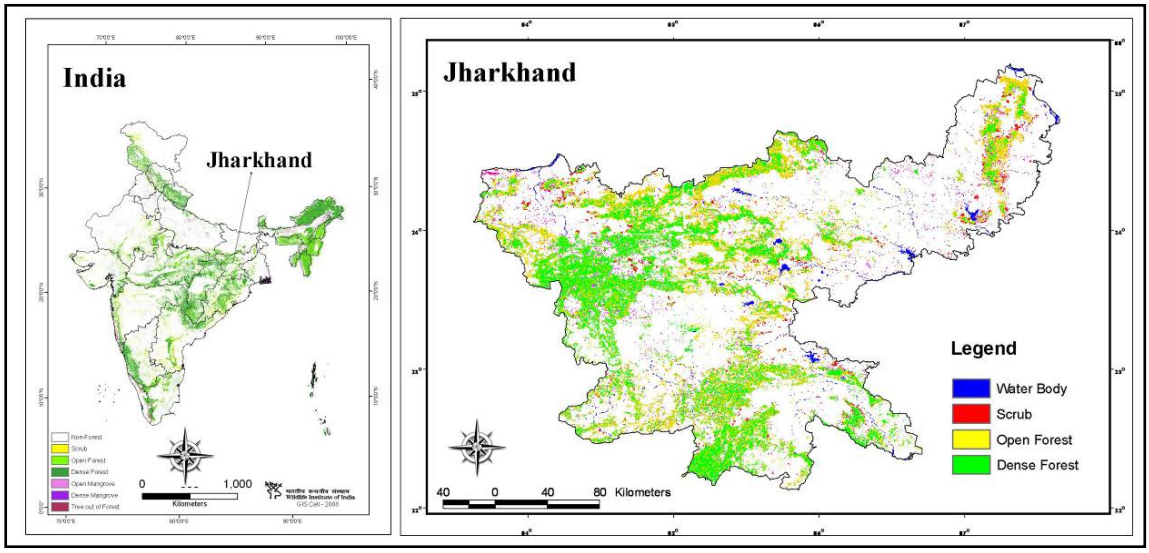

Fig. 1. Map of Jharkhand (Chotanagpur plateau).

Fig. 2. Flowers. 1: *D. formosum*. 2: *D. bicameratum*. 3: *D. crepidatum*. 4: *D. cucullatum*. 5: *D. regium*. 6: *D. fimbriatum*. 7: *D. moschatum*. 8: *D. peguanum*. 9: *D. transparens*. 10: *D. aphyllum*. 11: *D. herbaceum*. (3 - photo courtesy: - Dr. H. P. Wood; 5 - Misra, 2004).

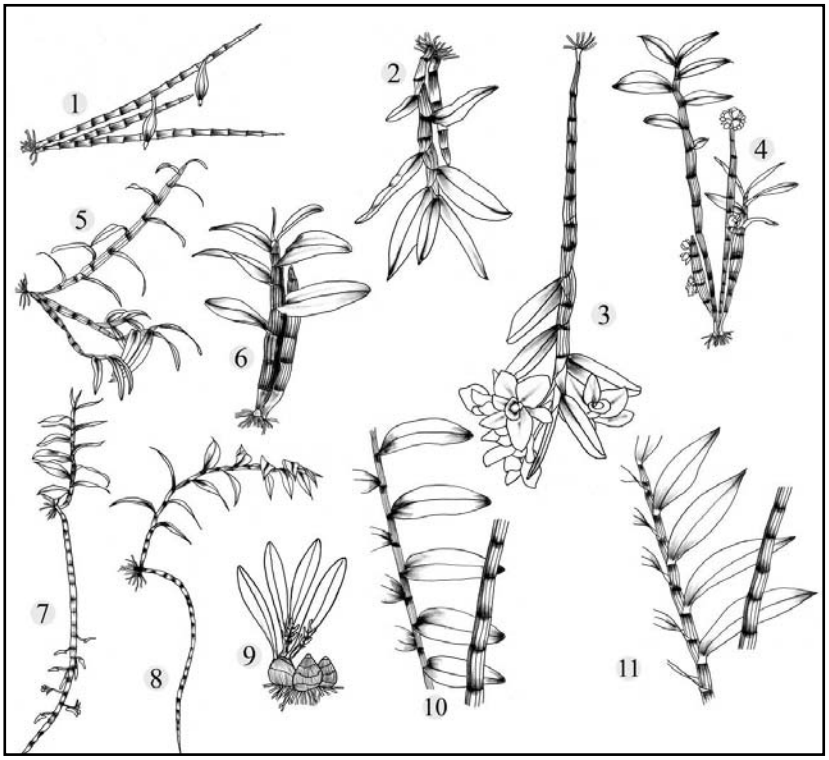

Fig. 3. Habit. 1: *D. transparens*. 2: *D. crepidatum*. 3: *D. regium*. 4: *D. bicameratum*. 5: *D. herbaceum*. 6: D. *formosum*. 7: *D. aphyllum*. 8: *D. cucullatum*. 9: *D. peguanum*. 10: *D. moschatum*. 11: *D. fimbriatum*. (3 – Misra, 2004; 4 – King and Pantling, 1898).

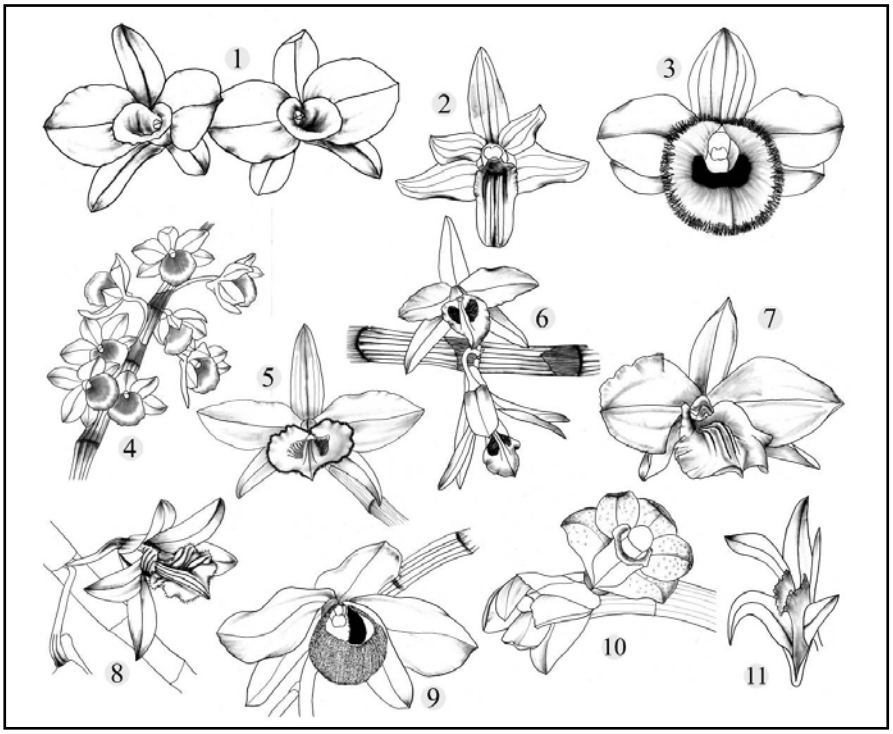

Fig. 4. Flower. 1: *D. regium*. 2; *D. herbaceum*. 3: *D. fimbriatum*. 4: *D. crepidatum*. 5: *D. cucullatum*. 6: *D. transparens*. 7: D. *formosum*. 8: *D. aphyllum*. 9: *D. moschatum*. 10: *D. bicameratum*. 11: *D. peguanum*. (1 – Misra, 2004; 4 – Cogniaux and Goossens, 1906; 9 – A. Müller *sine no.*, Acc. No. 1070800 RENZ).

