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Original Article

Climber Diversity across Vegetational Landscape of North-Eastern Uttar Pradesh, India

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Abstract

The composition and diversity of climbers among grassland, wasteland and forest vegetations was examined with respect to their woodiness, climbing mode and circumnutation pattern across the vegetational landscape of north-eastern Uttar Pradesh during 2011-2015. A total of 111 climbers, constituting 63 lianas and 48 vine species, under 35 families, were recorded. The forest and wasteland vegetation were quite similar in regard with climber diversity. Family Convolvulaceae included a maximum of 19 climbers. Majority of twining climbers showed right-handed twining. The wasteland vegetation was most suitable and quite similar to forest habitat for vines as well as for lianas. The right handed circumnutation was the dominant pattern among the twiners of the region. Local climbing flora provides considerable natural resource to the region. They often create special micro-habitats and increase the complexity of the ecosystem.

Keywords: circumnutation, climbing mode, liana, stratification, thicket, vine

Introduction

About half of the families of vascular plants contain climber species (Schenck, 1892). Gentry (1991) predicted a very high diversity of vines and lianas in the tropics with over 8,000 species under 130 families. A global analysis reported approximately 80% and 20% of lianas and vines in tropical regions, while in extra-tropical regions they account for 60% and 40%, respectively (Gallagher and Leishman, 2012). The ecological studies of climbers have dealt primarily with lianas (> 1 cm dbh) occurring in tropical forest communities (Schnitzer and Bongers, 2002; Burnham, 2004; Parthasarathy *et al*., 2004; Jayakumar and Nair, 2013). However, relatively few studies have included vines (Kokou *et al*., 2002; Gallagher *et al*., 2011) which play a significant role in the structure and function of grassland ecosystem (Mao and Zhu, 2006; Zhang *et al.,* 2011).

Climbing plants also show great diversity in their climbing mechanisms (Putz, 1984; Bongers *et al*., 2005). They include twiners, tendril climbers, root climbers and scramblers. Climbers also have evolved exaggerated form of circumnutation to increase the probability of encountering a support or avoiding hurdles (Darwin, 1875). Documentation on their behaviour and causes of circumnutation of twining and tendrilar climbers has been worked out by many researchers (Darwin, 1875; Brown, 1993; Larson, 2000; Silk and Holbrook, 2005; Gerbode *et al*., 2012; Silva *et al*., 2016). Twining plants generally show fixed handedness, either consistently forming right-handed or left-handed helices, as they climb (Hashimoto, 2002; Edwards *et al*., 2007). However, Davis (1974), exceptionally observed both in *Mikania micrantha* at different latitudes. Burnham and Revilla-Minaya (2011) presented the handedness of 60 twining taxa of a forest community in Peru and observed both the left and right handed twining in the same individual of a climbing species of family Dilleniaceae. The global trend in plant twining direction was analyzed by Edwards *et al*. (2007), but they were unable to observe any hand reversal in the same twining plant.

The present study provides an account on the diversity of taxa with climbing habit in different vegetation types of north-eastern Uttar Pradesh, India. The study also emphasizes the handedness in twining and tendrilar types of climbers across the vegetation. So far, no information on handedness is available for climbers of India.

Materials and Methods

Study area

The vegetational landscape of north-eastern Uttar Pradesh lies within the Terai belt of the foot hills of the Himalayas. The area extends between 26°21' to 27°32' N latitude and 81°34' to 83°57' E longitude. Mean altitude of the study area is 95 m. The climate of the region is generally tropical monsoonic with three distinct seasons *viz.* summer (March to mid June), monsoon (mid June to mid Oct) and winter (mid Oct to Feb). The total average of annual rainfall is aprox. 1,704 mm, most of which (>94%) is received during monsoon and the rest is

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distributed in the form of occasional showers. The annual mean of relative humidity ranges between 74-87%. The mean maximum temperature during wet summer, winter and dry summer seasons are 34.1 °C, 23.2 °C and 36 °C and mean minimum temperatures are 24.3 °C, 10.3 °C° and 19.7 °C, respectively. The soil of the region is a part of trans-Sarju plain and comprises Gangetic alluvium, ranging from clayey to sandy loam in texture with pH ranging from 6.5 to 7.5.

The major vegetation (physiognomic) types identified in the region are forest, wasteland and grassland (Shukla, 2009). Though regional climax vegetation is semi-evergreen forest (Champion and Seth, 1968), but most of these have been converted into agricultural fields, orchards, human habitations and commercial plantations.

Methods

The current study is based on extensive field survey and analysis of vegetation across the vegetational landscape of the 11 districts of north-eastern Uttar Pradesh during 2011-2015. The identification was done using local and regional flora (Srivastava, 1976; Saini *et al*., 2010) and online Indian floras. The species of climbers were identified with similar specimen of herbarium of Gorakhpur University. The botanical names and author citations were checked through International Plant Name Index (IPNI). An analysis of species diversity of climbers was made on the basis of taxa composing the vegetation types. The climbing mode, occurrence status and approximate life-span of different species have been tabulated in supplementary Table 1.

Climbing plants were inspected for their height they attained and grouped into upper strata (> 20 m), middle strata (10-20 m) and lower strata (< 10 m). The height was measured with the help of clinometer. The objects including plants which supported their climbing were marked and their circumnutation pattern was also observed. Tendrilar climbers were grouped into simple (or unbranched) and branched types. The pattern of handedness was also compared among individuals growing within different habitats or vegetation types. For common and abundant species, 20 individuals of each species were selected, separately for each vegetation types. However, only 5 individuals per species were inspected in case of rare species. The present study addresses climbers only of wild occurrence. The ornamental or garden climbers were excluded from the observation.

Results

Climber diversity

A total of 111 climbing species representing 81 genera under 35 families were encountered across the vegetational landscape of north-eastern Uttar Pradesh. The life-span data showed that about 58.6% of climbers were perennials and the remainders were annuals. Among the six dominant families, Convolvulaceae was the most climber-rich (19 species), followed by Papilionaceae (15 Species), Cucurbitaceae (10 species), Asclepiadaceae (9 species), Dioscoreaceae and Menispermaceae (6 each). The remaining 46.85% of climbers represented 29 families, of which 18 families were represented by only one species of climbers. In terms of genera, Papilionaceae was the most dominant (13), while *Ipomoea* was the most specious genera (11 climbers).

The number of species, genera and family of climbers was highly variable among the three vegetation types (Table 1). The forest and wasteland vegetation were quite similar in climber diversity as compared to grassland vegetation. The species per genus ratio and that of per family ratio was greater in the case of grassland. Among climbing plants, the woody climbers (lianas) were represented by 63 species and herbaceous climbers (vines) by 48 species. There were two parasitic vines *e.g. Cuscuta chinensis* and *C. reflexa*. The forest vegetation was largely dominated by lianas and grassland by vines. Wasteland vegetation was found to be the suitable habitat for both categories of climbers (Fig. 1).

