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Research Article

Diversity and Conservation Significance of Angiosperm Climbers in Bhadrak District of Odisha, India

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ABSTRACT

The present study seeks to investigate the distribution patterns of angiosperm climbers within the Bhadrak district of Odisha, India, along with an assessment of the ecosystem services they provide. The ongoing inquiry into climbing plant species within the Bhadrak district reflects the diversity of 103 species distributed across 71 genera and 33 families. The three most diverse families are Convolvulaceae (22), Cucurbitaceae (15), and Fabaceae (14). Out of 103 climbing plant species, 72 species are herbaceous vines and 31 species are woody vines representing 69.9%, and 30.1%, respectively. The most common climbing method in the studied sites is stem twining, accounting for 70 species or 68% of the total, the second most common is tendril climbing (22 species, 21.4%), and the least, root climber (2 species, 1.9%). Local communities use these climbers for various purposes. It has been observed that out of 103 species, 61 species have medicinal properties (59.2%), 16 species have ornamental value (15.5%), 17 species are edible (16.5%), and the remaining 8 species have other uses (8.8%). These results indicate the importance of climber communities to plant diversity of Bhadrak district, enhancing the regional diversity and the conservation value of these forest remnants. Habitat degradation because of rapid development activities with limitation of the supporting tree species is found to be a serious threat to climbing plants. Employing a multifaceted strategy such as securing their habitats through protection, restoration, managing invasive species and promoting collaboration among local stakeholders and organizations, ensures the preservation of these vital plants, sustaining biodiversity and ecosystem health for the future.

Keywords: lianas; medicinal plants; ornamental climbers; stem twiner; vines

Introduction

Various plant growth forms like herbs, shrubs, trees and climbers are structured by abiotic and biotic processes operating at multiple scales and contributed to the diversification of tropical forests (Givnish et al., 2014). It is well known that abundance and species richness of climbers are highest in tropical forests and decrease toward higher latitudes and drier ecosystems and represent about 25% of plant biodiversity in tropical and subtropical forests around the world (Gentry, 1991). Climbing plants are considered as all plants with flexible, thin, and quickly growing axes that germinate on the ground, and after a certain point of their growth, need to attach themselves to an external support—typically neighbouring plants—in order to grow vertically to a significant extent and enhance light acquisition (Moffett, 2000). Trellis availability influences climber diversity in forests (Garbin et al., 2012), and climbers that fail to encounter a trellis often show reduced growth and/or reproduction (Gonza lez-Teuber & Gianoli, 2008). Support finding involves enhanced fitness and triggers changes in growth form, biomass allocation, morphology and physiology (Gianoli, 2003). Therefore, the location (and colonization) of a suitable support is a key process in the life history of climbing plants (Hegarty, 1991). Darwin's observations on the oscillatory movements of exploring stems and tendrils (circumnutation) somehow founded the field of climbing plant behaviour (Darwin, 1875). Climbing mechanisms involve behavioural and structural modification of various organs such as roots, stems, leaves or inflorescence in order to climb. They are pretty much taxon-specific (Hegarty, 1991) and therefore are useful for identifying families, genera and even species. Climbers are taxonomically diverse, Gentry (1991) estimated the representation of climbers in at least 131 plant families before three decades. Gianoli (2015) documented climbers' representation in 171 plant families, including gymnosperms, pteridophytes, and angiosperms. Recently, (Vivek et al., 2022) reported a total of 194 flowering plant families roughly constitute 50% of the globally known angiosperm families. In families like Smilacaceae, Menispermaceae, Passifloraceae, Cucurbitaceae, Convolvulaceae Hippocrateaceae and Vitaceae nearly all the species are composed of or dominated by a climbing habit (Hegarty & Caballe, 1991). Four major characteristics i.e., high growth rates, roots lateral growth, propagation through seed and production of branches play vital roles in the colonization of climbers in the forest. Climbers are classified broadly into vines and lianas based on their stem type (Caballe, 1998). A vine is an herbaceous, thin-stemmed climber that prefers disturbed or high-light exposed habitats. A liana is a woody climber with roots that are usually found on the forest floor. Lianas are especially common in tropical forests (Rai et al., 2016). The climbers are further subdivided into five major types: twiners, tendril climbers, root climbers, hook

climbers, and scramblers, based on their climbing strategies (Putz, 1984; Bongers et al., 2005). Tendrils are vegetative organs generated from leaves or stems that can only climb narrow supports (Santos et al., 2009). Twiners' spiraling around the host tree stem necessitates a relatively significant energy expenditure in their growth. They have a larger maximum diameter than tendril climbers (about 10 cm) (Schnitzer et al., 2015). Hook and scrambler climbers cling to supporting trees with hooks and thorns. Understorey root climbers cling to a host trunk with the help of adventitious roots (Schnitzer et al., 2015). Similarly, environmental gradients that affect the distribution of other plant species, such as soil moisture, seasonality, light, topography, rainfall, and soil fertility, also affect the growth of climbing species (Reddy & Parthasarathy, 2006; Swaine & Grace, 2007).

It has also been shown that liana diversity increases with host abundance and diversity (Garbin et al., 2012) indicating that host-climber interactions can influence the composition and structure of climbing plant communities. In particular, host structural characteristics and parasite climbing mechanisms may play a critical role in community assembly (Leicht-Young, 2010). Additionally, young lianas can grow over old and large lianas (Campanello et al., 2007), suggesting that climber-climber interactions may also play a role in the assembly of liana communities. It has been reported that the structure of the host tree is important in the determination of climber association (Putz, 1984; Muthuramkumar & Parthasarathy, 2001). Some of the host trees lack sites for attachment of climber species; for example, smooth-barked trees will evade climber plant infestation (Putz, 1984). The distribution and abundance of climbers (lianas) are also apparently influenced by the architecture of hosts than by climate or soil factors (Balfour & Bond, 1993). For instance, a previous study concluded that tall palms had fewer climber species rising into their crowns than shorter palms (Rich et al., 1987). Gardette (1998) reported that the major factors that contributed to a high species richness or great abundance of climbers were the presence of many supports of different height classes and the proximity of climber parents. Climbing or veining has an impact on the magnificent economy of nature. It permits plants to reach full disclosure to sunlight, nutrients and water with the least expenditure in vegetation support. They add sustainability to cover shutting after the tree falls and help equalize the micro-climate beneath. Forest plant diversity specifically added by Lianas give a valuable niche and contacts amongst tree covers which allow arboreal animal to cross tree tops. A climber plant species is vital in the forest ecosystem as it provides habitat and food in the form of nectar, pollen, fruits, leaves, or sap to many animal species (Schnitzer & Bongers, 2002; Sarvalingam et al.,