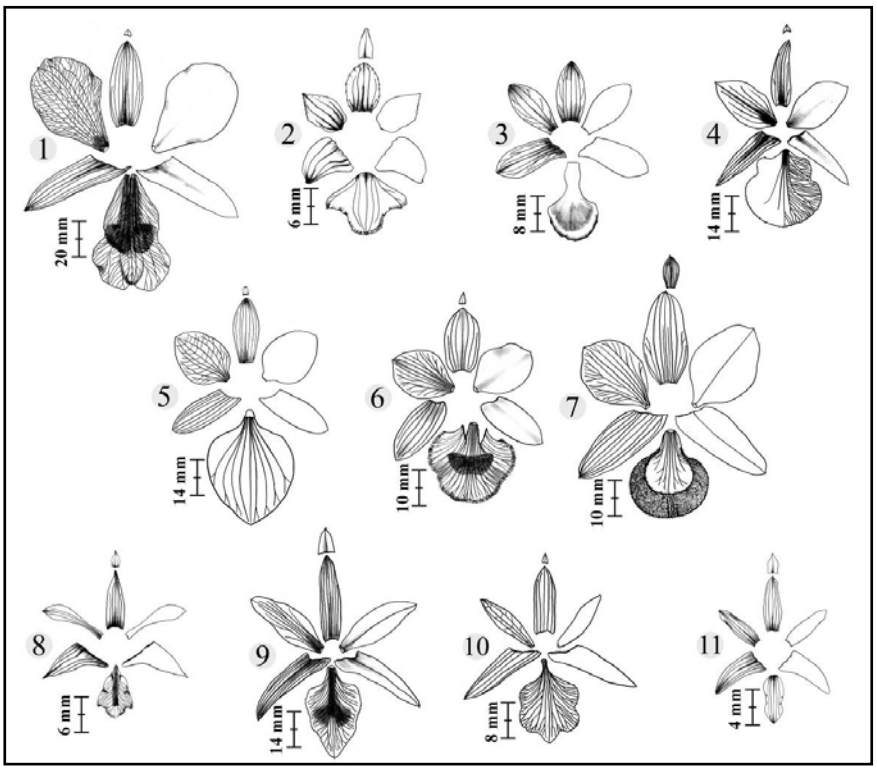

Fig. 5. Dissected Flower. 1: *D. formosum*. 2: *D. bicameratum*. 3: *D. crepidatum*. 4: *D. cucullatum*. 5: *D. regium*. 6: *D. fimbriatum*. 7: *D. moschatum*. 8: *D. peguanum*. 9: *D. transparens*. 10: *D. aphyllum*. 11: *D. herbaceum*. (3, 5, 8 & 11 – modified from Misra, 2004).

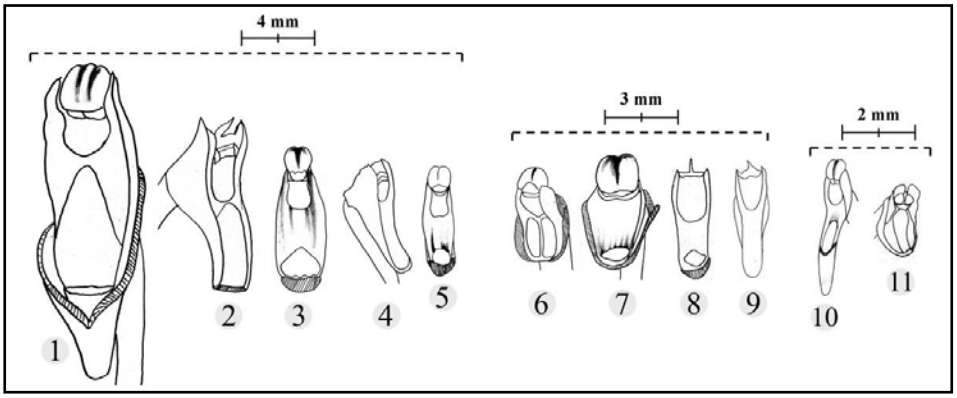

Fig. 6. Gynostemium. 1: *D. formosum*. 2: *D. regium*. 3: *D. moschatum*. 4: *D. transparens*. 5: *D. cucullatum*. 6: *D. bicameratum*. 7: *D. crepidatum*. 8: *D. fimbriatum*. 9: *D. aphyllum*. 10: *D. peguanum*. 11: *D. herbaceum* (1, 6, 7 & 10 – King and Pantling, 1898; 2, 4, 9 & 11 – Misra, 2004).

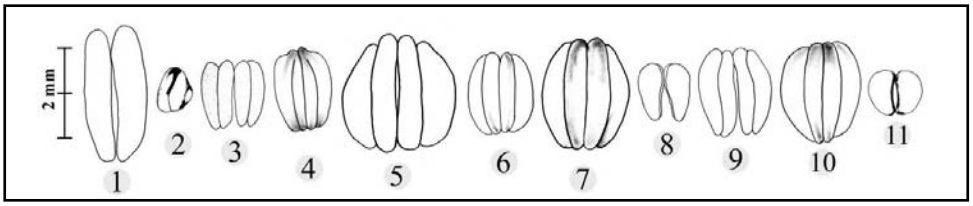

Fig. 7. Pollinia. 1: *D. formosum*. 2: *D. bicameratum*. 3: *D. crepidatum*. 4: *D. cucullatum*. 5: *D. regium*. 6: *D. fimbriatum*. 7: *D. moschatum*. 8: *D. peguanum*. 9: *D. transparens*. 10: *D. aphyllum*. 11: *D. herbaceum*. (1, 3, 5, 8, 9 & 11 – Misra, 2004)

8a. Petals and sepals green to greenish yellow .. *D. cucullatum* (DCUC)
8b. Petals and sepals pink ……...… *D. aphyllum* (DAPH)
9a. Flowers large (3-3.5 inch) …...……...…… *D. regium* (DREG)
9b. Flowers small (1-2 inch) …….. 10
10a. Stem erect, lip panduriform ……...… *D. transparens* DTRA)
10b. Stem drooping, lip orbicular ……..… *D. crepidatum* (DCRE)

TAXOMONIC TREATMENTS

Dendrobium aphyllum **(**Roxb.) C.E.C.Fisch. in Gamble, Fl. Pres, Madras, 8: 1416 (1928).

Limodorum aphyllum Roxb., Pl. Coromandel 1: 34 (1795).
Dendrobium macrostachyum Lindl. in Gen. *et* Sp. Orchid. Pl. 78 (1830).

Type: Sri Lanka, Sine. loc., *Macrae 1829*, K!. Iconotype: '*Limnodorum aphyllu*m' *Roxburgh* 241 (CAL, K).

Plants are epiphytic. Pseudobulbs 30-60cm high, slender, pendulous. Leaves sessile, up to 8cm, subfalcate ovate-lanceolate, subacuminate, thick, caducous. Inflorescence solitary or in cymes, peduncle solitary or in pair from the nodes of the leafless stem. Flowers not much spreading lemon green, inodorous. Bracts oblong-truncate. Sepals and petals subequal, acuminate with reflexed tips, pale greenish-yellow. Lip convolute throughout the length, edges fimbricate-serrate except towards the base and its wavy apex, yellowish with reddish-purple veins.

Flowering: May – July; Fruiting*:* August – November.