Five climbing mode of climbers were recognized (Fig. 2). Of these, twining (51.35%) was the most prominent mode for climbing, followed by tendrilar (20.72%), straggling-unarmed (15.32%), straggling-armed (10.1%) and aerial root climbing (0.9%).

Stratification

Quite large number of climbers of the region are under lower strata (78 species) followed by middle strata with 17 species and upper strata with 9 species (Table 2). *Tinospora sinensis* reached the most distant canopies (29.75), among the minor woody climbers, preferably over *Bombax cieba*. *Combretum decandrum,* the massive liana, also reached as high as 28 m. All the 9 climbing species of the upper stratum were twiners except *Antigonon leptopus*, which reached a relatively lower height. Majority of the middle strata climbers were lianas. The herbaceous and less woody climbers namely *Coccinia grandis, Dioscorea bulbifera, Ichnocarpus frutescens, Ipomoea quamoclit* and *Telosma pallida* may also reach this layer through twining over *Tinospora sinensis*. The climbers of the lower strata layer were generally of tendrilar type. They grow over shrubby plants and various other objects luxuriantly. The twiners of the lower stratum spread over ground in absence of any support.

Few massive lianas, especially straggling-armed climbers formed thickets in different strata. The chief thicket forming species namely, *Caesalpinia bonduc, C. cucculata, C. decapetatla Calamus tenuis, Capparis zeylanica, Rosa clinophylla* and

Table 1. The number of species, genera and families of climbers and their ratio across the terrestrial landscape of north-eastern Uttar Pradesh

	Vegetation types			Vegetational landscape
	Grassland	Wasteland	Forest	
No. of Species	34	81	83	111
No. of Genera	20	57	67	82
No. of Families	10	25	31	35
Species/genus ratio	1.7	1.4	1.2	1.4
Species/family ratio	3.4	3.2	2.7	3.2

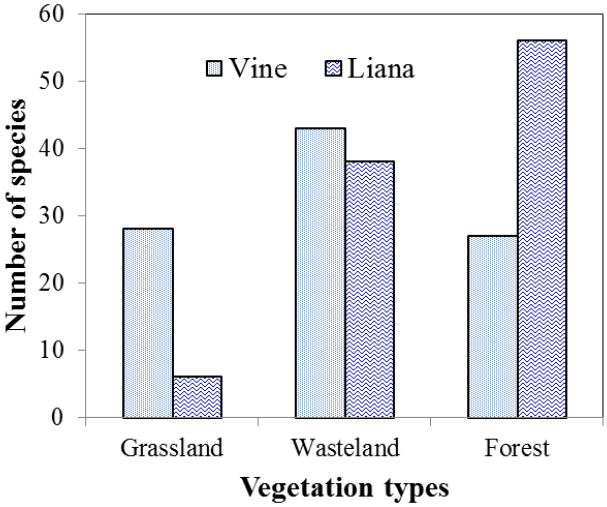

Fig. 1. Number of vines and lianas within different vegetation types

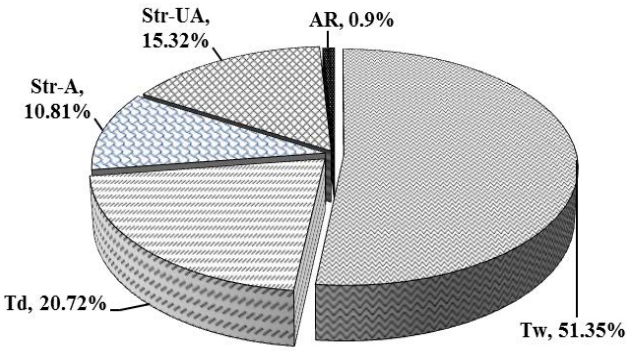

Fig. 2. The occurrence (%) of climbing species as per climbing modes within terrestrial landscape (Abbr. **Tw:** twining; **Td:** tendrilar; **Str-A:** straggling armed; **Str-UA:** straggling unarmed; **AR:** aerial root)

Ziziphus oenoplia constituted the lower strata. *Acacia concinna, Bridelia stipularis* and *Capparis zeylanica*, however, formed thickets and were the components of middle strata. These species often entangled with twiners and acted as a safe repository for rare plants and small mammals.

Climbing and circumnutation

All the twining and tendrilar climbers showed general pattern of handedness irrespective of the vegetation types. Of the 26 tendrilar climbers, 14 species had simple un-branched tendrils, while remaining had branched tendrils. In 9 such species the tendrils were bifid and in 3 species, namely *Antigonon leptopus*, *Naravelia zeylanica* and *Trichosanthes cucumerina* were trifid (Supplementary Table 2). Every tendril showed both the left-handed as well as right-handed coiling. The two species namely, *Smilax perfoliata* and *S. zeylanica* bore two simple tendrils in the axils of leaves. The growth of the bifid tendrils of *Cayratia trifolia* was typical. The branches of the tendrils of the species arise at different distances. One of the bifid branch terminates, while the other one again becomes bifid. Branching of tendril was similarly repeated up to 4th node (Fig. 3). Each terminating tendril ends into a knob like structure. The lower part of the tendrils of *A. leptopus* shows distinct node and internodes. The 4 nodes bent alternately on opposite sides to form a zig-zag pattern (Fig. 4A, B). Among twiners, majority of the species (91%) showed twining in right-handed direction along the support (Fig. 5A). Only in five species, namely *Dioscorea bulbifera*, *D. echinata*, *D. pentaphylla, Merremia dissecta* and *Mikania micrantha* left-handed twining was observed (Fig. 5B, Supplementary Table 3).

Commonness vs. rarity

The number and share of exclusive climber species as well as those common to grassland, wasteland and forest vegetation types has been presented in Venn diagram (Fig. 6). Twelve (12) species were exclusive to wasteland and 26 to forest vegetation. Only 4 species, namely *Ipomoea aquatica*, *Lathyrus aphaca*, *L. odoratus* and *L. sativus* were exclusive to grassland vegetation. Quite a greater number of species of climbers was common to wasteland and forest vegetation. All the three vegetation types were represented by 18 common species namely, *Cajanus scarabaeoides, Cayratia trifolia, Cissampelos pareira, Coccinia grandis, Cuscuta chinensis, C. reflexa, Ichnocarpus frutescens, Ipomoea cairica, I. pes-tigridis, I. quamoclit, Momordica charantia, Operculina turpethum, Oxystelma secamone, Tiliacora racemosa, Tinospora sinensis, Trichosanthes cucumerina* and *Trichosanthes nervifolia*.