2015). Climber distribution is influenced by type and forest locality as well (Balfour & Bond, 1993). Climbers play a major role in renewing forests' ecosystems and biodiversity, carbon sequestration, entire-forest transpiration and controlling soil erosion (Schnitzer & Bongers, 2002). A climber reduces the surrounding tree damage and reduces 50% of the post-harvest canopy gaps (Appanah & Putz, 1984). Climbers are essential resources used mainly by local communities, especially those living in nearby areas (Muthumperumal & Parthasarathy, 2013). Climbers provide medicine, food, artisan work, building materials for traditional houses, hunting tools for the local communities and constitute a large and important ornamental horticulture sector (Parthasarathy et al, 2015; Arroyo-Rodriguez & al., 2015). The evidence of climber dominance in certain forest ecosystems i.e., temperate (Allen et al., 2007) and tropical (Swaine & Grace, 2007;) are also attributed to climate change (Malhi & Wright, 2004). The higher frequency of lianas is not only caused by declining rainfall (Swaine & Grace, 2007) but also several other factors are known to favour them such as an increase in disturbance (Londre & Schnitzer, 2006), or especially high responsiveness to elevated CO_2 (Zotz et al., 2006). However, floristic data from 69 tropical forests worldwide found a negative correlation between mean annual precipitation and liana abundance (Schnitzer, 2005).

Various anthropogenic mechanisms such as cattle grazing, intentional or accidental fires, urbanization, agricultural expansion and invasion have caused significant effects on the forest structure, leading to habitat fragmentation with altered plant species composition and functions of forest dynamics (Zeballos et al., 2014; Newbold et al., 2015). Further, previous studies indicate that light availability, soil moisture, soil nutrients and vertical structure conditions are different among these fragmented vegetation patches (Zeballos et al., 2014). This environmental variability may promote a particular floristic and functional composition of the climbing community in each type of degraded forest. The majority of previous studies focused heavily on trees and shrubs and little consideration was given to climber plants in spite of various roles they play in ecosystems (Bongers et al., 2005). Over the past two decades, climber research has gained traction, scientists have discovered patterns in liana abundance and distribution across a variety of habitats and have been investigating the underlying causes of these patterns (Gentry, 1991; Schnitzer & Bongers, 2002; da Cunha Vargas et al., 2021). A number of inventories are available from different states of India addressing climber diversity and dynamics (Girish & Abdul, 2019; Bandyopadhyay & Mitra, 2021; Vivek et al., 2022; Vivek, 2023). However, such type of study is limited in Odisha (Jena et al. 2018) while reports from Bhadrak district are nil. The current study aims to explore the distribution

of angiosperm climbers in Bhadrak district of Odisha, India and their ecosystem services.

Materials and Methods

The state of Odisha (81° 43' and 87 ° 29' east longitudes and 17° 49' and 22 ° 34' north latitude), India, consisting of 30 districts and geographically situated at the head of the Bay of Bengal, has a coastal stretch of around 482 km. It extends over an area of 155,707 sq. km accounting for about 4.87% of the total area of the country. Based on physico-geographical characteristics, the state has been divided into 5 major regions i.e., the coastal plain in the east, the middle mountainous and highlands region, the central plateaus, the western rolling uplands and the major flood plains. The varying climatic condition provides suitable habitats for supporting rich flora and fauna in the region (Patnaik, 1996). Additionally, a number of perennial rivers such as Mahanadi, Brahmani, Baitarani, Rushikulya, Birupa, Budhabalanga and Subarnarekha, and their tributaries pass through Odisha, making the state prone to flooding. Furthermore, the Eastern Ghat range of hills runs through the heart of Odisha i.e., it starts from north of Similipal and runs through Malkangiri crossing 17 districts of the state harbouring primarily moist deciduous vegetation (Champion & Seth, 1968). The state encounters a hot and humid climate round the year with short winters.

Bhadrak district (20° 43′–21° 13′N and 86° 6′–87° E) is located in northeast Odisha. It spreads over 2505 km^2 with 1.507 million inhabitants (2011 Census). It borders the Balasore district in the north, Jajpur in the south, the Bay of Bengal and Kendrapara district in the east and Koenjhar in the west (**Figure 1**). The district contributes 1.61% and 3.62% of the state's territory and population respectively. Rice (*Oryza sativa* L.) is the major cereal crop cultivated by most of the people of the district. The district is located in the deltaic region close to the Bay of Bengal. Obviously, it has all the features of a coastal climate, i.e., saline weather, the influence of coastal wind, thunderstorms during monsoons, dust storms in summer and cyclone proneness.

Data collection

To assess the diversity of angiosperm climbers, field surveys were conducted monthly in different seasons (rainy, winter and summer) from July 2016 to July 2020. During field visits, plant samples were collected and photographs of plant species were taken from agricultural lands, wastelands, roadsides, railway tracks, parks, lawns, ponds, river banks and other relevant localities to cover

almost all the district in a systematic manner. Information was collected from respondents, especially the local farmers, elderly people, and local healers through interviews following standard procedures (Martin, 1995; Huntington, 2000).