Taxonomic notes: This plant with green flowers has been long treated as *Dendrobium macrostachyum* by various authors, until Christenson and Wood (2003) resolved the mystery of its identification. Later Wood (2006) followed this name for the particular species providing. On the other hand Wood (2006) called the plant with pink flowers as *Dendrobium cucullatum*.

Ecological notes: This is one of the most common Dendrobiums in the study area growing above 400m.

Distribution: India, Nepal and Sri Lanka.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (021039, 031043, 051055).

Dendrobium bicameratum Lindl. in Edw. Bot. Reg. 25: 85, misc. 52, (1839); Hook.*f*., Fl. Brit. India 5: 729, (1890)..

Callista bicamerata (Lindl.) Kuntze, Revis. Gen. Pl. 2: 654 (1891).

Type: North India, icon. *Gibson* (Holotype: K-Lindley).

Epiphytic. Pseudobulbs clavate, fusiform, erect. Leaves elliptic-oblong, to elliptic-lanceolate, up to 6cm long, apex bifid. Inflorescence capitate raceme arising from the apex of the pseudobulb. Flowers fleshy, densely crowded, on a short rachis, either lateral or subterminal. Bracts shorter than the ovary, sheathing. Sepals unequal, concave, yellow, dorsal sepal ovate-lanceolate. Petals ovate-lanceolate, caducous the sepals, yellowish with purple spots and strips. Lip small, fleshy, concave, triangular, 3-lobed, side-lobe small, erect, triangular, mid-lobe very short, truncate, oval, acute; disc with cushion shaped callus, Column foot biloculate.

Flowering: August; Fruiting: November – May.

Taxonomic notes: This plant has been added in the present work on the authority of Flora of British India where this plant has been reported from Parasnath Hills. Parasnath hill is a huge area and presently due to insurgency it was not possible for me to do a thorough survey in this area. CAL also has another material of this plant collected from Parasnath by K. Biswas (2180) dated 25.10.1934 from 6000 feet, under his work on Flora of Bengal and Borders.

Distribution: India, Nepal and Mayanmar; in Jharkhand: GIRIDIH – Parasnath Hills.

Other specimens examined: CAL: *K. Biswas* 2180, Parasnath Hills, Jharkhand. DD: *Mackinnon* 21744, Mussorie, Uttarakhand.

Dendrobium crepidatum Lindl. *et* Paxton, Paxton's Fl. Gard. 1: 63 (1850); Hook.*f*., Fl. Brit. India 5: 740, (1890).

Callista crepidata (Lindl. *et* Paxton) Kuntze, Revis. Gen. Pl. 2: 654 (1891).

Type: India, cult. P. Basset, icon. *Basset* (Holotype: K – Lindley).

Epiphytic. Pseudobulbs short, pendulous, greenish, covered with thin scarious sheaths of fallen leaves, up to 30cm long. Leaves oblong-lanceolate, acute, entire, many-nerved. Flowers white tinged with lilac, waxy, in pairs from the nodes of the apical part of pseudobulbs, pedicel purple. Bracts minute, scarious. Sepals subequal, oblong, obtuse tinged with lilac. Petals broadly oblong, spreading, tinged with lilac. Lip simple, shortly clawed, broadly obovate, base with incurved sides, glandular-papillose above and beneath, margins weakly undulate, entire, white with a large yellow blotch.

Flowering: February – April; Fruiting: May – January.

Ecological notes: Scarse. During present investigation it was encountered only thrice. Once it was found occurring on the rocks near the stream along with *Dendrobium moschatum* whereas twice it was found growing as epiphyte.

Distribution: India, China, Nepal, Bhutan, Myanmar and Thailand.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (021074, 041193 and 051045).

Dendrobium cucullatum R.Br. in Bot. Reg. 7: t. 548 (1821, also 21: t. 1756 (1835).

Dendrobium pierardii Roxb. ex Hook., Exot. Fl. 1: t. 9 (1822).

Type: Could not be traced.

Eptipytic with prominent rhizome. Pseudobulbs 60-120 cm long, pendulous, cmpressed, leafy. Leaves lanceolate, ovate-lanceolate, acuminate. Flowers fascicles of 1-3, from the swollen nodes, pale-rose, lip yellow. Sepals subequal, oblong-lanceolate, subacute. Petals much broader than sepals, elliptic, rounded, sepals and petals rose-coloured. Lip shortly clawed, broadly suborbicular, margin erose basally becoming ciliate towards apex, pubescent, convolute over the column. Stigma simple, rostellum short, obtuse. Anther subglobose, 2-loculed; pollinia 4 in two pairs.

Flowering: February – April; Fruiting: June – October.

Taxonomic notes: See under *Dendrobium aphyllum*.

Ecological note: A rare species in Jharkhand. Current authors have encountered only two individual bunches growing on avenue trees (*Ficus religiosa and Mangifera indica*) in Ranchi and Gumla district respectively.

Distribution in World: India, Nepal, Bhutan, China, Myanmar, Laos, Thailand, Malaysia, Vietnam and Laos.

Specimens examined: Chotanagpur plateau - *Pankaj Kumar* 021092 (Tatisilwai), *Pankaj Kumar* 031011 (Bansdih).

Dendrobium fimbriatum Hook., Exot. Fl. 1 (5): t. 71 (1823); Hook.*f*., Fl. Brit. India 5: 745, (1890).

Callista fimbriata (Hook.) Kuntze, Revis. Gen. Pl. 2: 653 (1891).

Type: Nepal, s*ine loc*. *N.Wallich 2011*, K-Lindley.

Plant epiphytic, upto 1m long or more. Stem erect, arching to pendent, tapering at each end, jointed, swollen at the base, many leaved; internodes sheathed. Leaves oblong-lanceolate, acute to acuminate, many veined, deciduous, sessile, joined with internode sheath. Inflorescence lateral, arising from nodes, penduluous, 6-15 flowered; pedunle sheathed at the base, 3 cm long. Floral bracts triangular. Flowers fragrant, 4-5.5cm across; petals and sepals light orange yellow, lip deep orange yellow, often with dark maroon blotch on the disc; pedicel and ovary slender. Dorsal sepal oblong-elliptic obtuse to acute; lateral sepals obliquely ovate, adnate at the base forming mentum; mentum short, saccate. Petals suborbicular to oblong-elliptic, rounded, shortly clawed. Lip shortly clawed, suborbicular, densely pubescent, margins plumose-fimbriate. Column 2-3mm long. Fruit ovoid.

Flowering: May – June; Fruiting: July.

Taxonomic notes: Deva and Naithani (1986) and Jalal (2005) designates this species as a synonym of *Dendrobium normale* Falc.. Former has also provided a long note on the confusion on his species due to its abnormal flowers. But we think even on the basis of the priority of publication the name *D. fimbriatum* Hook. should have been accepted. Pearce and Cribb (2002) accepts *D. fimbriatum* and designates *D. normale* as a synonym which current author has followed.

Distribution: India, Nepal, Mayanmar, China, Thailand, Laos, Vietnam and Malaysia.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* 051085

Dendrobium formosum Roxb. *ex* Lindl. in Wall., Pl. As. Rar. 1(2): 24, t. 29 (1830); [Wall. Num. List No. 1998 (1829), *nom. nud.*]; Roxburgh [Hort. Beng.: 63 (1814), *nom. nud.*] Fl. Ind. 3: 485, (1832); Hook.*f*., Fl. Brit. India 5: 721, (1890).

Callista formosa (Roxb. *ex* Lindl.) Kuntze, Revis. Gen. Pl. 2: 654 (1891).

Type: Bangladesh, *Syllet. M. R. Smith s.n.* (Holotype: BM).