A few rare climbers occurred in only one vegetation type but some other rare ones occurred in more than one type. The rare exclusive species were *Acacia concinna, Ampelocissus*

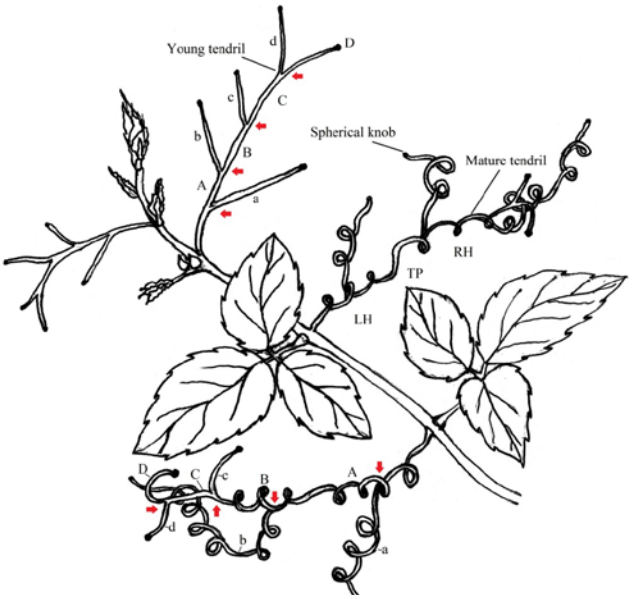

Fig. 3. The branched tendrils of *Cayratia trifolia*

The mature tendrils show both left- handed (LH) and right-handed (RH) coiling with point of tendril perversion (TP). The arrow indicates branching node. At each branching point, the two branches are labeled as A-a, B-b, C-c and D-d, respectively. Tendril branch 'A' bipartite to B-b branch, branch 'B' to C-c branch and eventually branch 'C' to D-d branch. The branches 'a', 'b', 'c' and 'd' remains un-branched. All branches show spherical knob like structure. The knob indicates termination of the branching.

latifolia, Aristolochia indica, Ipomoea nil, Naravelia zeylanica, Spatholobus parviflorus and *Vallaris solanacea*. The rare species, occurring in more than one vegetation types were *Abrus precatorius, Cardiospermum helicacabum, Clitoria ternatea Dioscorea pentaphylla* and *Gloriosa superba*.

Discussion

The present study aims to examine the composition and diversity of climbers among three vegetation types with respect to their woodiness, climbing mode and circumnutation pattern. Such studies with respect to Terai landscape are still lacking. Considerable investigations have been made on the diversity of lianas of forest vegetation in India (Reddy and Parthasarathy, 2003; Parthasarathy *et al*., 2004; Jayakumar and Nair, 2013), Recently, Aziz *et al*. (2016), observed the growth pattern of tendril in *Lagenaria sicereria*. The vines need attention especially with respect to their climbing pattern along the support.

The result indicates clear differences in the occurrence and diversity of climbers among different vegetation. The wasteland and forest vegetation were nearly similar in the composition of climbing species. Lianas were distributed in all the three vegetation but most diverse in forest vegetation. This may probably due to the greater support diameter. In absence of support, the pliable stems of the liana grow only up to the 1.5 meter in height (Putz, 1984). Lianas have to climb on trees, if not, and then they continue to grow very slowly in the low light of the understory (Putz, 1984). The anchoring strategies and stem anatomical features favours their growth over upright trees (Garrido-Perez and Burnham, 2010). Convolvulaceae was the most specious family of climbing plants as also reported from the southern Western Ghats of Coimbatore (Sarvalingan and Rajendran, 2015). Twining was the most prominent mode of climbing that has also been cited for other (DeWalt *et al*., 2000; Parthasarathy *et al*., 2004).

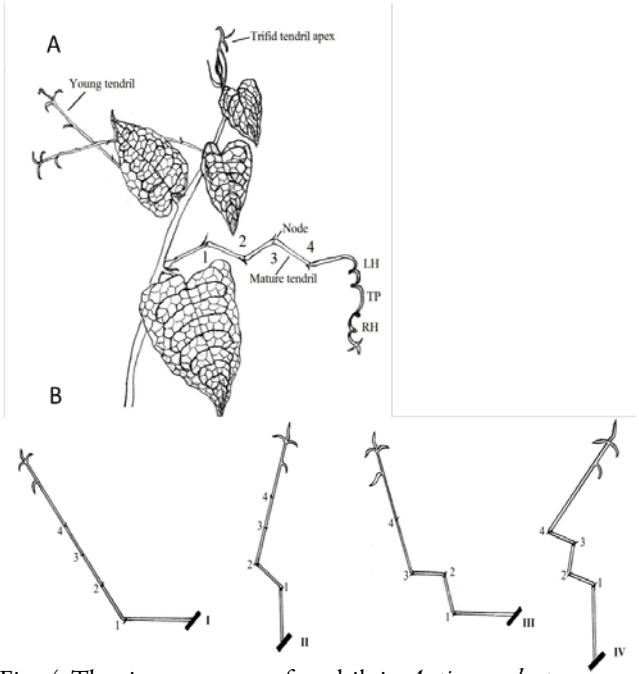

Fig. 4. The zig-zag pattern of tendrils in *Antigonon leptopus*
Each tendril has four nodes. A. The twig with tendril (the young upper tendrils are without any turn). The lower mature tendril has alternate turns (1-4). B. The developmental stages of turns (I-IV) in maturing tendril. The abbreviations LH, TP and RH stand same as in figure 5

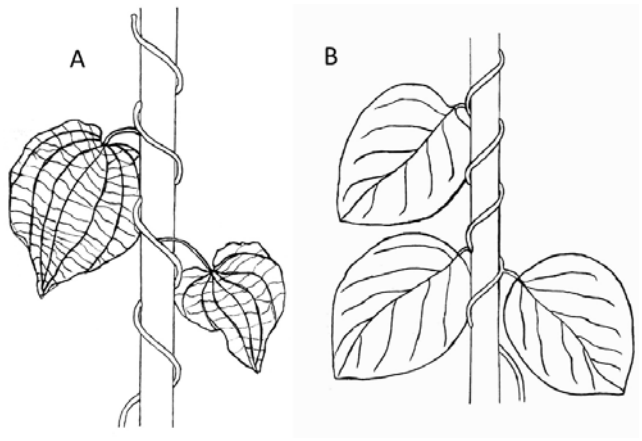

Fig. 5. The two species show their direction of twining. **A.** *Dioscorea bulbifera* stem twining in the left-hand direction and **B.** *Basella alba* stem in the right-hand direction