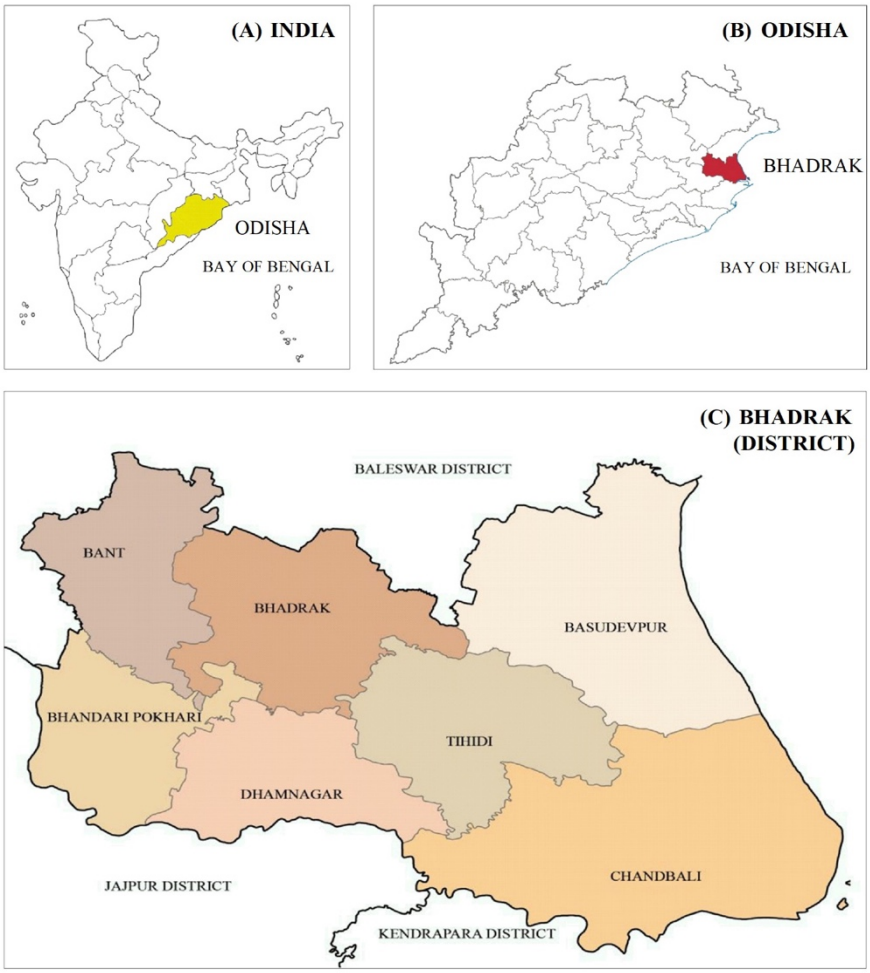

Figure 1. (A) Location of Odisha state in the eastern region of India **(B)** map of the Odisha state showing Bhadrak district and **(C)** study area showing different blocks of the Bhadrak district.

Two-hundred-and-seventy-nine (226 men and 53 women) persons were interviewed. Among the interviewees, 10% were aged 21–40, 40% were 61 or older, and 50% were aged 41–60. The questionnaire was semi-structured, followed by free interviews and informal conversations. Plant species were

identified with the help of previous scientific literature (Haines, 1925; Saxena & Brahmam, 1996) and with live specimens on the field itself. However, plant samples were identified in the laboratory when it was not found. During the survey, important taxonomic parameters such as vernacular names, and flowering time were recorded from the respondents. The ecological parameters noted were the habits and habitat of the species. The economic uses of these species, if any, were discussed with the local people. The plant list was categorized according to their systematic positions following the APG IV (2016) classification system. The current nomenclature of each species was determined by referring to database POWO (2022).

Results and Discussion

Our study provides important information about the diversity of climbing plant species in the Bhadrak district of Odisha, India. This research is, to our knowledge, one of the few studies that address climbing plant diversity from the Bhadrak district of Odisha state. We found climbers are spreading in all the habitats such as forests, wasteland, village hedges, near canals, river and pond banks, rice fields, railway tracks, roadside, educational and public institutions, and horticultural crop fields. Climbing plants account for a significant component of diversity and abundance and play a major role in tropical forest communities and ecosystems (Schnitzer & Bongers, 2002). The present study documented a total of 103 climber plant species belonging to 71 genera and 33 families (**Table 1** & **Figures 2–5**), contributing to the district's total floristic diversity of 524 plant species (Panda et al. 2020, 2023), with climbers constituting 19.65% of the recorded species. The number of species reported in the current investigation is consistent with floristic surveys from the Koch Bihar district of West Bengal, (98 spp.; Bandyopadhyay & Mukherjee, 2010; 116 spp. Saharanpur District, Uttar Pradesh (116 spp. Saini et al., 2021). However, compared to a few other districts in India, our numbers seem to be very high. Those are Dibrugarh district, Assam, Northeast India and Doaba region of Punjab, India which have 59 species and 53 species, respectively (Kaur et al., 2017; Gogoi & Nath, 2021).

Table 1. List of climbers in Bhadrak district, Odisha, India.

Scientific name with family	Local name	Life form	Climber type	Climbing mode	Frequency of occurrence	Economic uses
Abrus precatorius L. (Fabaceae)	Kaincha	P	Woody climber	Stem Twiner	+++	Medicinal
Allamanda blanchetii A. DC. (Apocynaceae)		P	Herbaceous climber	Stem Twiner	+++	Ornamental

Allamanda cathartica L. (Apocynaceae)		P	Herbaceous climber	Stem Twiner	+++	Ornamental
Antigonon leptopus Hook. & Arn. (Polygonaceae)		P	Herbaceous climber	Tendril climber	+++	Medicinal
Argyreia cymosa Roxb. ex Sweet (Convolvulaceae)		P	Woody climber	Stem Twiner	+++	Medicinal
Argyreia nervosa (Burm. f.) Bojer (Convolvulaceae)	Mundanoi	A	Herbaceous climber	Stem Twiner	+++	Medicinal
Aristolochia indica L. (Aristolochiaceae)	Panairi	P	Woody climber	Stem Twiner	+	Medicinal
Artabotrys hexapetalous (L.f.) Bhandari. (Annonaceae)	Chinichampa	P	Woody climber	Hook climber	+	Medicinal
Asparagus racemosus Willd. (Asparagaceae)	Satabari	P	Herbaceous climber	Scrambler armed	+	Medicinal
Azima tetracantha Lam. (Salvadoraceae)		P	Woody climber	Stem Twiner	++	Medicinal
Basella alba L. (Basellaceae)	Poi	A	Herbaceous climber	Stem Twiner	+++	Edible/ Medicinal
Benincasa hispida (Thunb.) Cogn. (Cucurbitaceae)	Panikakharu	A	Herbaceous climber	Stem Tendril	+++	Edible/ Medicinal
Bougainvillea spectabilis Willd. (Nyctaginaceae)	Kagajaphula	P	Woody climber	Hook climber	+++	Ornamental
Boerhavia diffusa L. (Nyctaginaceae)	Goudapuruni	P	Herbaceous climber	Hook Climber	+++	Edible/ Medicinal
Caesalpinia bonduc (L.) Roxb. (Fabaceae)	Gila	P	Woody climber	Stem twiner	+++	Medicinal
Caesalpinia crista L. (Fabaceae)	Nantei	P	Woody climber	Stem twiner	++	Medicinal
Campsis grandiflora (Thunb.) K.Schum. (Bignoniaceae)		P	Woody climber	Scrambler unarmed	+	Ornamental
Canavalia gladiata (Jacq.) DC. (Fabaceae)	Maharada	P	Woody climber	Stem Twiner	++	Edible
Capparis zeylanica L. (Capparaceae)	Asadua	P	Woody climber	Scrambler armed	++	Medicinal
Cardiospermum halicacabum L. (Sapindaceae)	Kanphuta	P	Herbaceous climber	Tendril climber	+++	Medicinal
Carissa spinarum L. (Apocynaceae)	Anku koli	P	Woody climber	Scrambler armed	++	Edible/ Medicinal
Cayratia pedata (Lam.) Gagnep. (Vitaceae)	Pitapotala	P	Woody climber	Tendril climber	+++	Medicinal
Cayratia trifolia (L.) Domin (Vitaceae)	Amla lata	P	Woody climber	Tendril climber	+++	Medicinal
Cissampelos pareira L. (Menispermaceae)	Akanbindi	P	Herbaceous climber	Stem Twiner	+++	Medicinal
Cissus quadrangularis L. (Vitaceae)	Hadabhanga	P	Woody climber	Tendril climber	++	Medicinal
Citrullus lanatus (Thunb.) Matsum. & Nakai (Cucurbitaceae)	Tarbhuja	A	Herbaceous climber	Stem Twiner	+++	Edible
Clerodendrum thomsoniae Balf.f. (Lamiaceae)		P	Woody climber	Stem Twiner	++	Ornamental
Clitoria ternatea L. (Fabaceae)	Aparajita	P	Woody climber	Stem Twiner	+++	Medicinal