Plant epiphytic. Stems terete, thick, ridged, erect (pointed upwards), woody, sheathed, swollen at the base tapering towards tip; internodes black pilose; sheaths black-pilose. Leaves oblong, obliquely subacute, emarginated, sessile, distichous 2-2.9 × 0.5-0.9cm. Inflorescence towards the tip 3 to 4 flowered; peduncle sheathed, 4.3-4.5cm long; sheaths funnel shaped, prominently veined; floral bracts ovate, obtuse, 1.1-1.2 × 0.2-0.4cm. Flowers fragrant, 5-9cm across, white, lip with large central yellowish-orange blotch; pedicel and ovary 3.5-5cm long. Dorsal sepal lanceolate, acute to acuminate, finely reticulate; lateral sepals oblong-lanceolate, subacute, adnate at base; mentum conical, 0.8-1cm long. Petals suborbicular, cuspidate, finely reticulate, margins undulate. Lip 3-lobed, obcuneate to broadly obovate, shortly clawed at base, 5.5-7.6 × 3.5-5cm; lateral lobes small, subtraingular; midlobe obscurely 2 lobed, emarginated to minutely mucronate, surface tuberculate especially along veins, margins undulate; disc 2-lamellate, tuiberculate- papillose centrally. Column broad, 1.3-1.9 cm × 0.6-1.1cm; foot short, 0.9-0.45-0.6cm. Fruit broadly ovoid.

Flowering: June – July; Fruiting: August – April.

Ecological notes: Not so commonly found in some isolated patches in dense forested areas on *Shorea robusta*.

Distribution: India, Nepal, Bhutan, Bangladesh, Thailand, Vietnam and Myanmar.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (051048, 051054, 051072, 051082, 051121).

Dendrobium herbaceum Lindl. in Edward's Bot. Reg. Misc. 69, (1840); Hook.*f*., Fl. Brit. India 5: 719, (1890).

Callista herbacea (Lindl.) Kuntze, Revis. Gen. Pl. 2: 654 (1891).

Type: East Indies, *sine loc*. Imported by *Ms. Loddiges s.n.* CAL.

Plant epiphytic, rarely lithophytic. Stems caespitose, erect, branched, elongated, fusiform, slightly swollen, yellowish or dark brown to black, ridged and furrowed. Leaves alternate, distichous, sessile, linear-lanceolate, subacute. Inflorescence condensed racemes, towards the tips, rarely lateral on nodes, 1-4 flowered; peduncle 5-10mm long, slender, greenish, sheathed at the base; sheaths oblong, subacute, transluscent, , base brownish. Flowers 10 × 8mm, greenish white, inodorous. Bracts aumamplexicaul, membranous, persistent, brownish, white oblong lanceolate, acuminate. Pedicel with ovary 10mm long, pale green. Sepals subequal, 5-veined; dorsal sepal oblong-lanceolate or ovate lanceolate; lateral sepal obliquely oblong-lanceolate, rounded, sometimes falcate. Petals elliptic oblong. Lip reflexed at the base, ovate-lanceolate, constricted below the middle, obscurely 3-lobed; lateral lobes narrow, obsolete, slightly turned upward along the margin; mid lobe greenish white, ovate, obtuse. Column 2mm long greenish white, lateral arms produced above into broad undulate wings, with a slit at the back. Foot 2mm long curved, pale green. Stigma deep seated, rounded; rostellum white, narrowly and transversely oblong, apex upturned. Anther transluscent-white, ovate; pollinia pale yellow, obliquely ovoid. Capsule clavate-fusiform, strongly ribbed, tapering at the base into a long pedicel.

Flowering: February – March; Fruiting: April – October.

Taxonomic notes: Misra (2004) claims that the variation in the lip, from different biotypes, may be used to classify some subspecies. However he did not designate any himself. All my specimens from different localities of Jharkhand seem similar, hence Orissa specimens needs further study.

Ecological notes: This orchid is restricted to the higher plateaues at around 1000m or above and never reported from below this altitude. Current author has seen one plant in Gumla growing at around 600m on step slope on *Mangifera indica*.

Distribution in World: Misra (2004) reports it to be endemic to India but Kew's website on world's checklist of monocotyledons (Goaverts 20003) reports its occurrence in Bangladesh.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (21060, 021071, 031010, 031014, 031019, 041010, 041081, 051046).

Dendrobium moschatum (Buch.-Ham.) Sw. in Schrad. Neues Journ. Bot. 1: 94. (1805); King *et* Pantl.: Orch. Sik. Him.: 60, t. 84 (1898).

Epidendrum moschatum Buch.-Ham. in M.Symes, Embassy, ed. 2, 3: 315 (1800).

Type: Myanmar, Ava. *Buchanan-Hamilton s.n.* BM

Plant epiphytic upto 150 cm high. Pseudobulbs stout, tufted. Leaves alternate, ovate to lanceolate, acute or faintly notched. Inflorescence from the apex of leafy or leafless pseudobulb, 8-16-flowered. Flowers fragrant, pale to pinkish-yellow. Sepals broadly ovate, obtuse. Petals larger than sepals, broadly ovate, obtuse. Lip shorter than petals, forming a globular or pear-shaped pouch, margins incurved, globose to entire, margins pilose, base with two dark maroon blotches. Column broad with a foot 4-7mm long. Fruit ovoid-pyriform, crenately ridged.

Flowering: May – June; Fruiting: July – April.

Ecological notes: This plant grows on rocks along streams courses. During the present survey this species could be found at only one locality where is grows on rocks near a stream. Though there are good numbers of individuals at that particular spot but it is restricted to that particular place.

Distribution: India. Nepal, Bhutan, Bangladesh, China, Laos, Myanmar, Thailand, Laos and Vietnam.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (021073, 041192, 051044).

Dendrobium peguanum Lindl. in J. Proc. Linn. Soc. 3: 19 (1859); Pearce *et* Cribb, Orch. Bhutan, 420 (2002); Misra, Orch. Ori.: 431 (2004).

Type: Myanmar (Burma), Pegu. *McLelland s.n.* (Syntype: K-Lindley).

Plant epiphytic, short, tufted, 3-3.5cm tall. Pseudobulbs globose, getting wrinkled with age, sheathed bearing 2-4 terminal leaves; sheaths membraneous, veined, ovate, subacute. Leaves linear-oblong, subacute, sessile, caducous, coriaceous, rugose, 5-6.5 × 0.3-0.4 cm. Inflorescence terminal on leafless stem, upto 15 flowered; peduncle shortly attenuate, sheathed, 3-5mm long; sheaths membranous, overlapping, lanceolate, 3-5mm; rachis ridged,; floral bracts lanceolate acute to acuminate, membranous. Flowers fragrant, 1-1.5cm across, white, lip pale brown, vein with dark brown to purple, anterior lobe purple. Pedicel and ovary glabrous. Dorsal sepal oblong-lanceolate, acute, 3-veined, erect; lateral sepals onlong-lanceolate, acute, falcate, decurved; mentum spur like. Petals oblanceolate, falcate, subacute, 1-veined. Lip 3-lobed, obovate-deltoid, shortly clawed, decurved; lateral lobes narrow, subacute, entire; midlobe broadly triangular, margins crisped-undulate; disc with a broad fleshy ridge, emarginate towards apex. Column broad; foot long, straight; anther cap margins minutely toothed. Fruits globose, turning yellow when ripe.

Flowering: December – February Fruiting: Fruits dehiscing during the rain.

Ecological notes: Found at a single locality in Jharkhand. It had been reported form Santhal parganas, but it could not be located at any place there during

present work. It grows on large number of hosts in the locality in Simdega, such as *Haldina cordifolia*, *Shorea robusta*, *Mangifera indica*, *Terminalia alata* and *Madhuca longifolia*..