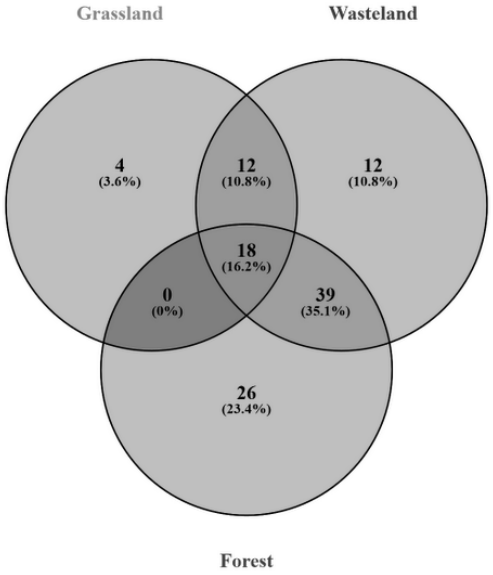

Fig. 6. The diagram showing the number of exclusive species and those common to three vegetation types

Stratification and thicket

Due to greater proportion of weak stems of twining, tendrilar and straggling-unarmed climbers lower strata shows maximum number of species. The species reaching to middle and upper strata were mostly lianas. In the absence of suitable support they grow with lower strata (Putz, 1984). The supports on which climbers ascend were not species-specific. They are the highest peak where a species of climber reached. Several studies demonstrated earlier that the lianas and trees are not in species-specific relation (Perez-Salicarp *et al*., 2001; Malizia and Garau, 2006). *Tinospora sinensis* is the most frequent climbing plant of all the three vegetation types and also provides support for various herbaceous climbers like

Basella alba, Cayratia trifolia, Coccinia grandis, Ipomoea quamoclit.

Climbers also have various resource value of ecological and economic importance (Tra Bi *et al*., 2005; Khare, 2007; Parthasarathy *et al*., 2015). The straggling-armed climbers e.g., *Caesalpinia bonduc, C. cucculata, C. decapetala, Calamus tenuis, Capparis zeylanica, Rosa clinophylla* and *Ziziphus oenoplia* form dense thickets. These lower strata thickets create suitable micro-habitat for rare plant taxa like *Baccopa monierii*, *Gloriosa superba*, *Helminthostachys zeylanica*, *Pergularia foetida*, *Oxystelma secamone*, *Rauwolfia serpentina* and many other shade tolerant species as also reported by Pandey and Shukla (2003). Gonzalez-Teuber and Gianoli (2008) reported greater reproductive output in *Convolvulus chilensis* that were associated with thorny shrubs. These thickets are also safe house for rodents and other small mammals which provide dispersal of the plant propagules during migration from one thicket to the others. Thus, thickets provide conservation of these special micro-habitats for conservation of small species.

Circumnutation pattern

Several authors mentioned that twining handedness can be constant within a species but differ between species (Sachs, 1882; Ornduff, 1991; Hashimoto, 2002; Lubkin, 2004). However, Davis (1974) observed both the left-handed and right-handed twining stem in *Mikania micrantha* at different latitudes. The current results confirm the verified principle that most of the twining plants ascend their host by forming right-handed helices. We observed 93% right-handed twining. Edwards *et al*. (2007) reported 92.5% of the twining stem in the same direction. Though, their data on twining direction is not based at species level. Burnham and Revilla-Minaya (2011) reported 83% taxa at species level that were dextral (right handed) in direction. Our results further indicate a general pattern of twining direction irrespective of the three vegetations and similar pattern was also claimed by Edwards *et al*. (2007) at wide range of vegetation types and geographical location across the globe. Burnham and Revilla-Minaya (2011) reported ambidextrous twining phenomenon in members of the family Dilleniaceae. They observed stem circumnutation in one direction, and after 2-3 revolutions they further noticed the changes in direction for 2-3 revolutions in the same individuals. Darwin (1875), Dufor (1902), Ornduff (2004) also reported this reversal in handedness in several species. In the present study no such reversal was observed. The species of genus *Dioscorea* showed both the left-handed and right-handed direction. Baillaud (1962) also reported that the species of this genus twin either right-handed or left-handed direction.

Among tendrilar climbers, 56% had simple un-branched tendril. The branched tendrilar climbers were either bifid or trifid. The branches may provide greater probability to find support and also may give greater chance to attach on the support under disturbed environment. This may probably makes the plant very flexible to their attachment under strain. Both the left- handed and right-handed circumnutations were observed in every tendril of a species. The two directions of handedness were separated by tendril perversion in successive manner. Tendril perversion is the change in the helix structure to hemi-helix structure (Liu *et al*., 2014). This helical coiling axially shortens the tendril, pulling the plants towards the attachment point (Gerbode *et al*., 2012). Tendril perversion provides quite greater flexibility than a regular coiled tendril in a plant (Aziz *et al*., 2016). The alternate turns of mature tendrils of *Antigonon leptopus* provides additional flexibility. During external pull on plants these alternate turns become relaxed and thus conquer its detachment from the support.

To explain circumnutation, different authors have proposed different empirical and theoretical explanations such as roles of thigmotropism (Darwin and Darwin, 1881), phototropism (Sachs, 1882), geotropism (Israelsson and Johnsson, 1967; Kitazawa *et al.,* 2005), microfibril orientation in xylem (Silk and Hubbard, 1991), epidermal cell anisotropism (Hashimoto, 2002), microtubule orientation in cells (Edwards *et al*., 2007), anatomical asymmetry (Silk and Hubbard, 1991; Bowling and Vaughn, 2009), radial stem expansion during primary growth or the growth of lateral structures (Silk and Holbrook, 2005; Isnard *et al*., 2009).

Common, exclusive and rare climbers

It has been observed that the exclusive climber diversity increases as the complexity of the vegetation changes from grassland to wasteland, to forest. The species occurring in all the three vegetation types are also very common in the region, except *Oxystelma secamone*. Some species like *Antigonon leptopus*, *Bauhinia vahlii* are abundant and frequent climbers of wasteland and forest vegetation types, respectively. The wasteland and forest share most of the climbing species (35%) and their diversity was also quite similar. Wasteland represented suitable habitat for both the vines and lianas. This was probably due to the greater protection of their propagules and availability of support in this vegetation type.

Grassland vegetation, represented by 34 climbing species, is the most disturbed vegetation across the landscape. Several species namely, *Cajanus scarabaeoides, Cayratia trifolia, Cissampelos pareira, Coccinia grandis, Ichnocarpus frutescens, Ipomoea cairica, Momordica dioica, Operculina turpethum, Teramnus labialis, Trichosanthes cucumerina* and *Trichosanthes nervifolia* have either rhizomatous or tuberous roots or woody rootstock that is helpful in the survival and growth of these climbers in disturbed habitat. Some herbaceous climbers like *Lathyrus aphaca*, *L. odoratus*, *L. sativa* and *Vicia hirsuta* were also present as common weeds in adjacent agricultural fields. Some rare climbers occurred in one or two vegetation types. A few climbers like *Oxystelma secamone*, *Rhynchosia minima* and *Spatholobus parviflorus* which are quite rare in this region are, however, included in the Least Concern category of Red Data Book (Lansdown 2011; Chadburn 2012; Poveda 2012). *Dioscorea deltoidea* is categorized as Vulnerable in India (Nayar and Sastry, 1990).