Coccinia grandis (L.) Voigt (Cucurbitaceae)	Kunduri	A	Herbaceous climber	Tendril climber	+++	Edible
Combretum indicum (L.) DeFilipps (Combrataceae)	Madhumalati	P	Woody climber	Stem Twiner	+++	Ornamental
Cucumis melo L. (Cucurbitaceae)	Banakakudi	A	Herbaceous climber	Tendril climber	+++	Edible
Cucumis sativus L. (Cucurbitaceae)	Kakudi	A	Herbaceous climber	Tendril climber	+++	Edible
Cucurbita maxima Duchesne (Cucurbitaceae)	Boitikakharu	A	Herbaceous climber	Tendril climber	+++	Edible
Cuscuta reflexa Roxb. (Convolvulaceae)	Nirmuli	P	Herbaceous climber	Stem Twiner	+++	Medicinal
Dioscorea alata L. (Dioscoreaceae)	Khamba alu	P	Herbaceous climber	Stem Twiner	+++	Edible
Dioscorea bulbifera L. (Dioscoreaceae)	Pitaalu	P	Herbaceous climber	Stem Twiner	++	Edible
Dioscorea glabra Roxb. (Dioscoreaceae)	Kanta-alu	P	Herbaceous climber	Stem Twiner	+++	Edible
Dioscorea pentaphylla L. (Dioscoreaceae)	Tungialu	P	Herbaceous climber	Stem Twiner	++	Edible
Diplocyclos palmatus (L.) C.Jeffrey (Cucurbitaceae)	Kundia	A	Herbaceous climber	Tendril climber	++	Medicinal
Epipremnum aureum (Linden & André) G.S.Bunting (Araceae)		P	Herbaceous climber	Root climber	+++	Ornamental
Evolvulus alsinoides (L.) L. (Convolvulaceae)	Bichhamali	P	Herbaceous climber	Stem Twiner	+++	Medicinal
Evolvulus nummularius (L.) L. (Convolvulaceae)		P	Herbaceous climber	Stem Twiner	+++	Medicinal
Gloriosa superba L. (Liliaceae)	Ognisikha	A	Herbaceous climber	Tendril climber	++	Medicinal
Gmelina philippinensis Cham. (Lamiaceae)		P	Woody climber	Stem Twiner	+	Medicinal
Gymnema sylvestre (Retz.) R.Br. ex Sm. (Apocynaceae)	Gurmari	P	Herbaceous climber	Stem Twiner	++	Medicinal
Hemidesmus indicus (L.) R.Br. (Apocynaceae)		P	Herbaceous climber	Stem Twiner	+++	Medicinal
Hewittia malabarica (L.) Suresh (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	+	Not known
Ichnocarpus frutescens (L.) W.T. Aiton (Apocynaceae)	Madhobi	P	Woody climber	Stem Twiner	+++	Medicinal
Ipomoea aquatica Forssk. (Convolvulaceae)	Kalamasaga	A	Herbaceous climber	Stem Twiner	+++	Edible/ Medicinal
I. batatas (L.) Lam. (Convolvulaceae)	Kandamula	A	Herbaceous climber	Stem Twiner	++	Edible/ Medicinal
I. hederifolia L. (Convolvulaceae)	Panikoda	A	Herbaceous climber	Stem Twiner	++	Medicinal
I. indica (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	++	Medicinal
I. marginata (Desr.) Verdcourt (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	+++	Medicinal
I. mauritiana Jacq. (Convolvulaceae)	Bhuinkakharu	A	Herbaceous climber	Stem Twiner	+	Medicinal

I. nil (L.) Roth (Convolvulaceae)	Khami khondo	A	Herbaceous climber	Stem Twiner	++	Medicinal
I. obscura (L.) Ker Gawl.(Convolvulaceae)		A	Herbaceous climber	Stem Twiner	+++	Medicinal
I. pes-caprae (L.) R.Br. (Convolvulaceae)	Kansari nata	A	Herbaceous climber	Stem Twiner	+++	Medicinal
I. purpurea (L.) Roth (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	+	Medicinal
I. quamoclit L. (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	++	Ornamental
I. sepiaria Koenig ex Roxb. (Convolvulaceae)	Mushkani	A	Herbaceous climber	Stem Twiner	++	Medicinal
I. triloba L. (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	++	Medicinal
Jasminum sambac (L.) Aiton (Oleaceae)	Malli	P	Herbaceous climber	Stem Twiner	+++	Ornamental
Jasminum auriculatum Vahl		P	Herbaceous climber	Stem twiner	+++	Ornamental
Lablab purpureus (L.) Sweet (Fabaceae)	Shimba	A	Herbaceous climber	Stem Twiner	+++	Edible
Lagenaria siceraria (Molina) Standl. (Cucurbitaceae)	Laoo	A	Herbaceous climber	Tendril climber	+++	Edible
Lantana camara L. (Verbenaceae)	Nagaauri	P	Woody climber	Scrambler armed	+++	Medicinal
Luffa cylindrica M.Roem. (Cucurbitaceae)	Pitataradi	A	Herbaceous climber	Tendril climber	+++	Medicinal
Luffa acutangula (L.) Roxb. (Cucurbitaceae)	Janhi	A	Herbaceous climber	Tendril climber	+++	Edible
Merremia hederacea (Burm. fil.) Hall. fil. (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	+++	Medicinal
M. tridentata (L.) Hallier f. (Convolvulaceae)		A	Herbaceous climber	Stem Twiner	++	Medicinal
Mikania micrantha Kunth (Asteraceae)		A	Herbaceous climber	Stem Twiner	+++	Not Known
Mimosa pudica L. (Fabaceae)	Lajkuli	P	Herbaceous climber	Stem twiner	+++	Medicinal
Momordica charantia L. (Cucurbitaceae)	Kalara	A	Herbaceous climber	Tendril climber	+++	Medicinal
Mucuna monosperma Wight (Fabaceae)	Baidanka	P	Woody climber	Stem Twiner	+	Medicinal
M. pruriens (L.) DC. (Fabaceae)	Baidanka	P	Woody climber	Stem Twiner	+++	Medicinal
Mukia maderaspatana (L.) M.Roem. (Cucurbitaceae)	Pahari kakharu	A	Herbaceous climber	Tendril climber	++	Medicinal
Operculina turpethum (L.) Silva Manso (Convolvulaceae)	Dudholomo	P	Herbaceous climber	Stem twiner	++	Medicinal
Paederia foetida L. (Rubiaceae)	Pasaruni	A	Herbaceous climber	Stem Twiner	+	Medicinal
Passiflora foetida L. (Passifloraceae)	Jhumkalata	A	Herbaceous climber	Tendril climber	++	Medicinal
P. incarnata L. (Passifloraceae)		A	Herbaceous climber	Tendril climber	+	Ornamental
Pergularia daemia (Forssk.) Chiov. (Apocynaceae)	Uturudi	P	Herbaceous climber	Stem Twiner	+++	Medicinal