Distribution: India, Nepal, Myanmar, Thailand and Indonesia.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (021045, 031002, 041068).

Dendrobium regium Prain. in Journ. As. Soc. Bengal 71 (1): 80 (1902).

Type: India, Jharkhand, Chhota Nagpur plateau *sine loc.* or Chattisgarh, Surguja *sine loc.* ('In Provinces Hindustaniae inferioribus'). *D. Prain s.n.*

Description quoted from Misra (2004): Stem tufted, 30-45 cm long, 15-18 mm thick, somewhat compressed, narrowed at the base, slightly swollen at the end; internodes 25-35 mm striated, thickened at the nodes; roots ca 2 mm thick, greenish white. Leaves on the upper half of the stem,, alternate, distichous, onlong, sub obtuse, apex obliquely notched, slightly narrowed at the base. Inflorescence 1-2, subterminal, subracemose on a short, peduncle from the leafy or leafless stems with 2-4 flowers. Bracts imbricating, scarious, oblong, ca 6 mm long, persistent. Pedicel with ovary 55-60 × 3 mm, suberect; ovary white, ridged and furrowed. Flowers 75-90 mm across, inodorous, perianth spreading, fleshy; tepals magenta, deeper along the veinsand the transverse veinlets, 7-veined. Sepals subequal, oblong-elliptic, rounded; dorsal ca 42 × 17 mm, laterals ca 50 × 19 mm, mentum short, conical, blunt. Petals much broader, ovatem obtuse ca 46 × 32mm, base shortly clawed. Lip broadly ovatem obtusem shortly clawed, ca 43 × 33 mm, basal one-third convolute, dialated above, margins recurved, 5-veined; lower half light yellow, deeper towards the base, upper half magenta. Column ca 7 × 5.5 mm light green, lateral arms winged, reducing the tip, deeply and obliquely emarginate above; foot ca 11 × 3 mm, slightly decurved, light green with a long, oblong, dark purple blotch in the base within. Stigma deep seated, oblong, ca 4.5 × 2 mm, obliquely oblong, outer ones shorter and thicker. Capsules drooping, ca 50 × 30 mm, robust, obvoid, with a broad, oblique thickening on top.

This plant has been included in the present work on the authority of Dr. T. K. Ghosh who claims that he has seen this species in Jharkhand in Saranda forests (pers. comm.) and Dr. S. Misra who owns live specimens from Orissa and Andhra Pradesh of this species and on the basis of herbarium specimen collected by Cardon, which is a holotype, present at CAL. It is assumed to be collected from Chotanagpur but the locality is doubtful.

Flowering: April – July; Fruiting: August – March.

Distribution: Endemic to India; Jharkhand, Chhattisgarh and Orissa.

Dendrobium transparens Wall. *ex* Lindl., Gen. Sp. Orchid. Pl.: 79 (1830); Hook.*f.*, Fl. Brit. India 5: 738. (1890); King *et* Pantl., Orch. Sik. Him., 50, t. 70, 1989; Prain, Bengal Pl.: 1009, (1903); Haines, Bot. Bih. and Ori. 1174 (1921 - 24) [Repr. ed., 3: 1226, (1961)]; Mooney, Sup. Bot. Bih. and Ori.: 213, (1950); Tiwari *et* Maheshwari, Orch. Madh. Pra., 431, (1963); Ghosh, Stud. Fl. Ranc. Dist. 2: 715, (1971); Pearce *et* Cribb, Orch. Bhutan, 414 (2002); Misra, Orch. Ori., 439 (2004).

Type: Nepal, *sine loc. N. Wallich* Num. List No. 2008 (K).

Plants epiphytic. Pseudobulbs slender, up to 50cm long, slightly thickend at nodes, ash-coloured or dark brown some times in young condition bright green, turns yellow with age, horizontally erect. Leaves linear-lanceolate, apex oblique and acute. Penduncle arise from the older leafless pseudobulbs. Flowers two to three, fragrant, white, tinged purplish-rose towards tip. Bracts broadly lanceolate. Sepals lanceolate, acute, tinged with purple at tips. Petals ovate, acute. Lip clawed, broadly elliptic-obovate to saggitate when spread, obscurely 3-lobed; lateral lobes broad, erose, rolled over the column; midlobe suborbicular, margins undulate, pubescent on the upper surface. Column with two horn like stelidia at apex. Fruit stalked, ovoid.

Flowering: April – June; Fruiting: July – August

Distribution: India, Nepal, Bhutan, Bangladesh and Myanmar.

Specimens examined: Chotanagpur Plateau - *Pankaj Kumar* (021068, 021072, 031015, 041012, 041080, 041191, 051049, 051073).

ECOLOGICAL STUDIES

Habitat Categories

On the basis of IVI, 5 different habitat types (Table 1) were categorised, namely, Pure *Shorea* (SP), *Shorea* dominated (SD), *Shorea –Terminalia alata* (SA), *Shorea -Madhuca* (SM) and *Shorea – Diospyros* (SK). The IVI value of *Shorea* for these 5 habitats have been given in Table 1. Apart from these, four more habitats were recognized for orchids in the study area, namely, Rocks and Boulders (RB), Avenue Trees (AV), Mixed Forests (MF) and Grasslands (GR).

Shorea dominated forest habitats harbored maximum number of (7 species) *Dendrobium* spp. whereas least number of *Dendrobium* spp, *i.e.*, 2 species were found in *Shorea – Diospyros* habitat. No epiphytic orchids including *Dendrobium* were found in *Shorea – T. alata* forests. *D. herbaceum* (SD, SK, SM and RB) and *D. aphyllum* (SD, SK, SM and AV) were found in four different forested habitats, whereas *D. fimbriatum*, D. *regium* and *D. cucullatum* were restricted to a single habitat (Table 2).

Table 1. Categorization of Forested Habitats based on IVI of trees

	Pure Sal	Sal Dominated	*Shorea - Diospyros*	*Shorea - T. alata*	*Shorea - Madhuca*
IVI (of Sal)	300	>155	138	192	163
Tree Density (per ha)	284.5	591.8	609.23	305.31	254.77
Average Canopy Cover (%)	72.58	64.88	68.38	69.79	79.16

Table 2. Distribution of *Dendrobium* spp. across different forested habitats

Habitats	*Dendrobium* Species									Total no. of *Dendrobiums*
	DCRE	DFIM	DFOR	DHER	DAPH	DMOS	DTRA	DREG	DAPH	
SD	+	-	+	+	+	+	+	+	-	7
SK	-	-	-	+	+	-	-	-	-	2
SM	-	+	+	+	+	-	-	-	-	4
SP	-	-	+	-	-	-	+	-	-	2
AV	-	-	-	-	+	-	+	-	+	3
RB	+	-	-	+	-	+	-	-	-	3
Total no. of Habitats	2	1	3	4	4	2	3	1	1	

Table 3. Flowering phenology of *Dendrobium* spp.

No.	Species	SEASONS													
				SUM			MONSOON								WIN
							PRE-MON		EAR		MID		LATE		
		JAN	FEB	MAR	APR	MAY1	MAY2	JUN1	JUN2	JUL	AUG	SEP	OCT	NOV	DEC
1	DCUC														
2	DCRE														
3	DHER														
4	DFIM														
5	DAPH														
6	DMOS														
7	DREG														
8	DTRA														
9	DFOR														
10	DBIC														
11	DPEG														

[SUM: Summer, PRE-MON: Pre-monsoon, EAR: Early Monsoon, MID: Mid-monsoon, LATE: Late Monsoon, WIN: Winter]

Flowering phenology

On the basis of flowering phenology, Dendrobiums of Chotanagpur plateau have been categorized into different phenological groups. *D. cucullatum*, *D. crepidatum* and *D. herbaceum* are winter orchids (the flower initiation takes place during peak cold of winter seasons). *D. fimbriatum*, *D. aphyllum*, *D. moschatum*, *D. regium* and *D. transparens* are placed amongst the summer orchids (flower initiation takes place in the summer season). *D. formosum*, *D. bicameratum* and *D. peguanum* are monsoon orchids (flowering initiation takes place in pre-monsoon, early monsoon and late monsoon respectively) (Table 3). These findings signify the water requirement of these epiphytic orchids for flowering.