Several climbers of grassland vegetation are known to produce secondary metabolites which repel their herbivores (Subramanayam *et al*., 2007). These plant species have evolved traits to tolerate or resist disturbance (Diaz *et al*., 2007 Dobarro *et al*., 2013). A number of climbers are used locally in various ways. The aerial bulbs of *D. bulbifera* and *D. oppositifolia* are consumed as food. The leaves of *Bauhinia vahlii* are used as meal plate by rural poor. The natural ingredient of seeds of *Mucuna pruriens* (L-DOPA) is valuable in the treatment of Parkinson disease (Dymock and Warden, 1980). In past, jewellers used the seeds of *Abrus precatorius* (Ratti) as weight measures. An herbaceous climber, *Mikania micrantha,* on the

Table 2. The height (ht) climbed by various climbers, grouped within upper strata (> 20 m), middle strata (10-20 m) and lower strata (< 10 m)

S.N.	Climbing species	Supporting plant/object	Average ht. climbed (mean ± S.E.) (m)
		UPPER STRATA (> 20 m)	
1.	*Antigonon leptopus*	*Bombax cieba*	21.90 ± 12.23
2.	*Bauhinia vahlii*	*Shorea robusta*	22.46 ± 8.45
3.	*Cissampelos pareira*	*T. sinensis-Terminalia bellerica*	27.47 ± 9.93
4.	*Combretum decandrum*	*Ailanthus excelsa*	28.07 ± 8.04
5.	*Scindapsus officinalis*	*Ficus benghalensis*	24.45 ± 2.10
6.	*Thunbergia grandiflora*	*Bombax cieba*	27.43 ± 3.32
7.	*Tiliacora racemosa*	*Terminalia bellerica*	22.45 ± 3.56
8.	*Tinospora sinensis*	*Bombax cieba*	29.75 ± 2.98
9.	*Ventilago maderaspatana*	*Terminalia bellerica*	20.68 ± 4.59
		MIDDLE STRATA (10-20 m)	
1.	*Acacia concinna*	*Shorea robusta*	12.85 ± 5.20
2.	*Bridelia stipularis*	*Adina cordifolia*	12.92 ± 2.26
3.	*Capparis zeylanica*	*Bombax cieba*	12.68 ± 2.51
4.	*Celastrus paniculatus*	*Alangium solvifolium*	17.92 ± 3.87
5.	*Cissus adnata*	*Terminalia cattapa*	11.57 ± 4.44
6.	*Coccinia grandis*	*Tinospora sinensis*	12.21 ± 1.63
7.	*Dalbergia volubilis*	*Bombax cieba*	12.63 ± 2.94
8.	*Derris scandens*	*Ailanthus excelsa*	16.88 ± 2.78
9.	*Dioscorea bulbifera*	*T. sinensis-Anthocephalus cadamba*	16.56 ± 3.31
10.	*Embelia ribes*	*Alangium solvifolium*	14.83 ± 2.68
11.	*Erycibe paniculata*	*Tectona grandis*	15.90 ± 3.35
12.	*Ichnocarpus frutescens*	*T. sinensis-Anthocephalus cadamba*	16.75 ± 4.25
13.	*Ipomoea quamoclit*	*Leucaena leucocephala*	12.68 ± 1.23
14.	*Milletia auriculata*	*Shorea robusta*	15.50 ± 3.12
15.	*Porana paniculata*	*Celtis australis*	12.30 ± 2.03
16.	*Spatholobus parviflorus*	*Toona ciliata*	11.32 ± 2.88
17.	*Telosma pallida*	*Tinospora sinensis*	16.18 ± 3.65
		LOWER STRATA (< 10 m)	
1.	*Abrus precatorius*	*Capparis zeylanica*	8.66 ± 1.33
2.	*Aganosma caryophyllata*	*Pongamia pinnata*	3.25 ± 1.45
3.	*Ampelocissus latifolia*	*Calamus tenuis*	6.43 ± 1.23
4.	*Argyreia sericea*	Bushes	4.45 ± 0.56
5.	*Argyreia speciosa*	Bushes	9.24 ± 2.22
6.	*Aristolochia indica*	*Bauhinia purpurea*	3.25 ± 0.87
7.	*Asparagus racemosus*	*Calamus tenuis*	6.84 ± 2.53
8.	*Basella alba*	*Ricinus communis*	4.60 ± 0.56
9.	*Caesalpinia bonduc*	Form self thicket	7.12 ± 1.63
10.	*Caesalpinia cucullata*	*Antidesma ghesembilla*	4.20 ± 1.23
11.	*Caesalpinia decapetala*	*Acacia concinna*	9.42 ± 2.12
12.	*Cajanus scarabaeoides*	*Tinospora sinensis*	3.45 ± 2.22
13.	*Calamus tenuis*	Form self thicket	5.43 ± 1.11
14.	*Campsis grandiflora*	*Tectona grandis*	9.22 ± 2.65
15.	*Cardiospermum halicacabum*	*Leucaena leucocephala*	2.45 ± 0.43
16.	*Cayratia trifolia*	*Tinospora sinensis*	4.20 ± 0.22
17.	*Clematis gouriana*	*Ehretia aspera*	5.03 ± 1.02
18.	*Clerodendrum splendens*	*Ficus religiosa*	5.89 ± 2.02
19.	*Clitoria ternatea*	*Mimosa himalayana*	2.94 ± 0.98
20.	*Cocculus hirsutus*	*Trema orientalis*	4.10 ± 1.12
21.	*Cocculus trilobus*	*Morus alba*	3.45 ± 1.53
22.	*Convolvulus arvensis*	Wire fence	2.21 ± 0.93
23.	*Cryptolepis dubia*	Bushes	5.20 ± 1.58
24.	*Cryptolepis elegans*	Bushes	3.11 ± 1.13