Psophocarpus tetragonolobus (L.) D.C. (Fabaceae)	Asanasimbo	A	Herbaceous climber	Stem Twiner	+	Medicinal
Piper betle L. (Piperaceae)	Pana	P	Woody climber	Stem Twiner	++	Medicinal
P. longum L. (Piperaceae)	Pipal	P	Woody climber	Stem Twiner	++	Medicinal
Pyrostegia venusta (Ker Gawl.) Miers (Bignoniaceae)		P	Herbaceous climber	Tendril climber	++	Ornamental
Rivina humilis L. (Petiveriaceae)		A	Herbaceous climber	Stem Twiner	++	Medicinal
Syngonium podophyllum Schott (Araceae)		P	Herbaceous climber	Root climber	+++	Ornamental
Tragia involucrata L. (Euphorbiaceae)	Bichuati	A	Herbaceous climber	Stem Twiner	+++	Medicinal
Telosma pallida (Roxb.) Craib (Apocynaceae)	Tokeikundhei	A	Herbaceous climber	Stem Twiner	+	Medicinal
Thunbergia erecta (Benth.) T.Anderson (Acanthaceae)		P	Herbaceous climber	Stem twiner	+++	Ornamental
T. fragrans Roxb. (Acanthaceae)	Chakrakedar	P	Herbaceous climber	Stem twiner	++	Ornamental
T. grandiflora (Roxb. ex Rottl.) Roxb. (Acanthaceae)	Chota-ganti	P	Woody climber	Stem twiner	++	Ornamental
Tiliacora racemosa Colebr. (Menispermaceae)	Kalajati noi	P	Woody climber	Stem twiner	+	Medicinal
Tinospora cordifolia (Willd.) Miers. (Menispermaceae)	Guluchilata	P	Woody climber	Stem twiner	++	Medicinal
Trichosanthes cucumerina L. (Cucurbitaceae)	Sallara	A	Herbaceous climber	Tendril climber	+++	Edible
Trichosanthes dioica Roxb. (Cucurbitaceae)	Potala	A	Herbaceous climber	Tendril climber	++	Edible
Trichosanthes tricuspidata Lour. (Cucurbitaceae)	Mahakal	A	Herbaceous climber	Tendril climber	+	Medicinal
Vigna pilosa Baker. (Fabaceae)	Jhikrai	A	Herbaceous climber	Stem Twiner	++	Medicinal
V. trilobata (L.) Verdc. (Fabaceae)	Sanmungo	A	Herbaceous climber	Stem Twiner	++	Medicinal
V. unguiculata (L.) Walp. (Fabaceae)	Judanga	A	Herbaceous climber	Stem Twiner	+++	Edible
Wisteria sinensis (Sims) DC.(Fabaceae)		P	Woody climber	Stem Twiner	++	Not known
Zanthoxylum armatum DC. (Rutaceae)	Tudapoda	P	Woody climber	Scrambler armed	+++	Medicinal
Ziziphus oenoplia (L.) Mill. (Rhamnaceae)	Kankoli	P	Woody climber	Scrambler armed	+++	Edible

Abbreviations: P=Perennial, A= Annual, + rare, ++ common, +++ frequent.

Figure 2. a. *Abrus precatorius* L. **b.** *Argyreia cymosa* Roxb. ex Sweet **c.** *Argyreia nervosa* (Burm. f.) Bojer **d.** *Aristolochia indica* L. **e.** *Asparagus racemosus* Willd. **f.** *Azima tetracantha* Lam. **g.** *Basella alba* L. **h.** *Boerhavia diffusa* L. **i.** *Caesalpinia bonduc* (L.) Roxb. **j.** *Canavalia gladiata* (Jacq.) DC. **k.** *Capparis zeylanica* L. **l.** *Cayratia pedata* (Lam.) Gagnep.

Figure 3. a. *Cissampelos pareira* L. **b.** *Cissus quadrangularis* L. **c.** *Dioscorea alata* L. **d.** *Diplocyclos palmatus* (L.) C. Jeffrey **e.** *Evolvulus alsinoides* (L.) L. **f.** *Evolvulus nummularius* (L.) L. **g.** *Gloriosa superba* L. **h.** *Gmelina philippinensis* Cham. **i.** *Gymnema sylvestre* (Retz.) R.Br. ex Sm. **j.** *Ichnocarpus frutescens* (L.) W.T. Aiton **k.** *Ipomoea aquatica* Forssk. **l.** *I. obscura* (L.) Ker Gawl.