Host – Orchid relationship

Dendrobium aphyllum, *D. herbaceum* and *D. peguanum* grows on maximum number of host tree species whereas the rest of the species were found on single hosts (Fig. 8). Among the host trees, namely, *Shorea robusta*, *Diospyros melanoxylon*, *Diospyros malabarica*, *Madhuca longifolia*, *Mangifera indica*, *Schleichera oleosa*, *Butea monosperma*, *Ficus benghalensis* and *Ficus religiosa*; *Shorea robusta* was found to harbour maximum numbers (8) of *Dendrobium* species (Fig. 9).

Box plots

Box plots were drawn for % canopy cover (Fig. 10) and altitude (Fig. 10), to study the distribution of orchids along these variables. *Dendrobium fimbriatum*, *D. herbaceum* and *D. transparens* prefer high canopy areas (> 80%) whereas *D. crepidatum*, *D. aphyllum* and *D. moschatum* prefer moderated canopy cover. *D. crepidatum*, *D. formosum*, *D. moschatum*, *D. transparens* and *D. herbaceum* were found exclusively on higher altitudes around 1000m asl, whereas *D. aphyllum* are distributed throughout the altitudinal gradient but were more frequent at lower altitudes (600 m).

Canonical Correspondence Analysis (CCA)

Species-environment correlation from Canonical Correspondence Analysis for Axis 1 and 2 were 0.882 and 0.739 respectively and Monte Carlo Test for significance was 0.01 which is highly significant. The inter-set correlation scores for the species obtained from CCA (Tables 4) were plotted on ARCGIS software and Kernels

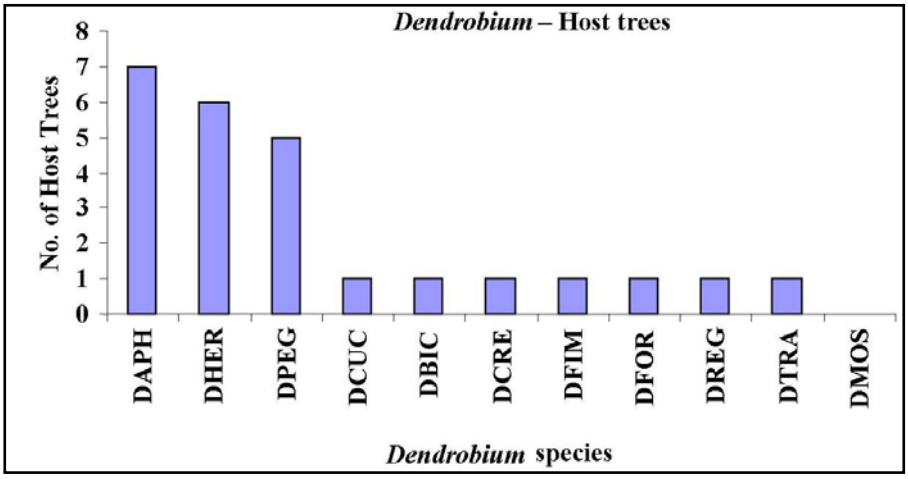

Fig. 8. Preference of Host trees by *Dendrobium*s.

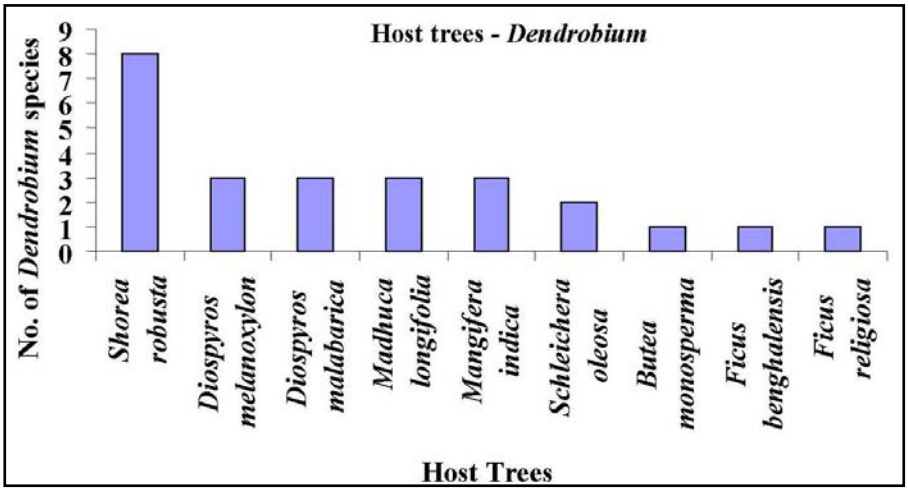

Fig. 9. Preference of *Dendrobium*s by Host trees.

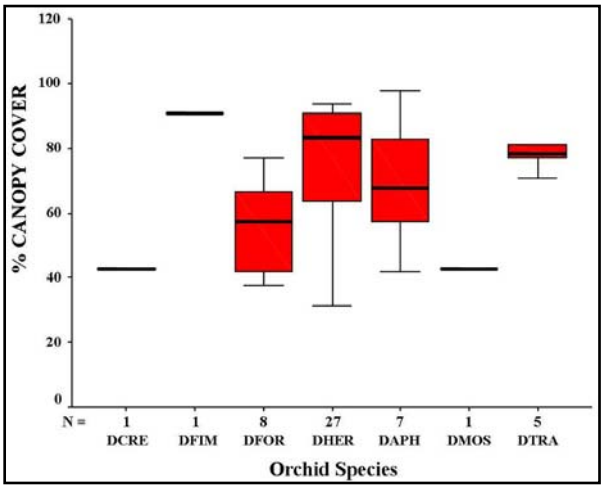

Fig. 10. Distribution of *Dendrobium*s with respect to % Canopy cover.

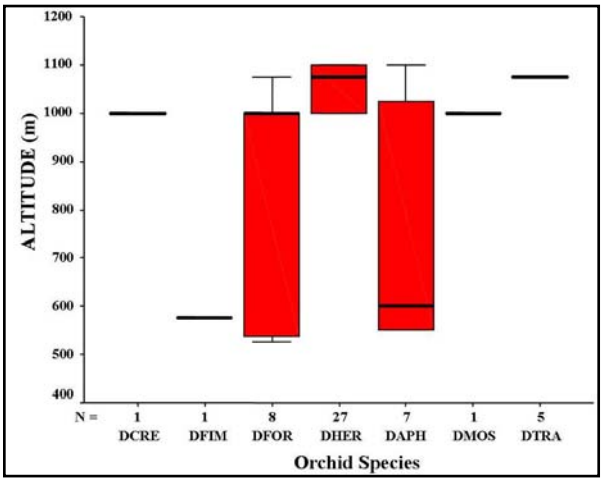

Fig. 11. Distribution of *Dendrobium*s with respect to Altitude.

Table 4. Species-Environment correlation.