25.	*Cryptostegia grandiflora*	*Antidesma ghesembilla*	2.10 ± 1.10
26.	*Cucumis trigonus*	*Cassia occidentalis*	1.82 ± 0.87
27.	*Cuscuta chinensis*	*Aeschynomene indica*	0.57 ± 0.11
28.	*Cuscuta reflexa*	*Mangifera indica*	4.53 ± 0.65
29.	*Dioscorea deltoidea*	*Tinospora sinensis*	3.20 ± 0.69
30.	*Dioscorea echinata*	*Cassia fistula*	3.56 ± 1.03
31.	*Dioscorea japonica*	*Bridelia squamosa*	4.12 ± 1.50
32.	*Dioscorea oppositifolia*	*Melia azadirach*	5.43 ± 1.79
33.	*Dioscorea pentaphylla*	*Flacourtia jangomas*	2.23 ± 0.37
34.	*Diplocyclos palmatus*	*Ziziphus mauritiana*	3.68 ± 0.91
35.	*Embelia tsjeriam-cottam*	*Biscofia javanica*	2.80 ± 1.02
36.	*Ficus heterophylla*	*Calamus tenuis*	2.85 ± 0.97
37.	*Gloriosa superba*	*Saccharum spontaneum*	2.95 ± 0.56
38.	*Hemidesmus indicus*	*Mallotus philippensis*	3.52 ± 1.02
39.	*Ipomoea aquatica*	*Ipomoea fistulosa*	2.12 ± 1.10
40.	*Ipomoea cairica*	Electric pole	5.46 ± 1.11
41.	*Ipomoea eriocarpa*	*Saccharum spontaneum*	2.56 ± 1.05
42.	*Ipomoea hederifolia*	*Cissampelos pariera-Mangifera indica*	5.43 ± 1.85
43.	*Ipomoea maxima*	Bushes	4.62 ± 1.72
44.	*Ipomoea muricata*	Fence walls	2.40 ± 1.68
45.	*Ipomoea nil*	Fence walls	4.34 ± 1.89
46.	*Ipomoea obscura*	*Calotropis procera*	2.23 ± 1.52
47.	*Ipomoea pes-tigridis*	Electric pole	6.06 ± 1.50
48.	*Ipomoea purpurea*	*Tinospora sinensis*	1.98 ± 0.55
49.	*Merremia dissecta*	*Mimosa himalayana*	4.10 ± 1.23
50.	*Merremia hederacea*	*Saccharum officinarum*	2.52 ± 1.10
51.	*Mikania micrantha*	Bushes	3.34 ± 1.10
52.	*Momordica charantia*	*Morus indica*	2.32 ± 1.02
53.	*Momordica dioica*	*Ziziphus mauritiana*	2.43 ± 0.98
54.	*Mucuna pruriens*	*Tectona grandis*	8.24 ± 2.54
55.	*Mukia maderaspatana*	*Capparis zeylanica*	3.25 ± 1.12
56.	*Naravelia zeylanica*	*Pithecellobium dulce*	8.20 ± 1.89
57.	*Operculina turpethum*	*Trema orientalis*	4.46 ± 1.71
58.	*Oxystelma secamone*	*Ipomoea fistulosa*	2.20 ± 1.02
59.	*Paederia foetida*	*Eugenia jambos*	8.21 ± 3.05
60.	*Passiflora foetida*	*Trema orientalis*	3.26 ± 0.77
61.	*Pentatropis spiralis*	*Trema orientalis*	4.25 ± 0.53
62.	*Pergularia daemia*	*Calotropis procera*	1.08 ± 0.36
63.	*Piper longum*	*Caesalpinia bonduc*	3.20 ± 0.96
64.	*Rhynchosia minima*	*Cerodendron indicum*	1.23 ± 1.03
65.	*Rosa clinophylla*	*Calamus tenuis*	6.54 ± 1.98
66.	*Solena heterophylla*	*Diospyros melanoxylon*	7.68 ± 2.78
67.	*Smilax perfoliata*	*Azadirachta indica*	8.24 ± 2.56
68.	*Smilax zeylanica*	*Streblus asper*	7.78 ± 3.34
69.	*Stephania japonica*	*Bombax cieba*	8.82 ± 1.45
70.	*Teramnus labialis*	*Caesalpinia bonduc*	3.40 ± 1.26
71.	*Tragia involucrata*	*Adhatoda vasica*	2.81 ± 1.02
72.	*Trichosanthes cucumerina*	*Shorea robusta*	3.68 ± 1.23
73.	*Trichosanthes nervifolia*	*Ziziphus oenoplia*	3.37 ± 1.54
74.	*Tylophora indica*	*Calotropis procera*	1.30 ± 1.10
75.	*Vallaris solanacea*	Bushes	7.23 ± 2.39
76.	*Wagatea spicata*	*Pithecellobium dulce*	4.71 ± 1.58
77.	*Ziziphus oenoplia*	*Streblus asper*	3.32 ± 1.47
78.	*Ziziphus xylopyrus*	*Ficus cunia*	1.83 ± 1.06

other hand, is one of the 100 worst invasive alien species in the world (Lowe *et al*., 2001). It has been reported as a problematic weed in the plantation forests of north-east and south-west India (Parker, 1972). Due to recurrent disturbances and degradation of forest and wastelands, most of the valuable climbers have currently become much scarce.

Conclusions

Local climbing flora provides considerable natural resource to the region. They often create special micro-habitats and increase the complexity of the ecosystem. But in recent past, recurrent disturbances in the form of habitat destruction, grazing, trampling and fire across the landscape have wiped out

a number of climbers. The basic information on their diversity, distribution and circumnutation or climbing handedness pattern may be used to emphasize the need of their conservation at regional level.

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References

Aziz R, Barman A, Bhattacharjee U, Kumar R, Kalita E, Ray SK (2016). Tendril perversion in cucurbits. Everyman's Science 289-294.

Baillaud L (1962). Les mouvements d'exploration et d'enroulement des plantes volubiles [Exploration movements and winding twiners]. Handb Pflanzenphysiologie 17:635-715.

Bongers F, Parren MPE, Swaine MD, Traore D (2005). Forest climbing plants of West Africa: Introduction. In: Bongers F, Parren MPE, Traore D (Eds). Forest climbing plants of West Africa: Diversity, Ecology and Management. CAB International, Wallingford, Oxfordshire, UK pp 5-18.

Bowling AJ, Vaughn KC (2009). Gelatinous fibers are widespread in coiling tendrils and twining vines. American Journal of Botany 96:719-727.

Brown AH (1993). Circumnutations: from Darwin to space flights. Plant Physiology 101:345-348.

Burnham R, Revilla-Minaya, C (2011). Phylogenetic influence on twining chirality in lianas from Amazonian Peru. Annals of Missouri Botanical Garden 98:196-205.

Burnham RJ (2004). Alpha and beta diversity of Lianas in Yasuní Ecuador. Forest Ecology and Management 190:43-55.

Chadburn H (2012). *Spatholobus parviflorus*. The IUCN Red List of Threatened Species 2012: e.T19892187A20144268. Retrieved 2016 Jul 26 from http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T19892187A20144268.en.

Champion HG, Seth SK (1968). General silviculture for India. Publication branch, Department of Printing and Stationary, Government of India, Delhi.

Darwin C (1875). The movements and habits of climbing plants (2nd ed), D. Appleton and Company, New York.

Darwin C, Darwin F (1881). The power of movement in plants. John Murray, London.

Davis TA (1974). Enantiomorphic structures in plants. Proceedings of Indian National Science Academy B 40:424-429.