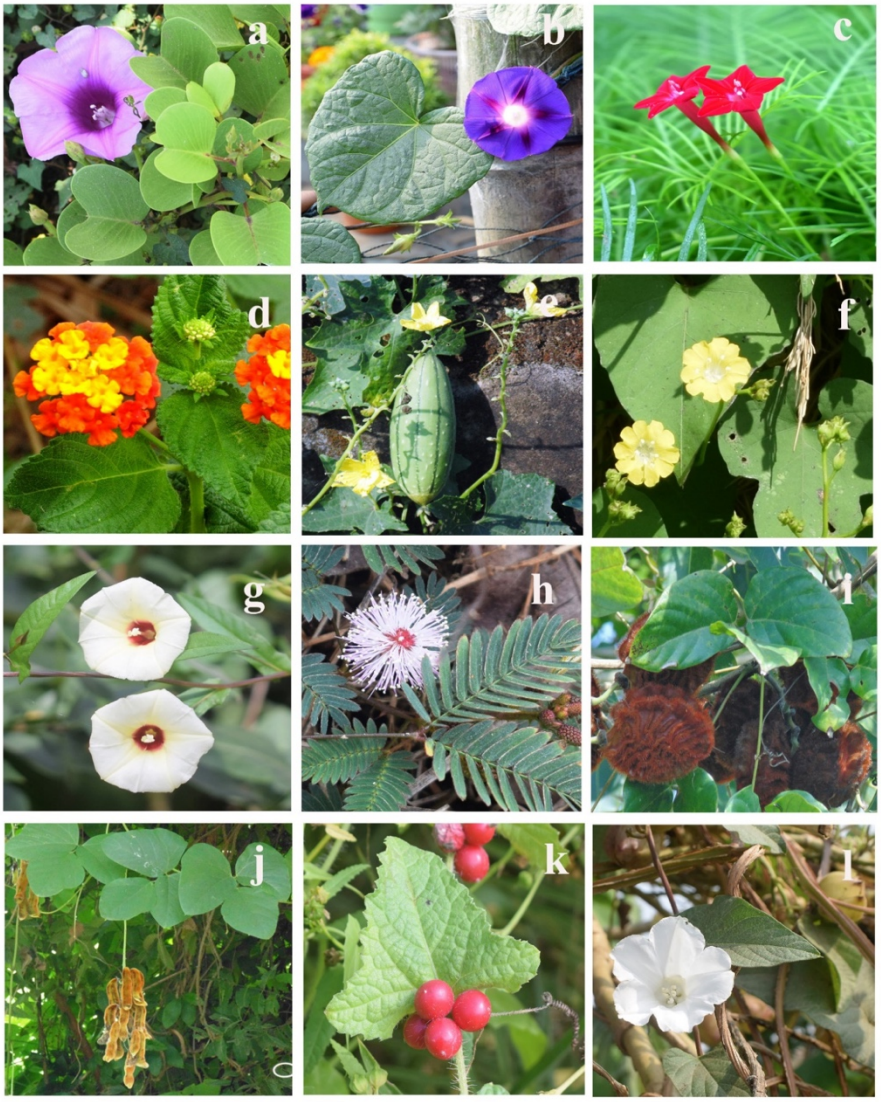

Figure 4. a. *Ipomoea. pes-caprae* (L.) R.Br. **b.** *I. purpurea* (L.) Roth **c.** *I. quamoclit* L. **d.** *Lantana camara* L. **e.** *Luffa cylindrica* M.Roem. **f.** *Merremia hederacea* (Burm. fil.) Hall. fil. **g.** *M. tridentata* (L.) Hallier f. **h.** *Mimosa pudica* L. **i.** *Mucuna monosperma* Wight **j.** *M. pruriens* (L.) DC. **k.** *Mukia maderaspatana* (L.) M. Roem. **l.** *Operculina turpethum* (L.) Silva Manso

Figure 5. a. *Paederia foetida* L. **b.** *Passiflora foetida* L. **c.** *P. incarnata* L. **d.** *Psophocarpus tetragonolobus* (L.) D.C. **e.** *Pyrostegia venusta* (Ker Gawl.) Miers **f.** *Rivina humilis* L. **g.** *Telosma pallida* (Roxb.) Craib **h.** *Tiliacora racemosa* Colebr. **i.** *Tinospora cordifolia* (Willd.) Miers. **j.** *Trichosanthes tricuspidate* Lour. **k.** *Zanthoxylum armatum* DC. **l.** *Ziziphus oenoplia* (L.) Mill.

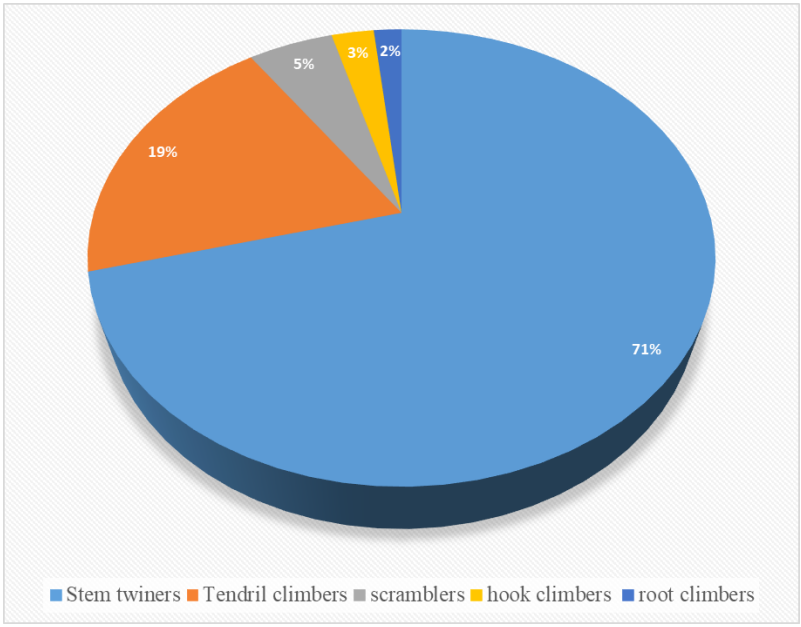

Figure 6. Different climbing mechanisms of climbers in Bhadrak district.