Monte carlo test result—species-environment correlations		
Axis	Spp-Envt Corr.	*p*
1	0.882	
2	0.739	0.010
3	0.411	

were used at confidence intervals of 95% - 50%. Three distinct clusters were formed using Kernels (Fig. 12). First cluster is characterized by 2 species, *i.e.*, *D. formosum* and *D. fimbriatum*, growing in comparatively moderate altitude and lower canopy, second cluster is characterised by 4 species, *i.e.*, *D. herbaceum*, *D. crepidatum*, *D. transparens* and *D. moschatum* growing in higher altitude and higher canopy and third cluster is characterized by single species, *i.e.*, *D. aphyllum*, growing in lower altitude and moderate canopy.

CONCLUSION

Eleven species have been recorded from the Chotanagpur plateau. Key to the species and sketches has been given to aid identification. *Dendrobium peguanum*, *D. transparens*, and *D. moschatum*, are new records for the study area. On the other hand, *D. fimbriatum* was collected earlier from gardens, but during the present study it was found in wild. While studying the habitats of these species, *D. moschatum* was found exclusively growing on rocks, whereas *D. crepidatum* and *D. herbaceum* were found both as lithophytes as well as epiphytes growing on host trees. *D. herbaceum*, *D. aphyllum* and *D. formosum* were found in 3 or more than 3 forested habitats showing their generalized habitat requirements. *Shorea* dominated habitats harbours maximum number of *Dendrobium* sp. owing to their diverse habitat conditions, whereas *Shorea* - *Diospyros* habitat least numbers of *Dendrobium*. *Shorea – T. alata* harboured no epiphytic orchids.

All these 11 species of *Dendrobium* have been categorized into Summer, Monsoon and Winter orchids on the basis of their flowering phenology. Comparatively, an orchid that is flowering in summer requires less water and higher temperature than the one that flowers in monsoon period.

Out of 8 host trees of *Dendrobium* sp. present in the study area, *Shorea robusta* was found to be the most preferred. *D. aphyllum*, *D. herbaceum* and *D. peguanum* were found to be growing on maximum number of host trees. These 8 tree species, namely, *Shorea robusta*, *Diospyros melanoxylon*, *D. malabarica*, *Madhuca longifolia*, *Mangifera indica*, *Schleichera oleosa*, *Butea monosperma*, *Ficus benghalensis* and *Ficus religiosa* should be prioritized for plantation by the state forest department to improve the habitat conditions of these orchids.

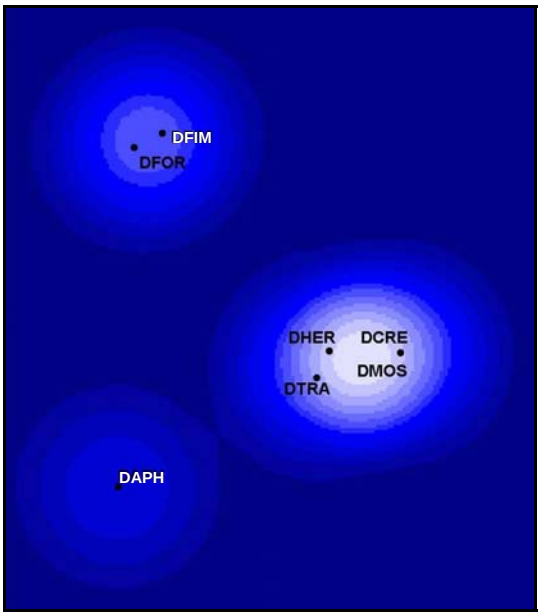

Fig. 12. Clusters of *Dendrobium* species, obtained by using kernels on the CCA scores.

Species-environment correlation was found to be highly significant. *D. crepidatum*, *D. formosum*, *D. moschatum*, *D. transparens* and *D. herbaceum* were found exclusively on higher altitudes at around 1000m asl, whereas *D. aphyllum* were distributed throughout the altitudinal gradient but are more frequent at lower altitudes (600 m). *D. fimbriatum*, *D. herbaceum* and *D. transparens* prefer higher canopy cover areas. Orchid species are highly specific to mycorrhiza and their distribution is highly governed by the availability of mycorrhiza (Otero et al., 2007), the distribution of which in turn is governed by humidity, light intensity and altitude.

ACKNOWLEDGEMENTS

Authors are thankful to Mr. P. R. Sinha, Director, WII; Dr. C. Sathish Kumar, Coordinator (TBGRI), All India coordinated research project on Taxonomy of Orchids funded by GOI-MOEF; Dr. P. J. Cribb, Royal Botanic Gardens, Kew, Dr. J. F. Veldkamp, National Herbarium of the Netherlands; Dr. D. Scherberich, Botanical Garden of Lyon, France; Dr. P. Palee, Chiang Mai, Thailand, Renata Borosova, Royal Botanic Gardens, Kew and Dr. S. Misra, Orissa for their help in many ways. *This article is dedicated to Dr. H.P. Wood, who passed away before the communication of this article. Authors are grateful to him for his appreciation, encouragements, for reviewing this manuscript and giving his valuable suggestions.*

LITERATURE CITED

Allen, P. H. 1959. Orchid hosts in the tropics. Amer. Orchid Soc. Bull. **28**: 243-244.

Barnett, P. and S. Beattie. 1986. Host species of Gunn's orchid (*Sarcochilus australis*) from Orway National Park. Victorian Naturalist **103**: 168-169.

Bernard, N. 1909. L'evolution dans la symbiose. Ann. Sci. Nat. Bot. Paris **9**: 1-196.

Champion, H. G. and S. K. Seth. 1968. A revised survey of Forest types of India. Delhi.

Christenson, E. and H. P. Wood. 2003. The mystery of *Limodorum aphyllum*, resolving lingering taxonomic problems concerning two Dendrobiums. Orchids **72**: 774-777.

Clarke, C. B. 1898. Subareas of British India illustrated by the detailed description of Cyperaceae in that Empire. J. Linn. Soc. London. **34**: 1-146.

Clements, M. A. 1987. Orchid-fungus-host associations of epiphytic orchids. In: Saito, K. and R. Tanaka (eds.), Proceedings of the 12th World Orchid Conference, 80-83. 12th World Orchid Conference, Tokyo, Japan.

Cogniaux, A. C. and A. Goossens. 1906. Dictionnaire Iconographique des Orchidees. F. Havermans, t. 40, 8.

Cozzolino, S. and A. Widmer. 2005. Orchid diversity: An evolutionary consequence of deception? Trends Ecol. Evol. **20**: 487-494.

Curtis, J. J. and R. P. MacIntosh. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology. **32**: 476-496.

Darwin, C. 1862. The various contrivances by which orchids are fertilised by insects. John Murray, London, UK.

Deva, S. and H. B. Naithani. 1986. The Orchid Flora of North West Himalayas. Print and Media Associate, New Delhi.

FSI. 2005. State of forest report. FSI. Dehra Dun.

Gill, D. E. 1989. Fruiting failure, pollinator inefficiency, and speciation in orchids. In: Otte, D. and J. A. Endler (eds.), Speciation and its consequences, 458-481. Sinauer, Sunderland, Massachusetts, USA.

Hadley, G. 1970. Non-specificity of symbiotic infection in orchid mycorrhizae. The New Phytologist. **69**: 1015-1023.

Haines, H. H. 1921 - 1924. The botany of Bihar and Orissa. 6 parts. Allard and Son and West Newman Ltd., London. Vol. I – VI.

Harley, J. L. and S. E. Smith. 1983. *Mycorrhizal symbiosis.* Academic Press, London, UK.

Hora, S. L. 1949. Symposium on Satpura Hypothesis of the distribution of the Himalayan Flora and Fauna to Peninsular India. Proc. Natl. Instit. Sci. India. **15**: 309-422.