DeWalt SJ, Schnitzer SA, Denslow JS (2000). Density and diversity of lianas along a chronosequence in a central Panamanian lowland forest. Journal of Tropical Ecology 16:1-9.

Díaz SS, Lavorel F, de Bello F, Quétier K, Grigulis, Robson TM (2007). Incorporating plant functional diversity effects in ecosystem service assessments. Proceedings of National Academy of Science USA 104:20684-20689.

Dobarro I, Pérez Carmona C, Peco B (2013). Dissecting the effects of simulated cattle activity on floristic composition and functional traits in Mediterranean grasslands. PLoS ONE 8: e79822. doi:10.1371/journal.pone.0079822.

Dufour A (1902). Climbing plants of Ohio. Ohio Naturalist 2:197-200.

Dymock W, Warden CJ (1980). *Mucuna*. Pharmacographia Indica 1:477-480.

Edwards W, Moles AT, Franks P (2007). The global trend in plant twining direction. Global Ecology and Biogeography 16:795-800.

Gallagher RV, Leishman MR (2012). A global analysis of trait variation and evolution in climbing plants. Journal of Biogeography 39:1757-1771.

Gallagher RV, Leishman MR, Moles AT (2011). Traits and ecological strategies of Australian tropical and temperate climbing plants. Journal of Biogeography 38:828-839.

Garrido-Perez EI, Burnham RJ (2010). The evolution of host specificity in liana-tree interactions. Puente Biológico 3:145-157.

Gentry AH (1991). The distribution and evolution of climbing plants. In: Putz FE, Mooney HA (Eds). The Biology of Vines. Cambridge University Press, Cambridge pp 3-49.

Gerbode SJ, Puzey JR, McCormick AG, Mahadevan L (2012). How the cucumber tendril coils and overwinds. Science 337:1087-1091.

González-Teuber M, Gianoli E (2008). Damage and shade enhance climbing and promote associational resistance in a climbing plant. Journal of Ecology 96:122-126.

Hashimoto T (2002). Molecular genetic analysis of left–right handedness in plants. Philosophical Transaction of the Royal Society of London B: Biological Sciences 357(1422):799-808.

Isnard S, Cobb AR, Holbrook NM, Zwieniecki M, Dumais J (2009). Tensioning the helix: a mechanism for force generation in twining plants. Philosophical Transaction of the Royal Society of London B: Biological Sciences. doi: 10.1098/rspb.2009.0380

Israelsson D, Johnsson A (1967). A theory of circumnutation in *Helianthus annuus*. Physiologia Plantarum 20:957-976.

Jayakumar R, Nair KKN (2013). Diversity and distribution of vines in the tropical forests of Nilgiri Biosphere Reserve, India. Current Science 105:470-479.

Khare CP (2007). Indian medicinal plants: an illustrated dictionary, Springer, New York.

Kitazawa D, Hatakeda Y, Kamada M, Fujii N, Miyazawa Y, Hoshino A, Iida S, Fukaki H, Morita MT, Tasaka M, Suge H, Takahashi H (2005). Shoot circumnutation and winding movements require gravisensing cells. Proceedings of National Academy of Science USA 102:18742-18747.

Kokou K, Couteron P, Martin A, Caballé G (2002). Taxonomic diversity of lianas and vines in forest Fragments of southern Togo. Revue d Ecologie (Terre Vie) 57:1-16.

Lansdown RV 2011. *Oxystelma esculentum*. The IUCN Red List of Threatened Species. Version 2015.2. Retrieved 2016 Jul 26 from http//:*www.iucnredlist.org*.

Larson KC (2000). Circumnutation behavior of an exotic honeysuckle vine and its native congener: Influence on clonal mobility. American

Journal of Botany 87:533-538.

Liu J, Huang J, Su T, Bertoldi K, Clarke DR (2014). Structural transition from helices to hemihelices. PLoS ONE 9:e93183. doi:10.1371/journal.pone.0093183

Lopez Poveda L (2012). *Rhynchosia minima*. The IUCN Red List of Threatened Species. Version 2015.2. Retrieved 2016 Jul 26 from http//:*www.iucnredlist.org*.

Lowe S, Browne M, Boudjelas S, De Poorter M (2001). 100 of the World's Worst Invasive Alien Species: A selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG) 12 pp.

Lubkin S (2004). Unidirectional waves on rings: Models for chiral preference of circumnutating plants. Bulletin of Mathematical Biology 56:795-810.

Malizia A, Grau R (2006). Liana-host tree associations in a subtropical montane forest of north-western Argentina. Journal of Tropical Ecology 22:331-339.

Mao ZH, Zhu JJ (2006). Effects of disturbances on species composition and diversity of plant communities. Acta Ecologica Sinicia 26:2695-2701.

Nayar MP, Sastry ARK (1990). Red Data Book of Indian plants, Vol. III. Botanical Survey of India, Calcutta, India.

Ornduff R (1991). Handedness in twining tracheophytes. American Journal of Botany 78:208.

Ornduff R (2004). Handedness in twining tracheophytes. In: Gleanings in Plant Sciences: Feschrift [sic] in Honour of Prof. Bir Bahadur. Regency Publications, New Delhi pp 1-20.

Pandey SK, Shukla RP (2003). Plant diversity in managed sal (*Shorea robusta* Gaertn.) forests of Gorakhpur, India: species composition, regeneration and conservation. Biodiversity and Conservation 12:2295-2319.

Parker C (1972). The *Mikania* problem. Tropical Pest Management 18:312-315.

Parthasarathy N, Muthuramkumar S, Reddy MS (2004). Patterns of liana diversity in tropical evergreen forests of peninsular India. Forest Ecology and Management 190:15-31.

Parthasarathy N, Vivek P, Anil K (2015). Liana diversity and their ecosystem services in tropical dry evergreen forest on the Coromandel Coast of India. In: Parthasarathy N (Ed). Biodiversity of Lianas, Sustainable Development and Biodiversity 5, Springer International Publishing Switzerland. doi: 10.1007/978-3-319-14592-1_10

Pérez-Salicrup DR, Sork VL, Putz FE (2001). Lianas and trees in a liana forest of Amazonian Bolivia. Biotropica 33:34-47.

Putz FE (1984). The natural history of lianas on Barro Colorado Island, Panama. Ecology 65: 1713-1724.

Reddy MS, Parthasarathy N (2003). Liana diversity and distribution in four tropical dry evergreen forests on the Coromandel coast of south India. Biodiversity and Conservation 12:1609-1627.

Sachs J (1882). Text-book of Botany, Morphological and Physiological, Clarendon Press, Oxford, UK

Saini DC, Singh SK, Rai K (2010). Biodiversity of aquatic and semi-aquatic plants of Uttar Pradesh with special reference to eastern Uttar Pradesh. Uttar Pradesh State Biodiversity Board, Lucknow, India.