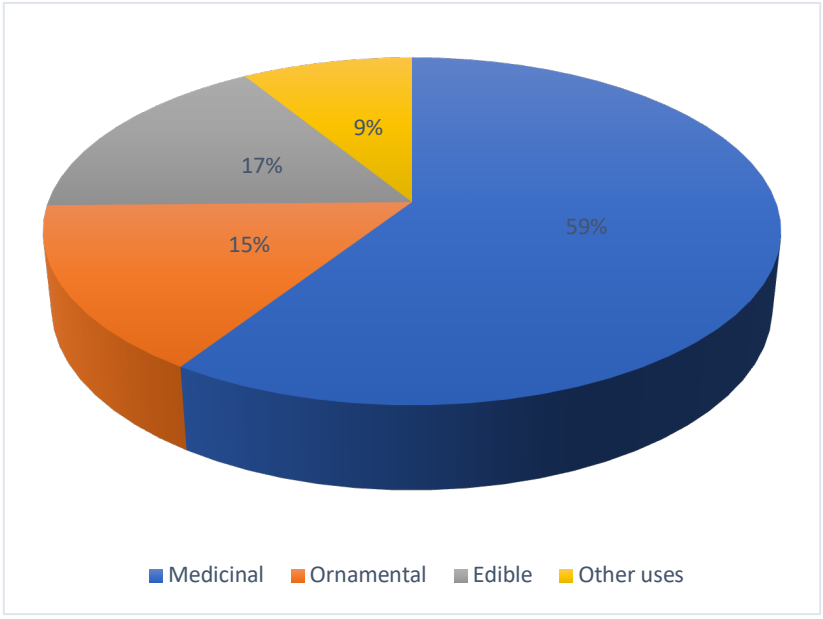

Figure 7. Traditional uses of climbers in Bhadrak district.

Moreover, a higher number of species is also reported from Papum Pare District of Arunachal Pradesh (187 sp. Kashung et al., 2021). Among the families, the most speciose families were Convolvulaceae (22 species), followed by Cucurbitaceae (15 species) and Fabaceae (14 species). Naidu et al. (2014), reported the most specious families, Convolvulaceae (23 spp.), Leguminosae (22 spp.), and Cucurbitaceae (9 spp.) in northern Eastern Ghats of India which is in accordance with the current study. Similarly, the dominant genera were *Ipomoea* possessing the highest number of species (13 species). Out of 103 climbing plant species, 72 species were herbaceous vines and 31 species were woody vines representing 69.9%, and 30.1%, respectively. Representation of perennials was higher (57 sp.) than the annuals (46 sp.). The enumerated climbing plants showed 5 different climbing mechanisms which were stem twiners (68 %), tendril climbers (21.4%), hook climbers (2.9%), scramblers (5.8%) and root climbers (1.9%) (**Figure 6**). The varied climbing mechanisms adopted by the climbers were similar to those studied in tropical forests by Jayakumar & Nair (2013) and Seger & Hartz (2014). According to several studies, stem twiners were the most frequent climbing plants in tropical forests (Gollasimood et al., 2012; Anbarashan & Parthasarathy, 2013). The most frequent climber species include *Boerhavia diffusa* L., *Bougainvillea spectabilis* Willd., *Caesalpinia bonduc* (L.) Roxb., *Cardiospermum halicacabum* L., *Cissampelos pareira* L., *Clitoria ternatea* L., *Coccinia grandis* (L.) Voigt, *Combretum indicum* (L.) DeFilipps, *Cuscuta reflexa* Roxb., *Evolvulus alsinoides* (L,) L., *Ipomoea aquatica* Forssk., *Lantana camara* L., *Luffa cylindrica, Mimosa pudica* L., *Mucuna pruriens* (L.) DC., *Pergularia daemia* (Forssk.) Chiov., *Tragia involucrata* L. and *Ziziphus oenoplia* (L.) Mill. Similarly, *Capparis zeylanica* L., *Carissa spinarum* L., *Cissus quadrangularis* L., *Gymnema sylvestre* (Retz.) R.Br. ex Sm. and *Mukia maderaspatana* (L.) M.Roem. were commonly found in the study site. Some species like *Aristolochia indica* L., *Asparagus racemosus* Willd., *Gmelina philippinensis* Cham., *I. mauritiana* Jacq., *Mucuna monosperma* Wight, *Psophocarpus tetragonolobus* (L.) D.C., and *Tiliacora racemosa* Colebr. were found restricted to only a few areas of the study site. Local communities were using these climbers for various purposes. It had been observed that out of 103 species, 61 species had medicinal properties (59.2%), 16 species had ornamental value (15.5%), 17 species were edible (16.5%), and the remaining 8 species had other uses (8.8%) (**Figure 7**). The most prominent species used for medicinal purposes include *Abrus precatorius* L., *Aristolochia indica* L., *Asparagus racemosus* Willd., *Capparis zeylanica* L., *Cissampelos pareira* L., *Cissus quadrangularis* L., *Gloriosa superba* L., *Gymnema sylvestre* (Retz.) R.Br. ex Sm., *Lantana camara* L., *Luffa cylindrica* M. Roem., *Momordica charantia* L., and *Zanthoxylum armatum* DC.

The local people of the study area use *Aristolochia indica* for the treatment of snake bites. The root of *Aristolochia indica* with long peppers was ground to make a paste. The paste was given as an antidote for snake bites. The present result concomitates with Bhattacharjee and Bhattacharyya's results (2013). Similarly, the decoction obtained from the root tuber of *Asparagus racemosus* was used to cure diarrhoea, cough, bronchitis, fever and jaundice. The root boiled with cow's milk was used to increase milk secretion during lactation. Root tuber was eaten raw to remove kidney stones. The present result corroborates the finding of Kohli et al. (2022). The fruit of *Capparis zeylanica* was mildly burnt and the whole content was taken for diabetes. The present report draws support from the studies of Amit et al. (2010). The treatment of diabetic rats with *Capparis zeylanica* fruit methanolic extract leads to improved body weight, blood glucose and insulin levels in comparison with the diabetic control group. Improved body weight in diabetic animals specifies the role of extract in protecting the body tissues from hyperglycemic damage (Gireesh et al., 2009) by enhancing glycemic control and structural protein synthesis (Eliza et al., 2009). Likewise, the leaves of *Gymnema sylvestre* were consumed orally for the treatment of diabetes. This plant's most widely known effect is anti-diabetic activity (Laha & Paul, 2019). Ethanol extract of this plant is reported to reduce glucose level by 46% whereas the water extracts reduced glucose level by 26% and methanol extract by 12% (Tiwari et al., 2014). Similarly, leaves and fruits of *Momordica charantia* were used to control diabetes. The present result draws support from the studies of Liu et al. (2021). In the studied region, gently warmed leaf of *Cissampelos pareira* was kept on wounds to draw out purulent matter and help in healing wounds. The present result draws support from the studies of Kumari et al. (2021). Paste of the whole plant of *Cissus quadrangularis* with banana leaf was bandaged over the affected area to enhance bone fracture healing (Naveen Joshi, 2020; Ramachandran et al., 2021). Six species had both medicinal and nutritional values: *Basella alba* L., *Benincasa hispida* (Thunb.) Cogn., *Boerhavia diffusa* L., *Carissa spinarum* L., *Ipomoea aquatica* Forsk. and *I. batatas* (L.) Lam. In the current investigation, leaves of *Basella alba* are rubbed over the affected part to cure irritation and swellings due to caterpillar. In the present study, tender leafy shoots of *Boerhavia diffusa* are eaten fried or cooked. Root paste of the plant is taken orally for a week for the treatment of jaundice. Aqueous and powdered extracts of roots of *Boerhavia diffusa* L. have shown hepatoprotective properties against Thioacetamide induced hepatotoxicity in Wister albino rats (Rawat et al., 1997). Ursolic acid, a common triterpenic acid found in *Boerhavia diffusa* L. has been reported to have hepatoprotective activity against carbon tetrachloride, ethanol, thioacetamide and galactosamine damaged liver in rats (Negi et al., 2007). The most widely