Jain, S. K. and R. R. Rao. 1977. Handbook of field and herbarium methods. Goyal Offsets, Delhi.

Jalal, J. S. 2005. Systematics, Phytogeography and Habitat ecology of orchids of Uttarahcnal. Ph.D. thesis. Kumaun University.

Johansson, D. 1974. Ecology of vascular epiphytes in West African rain forests. Acta Phytogeogr. Suec. **59**: 1-129.

King, G. and R. Pantling. 1898. The orchids of Sikkim Himalaya. Ann. Roy. Bot. Gard. (Calcutta) **8**: 1-212.

Kumar, P., J. S. Jalal and G. S. Rawat. 2007. Orchidaceae, Chotanagpur, state of Jharkhand, India. Check List **3**: 297-304.

Linder, H. P. 1995. Setting conservation priorities — The importance of endemism and phylogeny in the southern African orchid genus *Herschelia.* Conser. Bio. **9**: 585-595.

Ludwig, J. A. and J. F. Reynolds. 1988. Statistical ecology: a primer on methods and computing. New York. John Wiley and Sons.

Masuhara, G. and K. Katsuya. 1989. Effects of mycorrhizal fungi on seed germination and early growth of three Japanese terrestrial orchids. Sci. Hortic. **37**: 331-337.

Masuhara, G. and K. Katsuya. 1991. Fungal coil formation of *Rhizoctonia repens* in seedlings of *Galeola septentrionalis* (Orchidaceae). Bot. Mag. (Tokyo) **104**: 275-281.

Masuhara, G., K. Katsuya and K. Yamaguchi. 1993. Potential for symbiosis of *Rhizoctonia solani* and binucleate *Rhizoctonia* with seeds of *Spiranthes amoena* var. *amoena* in vitro. Mycol. Res. **97**: 746-752.

McCormick, M. K., D. F. Whigham and J. O' Neill. 2004. Mycorrhizal diversity in photosynthetic terrestrial orchids. New Phyto. **163**: 425-438.

Misra, S. 2004. Orchids of Orissa. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Misra, S. 2007. Orchids of India, a glimpse. Bishen Singh Mahendra Pal Singh. Dehradun.

Mueller - Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York, USA.

Muir, H. J. 1989. Germination and mycorrhizal fungus compatibility in European orchids. In: Prichard, H. W. (ed.), Modern methods in orchid conservation: the role of physiology, ecology and management, 39–56. Cambridge University Press, Cambridge, UK.

Otero, J. T. and N. S. Flanagan. 2006. Orchid diversity — Beyond deception. Trends Ecol. Evol. **21**: 64-65 .

Otero, J. T., N. S. Flanagan, E. A. Herre, J. D. Ackerman and P. Bayman. 2007. Widespread mycorrhizal specificity correlates to mycorrhizal function in the neotropical, epiphytic orchid *Ionopsis utricularioides* (Orchidaceae). Amer. J. Bot. **94**: 1944-1950.

Pearce, N. R. and P. J. Cribb. 2002. The Orchids of Bhutan. Royal Botanic Gardens, Edinburgh and The Royal Government of Bhutan.

Rasmussen, H. N. 1995. Terrestrial orchids: from seeds to mycotrophic plants. Cambridge University Press, Cambridge, UK.

Rodgers, W. A. and H. S. Panwar. 1988. Planning wildlife protected areas network in India. Vol 1 and 2. Dept of Environment, Forests, and Wildlife/Wildlife Institute of India report. Wildlife Institute of India.

Sanford, W. W. 1974. The ecology of Orchids. In: Withner, C. The Orchids: Scientific studies. John Wiley 7 Sons, New York, USA.

Shefferson, R. P., D. L. Taylor, M. Weiß, S. Garnica, M. K. McCormick, S. Adams, H. M. Gray, J. W. McFarland, T. Kull, K. Tali, T. Yukawa, T. Kawahara, K. Miyoshi and Y.-I. Lee. 2007. The evolutionary history of mycorrhizal specifi city among lady's slipper orchids. Evolution **61**: 1380-1390.

Shefferson, R. P., M. Weiß, T. Kull and D. L. Taylor. 2005. High specificity generally characterizes mycorrhizal association in rare lady's slipper orchids, genus *Cypripedium.* Mol. Ecol. **14**: 613-626.

Shefferson, R. P., T. Kull and K. Tali. 2008. Mycorrhizal interactions of orchids colonizing Estonian mine tailings hills. Amer. J. Bot. **95**: 156-164.

Smreciu, E. A. and R. S. Currah. 1989. Symbiotic germination of seeds of terrestrial orchids of North America and Europe. *Lindleyana* **4**: 6-15.
Takhtajan, A. L. 1978. Floristic regions of the World, Nauta, Leningrad, English edn., Transl. T. J. Crovello. 1986. University of California Press, Berkeley.
Taylor, D. L. and T. D. Bruns. 1997. Independent, specialized invasion of ectomycorrhizal mutualism by two nonphotosynthetic orchids. Proc. Natl. Acad. Sci. USA **94**: 4510-4515.
Ter Braak, C. J. F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology. **67**: 1167-1179.
Ter Braak, C. J. F. 1987. The analysis of vegetation-environment relationships by CCA. Vegetatio **69**: 69-77.
Tukey, J. W. 1989. Some implementations of the Boxplot. The American Statistician. **43**: 50-54.
Went, F. W. 1940. Soziologie de epiphyten cines tropischen urwaldes. Ann. Jard. Bot. Buitenzorg **50**: 1-98.
Wood, H. P. 2006. The Dendrobiums. A. R. G. Gantner Verlag K. G., Germany.

印度 Chotanagpur 高原蘭科植物石斛蘭屬之生態與多樣性

Pankaj Kumar[(1*)], Gopal Singh Rawat[(1)] and Howard Page Wood[(2)]

1. Department of Habitat Ecology, Wildlife Institute of India, Post Box # 18, Chandrabani, Dehradun – 248001, Uttarakhand, India.
2. 3300 Darby Road, C-802, Haverford, Philadelphia, PA 19041, USA.
* 通信作者。 *Email: pankajsahani@rediffmail.com*

(收稿日期：2010 年 9 月 20 日；接受日期：2010 年 11 月 17 日)

摘要：因執行「全印度系統分類合作研究計畫」(AICOPTAX)之蘭科植物部分，在 2002~2006 年間，在 Chotanagpur 高原擴大調查記錄蘭科植物的種類和分布。在 63 種蘭科植物中，石斛蘭屬是附生蘭屬最大的一類且多出現在以龍腦香科梭羅雙樹(*Shorea robusta*) 為優勢種的森林中，共包括：兜唇石斛(*Dendrobium aphyllum*)、*D. bicameratum*、玫瑰石斛(*D. crepidatum*)、*D. cucullatum*、*D. formosum*、流蘇石斛(*D. fimbriatum*)、*D. herbaceum*、杓唇石斛(*D. moschatum*)、*D. peguanum*、*D. regium* 及 *D. transparens* 等 11 種，本生態調查是以分層隨機取樣的方式在此森林進行，結果顯示兜唇石斛幾乎在各個海拔均可以發現，也是這 11 種石斛蘭中分布最廣，其餘種類多在較高海拔地區；*Dendrobium herbaceum* 則主要出現在本高原海拔 900 至 1000 公尺間，玫瑰石斛則同時為附生蘭且亦生長於石頭上，而杓唇石斛僅出現於溪邊的石頭上，其餘的種類全是附生。本文同時指出一些影響其分布的微棲地特徵且併入檢索表中協助鑑定。

關鍵詞：石斛蘭、多樣性、生態、Chotanagpur 高原、印度。