used hepatoprotective plant species in India was *Boerhavia diffusa* L., which is noted to be used in different regions of India (Alagesaboopathii, 2009; Janghel et al., 2019; Raghuvanshi et al., 2021; Sharma, 2022). Devaki et al (2005) studied the effect of ethanolic extract of *Boerhavia diffusa* on the tissue defense system against ethanol-induced hepatic injury in rats. The administration of *Boerhavia diffusa* extract (150 mg/kg/day for 30 days, orally) reversed the increase in the levels of lipid peroxides and increased the activities of superoxide dismutase, catalase, glutathione peroxidase, and glutathione-S-transferase and reduced glutathione levels. Rawat et al. (1997) studied the effect of various factors on the hepatoprotection by *Boerhavia diffusa* extract and found that aqueous extract (2 mL/Kg) of 1–3 cm diameter roots from May displayed significant protection for serum parameters, like GOT (glutamate oxaloacetate transaminase), GPT (glutamate pyruvate transaminase), ACP (acid phosphatase), and ALP (alkaline phosphatase) but not GLDH and bilirubin in thioacetamide-induced liver toxicity in rat. It has been noted in this study that the roots, which were thin, showed maximum protection of serum parameters. Likewise, tender leafy shoots of *Ipomoea aquatica* are eaten fried or cooked. *Ipomoea aquatica* is a common food eaten by all social groups throughout tropical Asia (Burkill, 1966). A Literature survey revealed the presence of fiber (11.67%), carbohydrates (54.2%), lipid (11.0%), protein (6.3%), sodium (135mg/100g), phosphorous (109mg/100g), calcium (416mg/100g), iron (210mg/100g), zinc (2.47mg/100g) and magnesium (301 mg/100g) in the leaves of the plant (Vishwakarma & Dubey, 2009).The species also contains several vitamins, including A, B, C, E, and "U" (S-methyl-methionine), flavonoids, phenolic compounds, ß-carotene and ascorbic acid (Sundar Rao, 1990). Traditionally, *Ipomoea aquatica* is effectively used against nosebleeds, high blood pressure, leukoderma, liver complaints, worm infection, fever and so forth in humans (Alkiyumi et al., 2012; Srikanth et al., 2018). The fruits of *Coccinia grandis* (L.) Voigt, *Cucumis melo* L. and roots tubers of *Dioscorea pentaphylla* L. were widely collected for human consumption. It was observed that wild fruits of *Zanthoxylum armatum* DC. and *Zizyphus oenoplia* were consumed by children on the way to school, or when tending livestock. Some people still pick them on walks to relive the flavours of their childhood. Several workers have also reported such types of observation (Campbell, 1987; Balemie & Kebebew, 2006).

A sizeable number of ornamental climbers (16 sp.) were reported from the district. Prominent among them include. *Allamanda blanchetii* A. DC., Bougainvillea spectabilis Willd., *Campsis grandiflora* (Thunb.), *Clerodendrum thomsoniae* Balf.f., *Epipremnum aureum* (Linden & André) G.S.Bunting,

Pyrostegia venusta (Ker Gawl.) Miers and *Syngonium podophyllum* Schott. Presently in the era of stressful lifestyles and anthropogenic climate change, a large number of people throughout the globe are enriching their surroundings with different types of ornamental plants. The ornamental plants play a significant role in preparing and modifying urban and rural landscapes, fallow land development, afforestation and managing open-air and indoor spaces (Nassary et al., 2022). These plants are essentially grown in our homes, educational and public institutions, and workplaces for beautification, amusement, and enlightenment (Ciftcioglu et al., 2019). The climbers such as *Cuscuta reflexa* Roxb., *Lantana camara* L. and *Mikania micrantha* Kunth were the most abundant and were found across the study region. These invasive plants are quick to colonize damaged areas, causing significant ecological damage to natural ecosystems. The *Lantana camara* is a significant scrambler that has grown naturally all over the world. *L. camara* is one of the major invasive species in Indian forests and an aggressive colonizer practically at forest edges and disturbed and denuded areas (Sahu & Singh, 2008). The perennial *Mikania micrantha* which is a fast-growing species, is covering the habitats of the district and suppressing the growth of agricultural crops as well as natural vegetation through competition and allelopathic effects (Sankaran & Srinivasan, 2001; Huang et al., 2009). Moreover, the relative abundance of woody climbers is increasing in tropical forests (Phillips et al., 2002; Schnitzer & Bongers, 2011) and several of the most aggressive invasive plants worldwide are vines (Holm et al., 1991).

Conclusion

Documentation of diversity of plants especially climbers of angiosperms in Bhadrak district, Odisha, India will be of great significance to assess the present status of floristic diversity in the area. The present study revealed that the climbing plant diversity of Bhadrak district not only contributes to the overall plant biodiversity significantly, but also maintains ecological balance of the whole ecosystem. The results of the present study showed that climber resources of the district continue to play a crucial role in daily livelihood as well as the health care system. Presently, many anthropogenic factors pose a threat to the abundance and distribution of the climbing species. Moreover, invasive alien plant species like *Lantana camara* and *Mikania micrantha* are considered a major threat to the local biodiversity. It is also noticed that the abundance of important climbers of the region like *Aristolochia indica*, *Asparagus racemosus*, *Gloriosa superba*, *Gymnema sylvestre* and *Telosma pallida* are declining day by day. Therefore, there is a need to create awareness among local people to

conserve these plants to ensure their continued existence in the long run. In addition, a multi-pronged approach such as securing their habitats through protection, restoration, managing invasive species, and promoting collaboration among local stakeholders and organizations, safeguards the preservation of these vital plants, sustaining biodiversity and ecosystem health for the future. It is also necessary to continue the study of the climbing plant covering all the ecosystems, as a way to detect the influence of different biotic and abiotic factors in this group of plants.

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