Sarvalingam A, Rajendran A (2015). Climbing Plants of the Southern Western Ghats of Coimbatore in India and Their Economic Uses. American-Eurasian Journal of Agriculture and Environmental Science 15:1312-1322.

Schenk H (1892). Beitrage zur Biologie und Anatomie der Lianan, im Besonderen der in Brasilien einheimischen Arten. Theil I. Beitrage zur Biologie der Lianen [Contributions to biology and anatomy of vines, in particular the indigenous species in Brazil. Section I. Contributions to the biology of lianas]. Biologiches Zentralblatt 12:708-713.

Schnitzer SA, Bongers F (2002). The ecology of lianas and their role in forests. Trends in Ecology and Evolution 17:223-230.

Shukla RP (2009). Pattern of plant species diversity across *Terai* landscape in north-eastern Uttar Pradesh, India. Tropical Ecology 50:111-123.

Silk WK, Holbrook NM (2005). The importance of frictional interactions in maintaining the stability of the twining habit. American Journal of Botany 92:1820-1826.

Silk WK, Hubbard M (1991). Axial forces and normal distributed loads in twining stems of morning glory. Journal of Biomechanics 24:599-606.

Silva PES, Trigueiros JL, Trindade AC, Simoes R, Dias RG, Godinho MH, de Abreu FV (2016). Perversions with a twist. Scientific Repor 6:23413. doi: 10.1038/srep23413

Srivastava TN (1976). Flora Gorakhpurensis. Today & Tomorrow's Printers & Publishers, New Delhi, India.

Subramanyam R, Newmaster SG, Paliyath G, Newmaster CB (2007). Exploring ethnobiological classifications for novel alternative medicine: A case study of *Cardiospermum halicacabum L.* (Modakathon, Balloon Vine) as a traditional herb for treating rheumatoid arthritis. Ethnobotany 19:1-18.

Tra Bi FH, Kouame FN, Traore D (2005) Utilisation of climbers in two forest reserves in west Coted'Ivoire. In: Bongers F, Parren MPE, Traore D (Eds). Forest climbing plants of West Africa: diversity, ecology, and management. CABI Publishing, Wallingford pp 167-182.

Zhang H, Tao J, Wang L, Zuo J, Wang Y, He Z, Liu J, Guo Q (2011). Influences of herbaceous vines on community characteristics in pioneer succession stages. Acta Ecologica Sinica 31:186-191.

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Supplementary files

Climber Diversity across Vegetational Landscape of North-Eastern Uttar Pradesh, India

Supplementary Table 1.

General habitat and climbing categories of climbers of north-eastern Uttar Pradesh. Vegetation (Habitat) types - G = Grassland, W = Wasteland, F = Forest. Life span- A = Annual, Per = Perennial; Climber category- L = Liana (woody climber), V = Vine (herbaceous climber); Climbing mode- Tw = Twining, Td = Tendrilar, Str-A = Straggling Armed, Str-UA = Straggling Unarmed, AR = Aerial Root

[Nomenclature according to The Plant List database (*http://www.theplantlist.org*)]

S.N.	Species	Family	Vegetation (Habitat) types	Life span	Climber category	Climbing mode
1.	*Abrus precatorius* L.	Papilionaceae	W, F	Per	L	Tw
2.	*Acacia concinna* (Willd.) DC.	Mimosaceae	F	Per	L	Str-A
3.	*Aganosma caryophyllata* (Roxb. ex Sims) G. Don	Apocynaceae	F	Per	L	Tw
4.	*Ampelocissus latifolia* (Roxb.) Planch.	Vitaceae	F	Per	L	Td
5.	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	W	Per	V	Td
6.	*Argyreia sericea* Dalzell	Convolvulaceae	W	Per	L	Str-UA
7.	*Argyreia speciosa* (L. f.) Sweet	Convolvulaceae	W	Per	L	Str-UA
8.	*Aristolochia indica* L.	Aristolochiaceae	F	Per	L	Tw
9.	*Asparagus racemosus Willd.*	Liliaceae	F	Per	V	Tw
10.	*Basella alba* L.	Basellaceae	W	A	V	Tw
11.	*Bauhinia vahlii* Wight & Arn.	Caesalpiniaceae	F	Per	L	Td
12.	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae	W	A	V	Td
13.	*Bridelia stipularis* (L.) Blume	Euphorbiaceae	F	Per	L	Str-A
14.	*Caesalpinia bonduc* (L.) Roxb.	Caesalpiniaceae	W, F	Per	L	Str-A
15.	*Caesalpinia cucullata* Roxb.	Papilionaceae	F	Per	L	Str-A
16.	*Caesalpinia decapetala* (Roth) Alston	Caesalpiniaceae	W, F	Per	L	Str-A
17.	*Cajanus scarabaeoides* (L.) Thouars	Papilionaceae	G, W, F	A	V	Tw
18.	*Calamus tenuis* Roxb.	Arecaceae	F	Per	L	Str-A
19.	*Campsis grandiflora* (Thunb.) K.Schum.	Bignoniaceae	W, F	Per	L	Str-UA
20.	*Capparis zeylanica* L.	Capparidaceae	W, F	Per	L	Str-A
21.	*Cardiospermum halicacabum* L.	Sapindaceae	G, W	A	V	Tw
22.	*Cayratia trifolia* (L.) Domin	Vitaceae	G, W, F	Per	V	Td
23.	*Celastrus paniculatus* Willd.	Celastraceae	F	Per	L	Tw
24.	*Cissampelos pareira* L.	Menispermaceae	G, W, F	Per	L	Tw
25.	*Cissus adnata* Roxb.	Vitaceae	W, F	Per	L	Td
26.	*Clematis gouriana* Roxb. ex DC.	Ranunculaceae	W, F	Per	L	Tw
27.	*Clerodendrum splendens* G.Don	Verbenaceae	W, F	Per	L	Tw
28.	*Clitoria ternatea* L.	Papilionaceae	W, F	Per	L	Tw
29.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	G, W,F	A	V	Td
30.	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae	W	Per	L	Tw
31.	*Cocculus trilobus* (Thunb.) DC.	Menispermaceae	W	Per	L	Tw
32.	*Combretum decandrum* Jacq.	Combretaceae	F	Per	L	Str-UA
33.	*Convolvulus arvensis* L.	Convolvulaceae	W, F	A	V	Tw
34.	*Cryptolepis dubia* (Burm.f.) M. R. Almeida	Asclepiadaceae	W, F	Per	L	Str-UA
35.	*Cryptolepis elegans* Wall. ex G.Don	Asclepiadaceae	W, F	Per	L	Str-UA

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36.	*Cryptostegia grandiflora* Roxb. ex R.Br.	Asclepiadaceae	W, F	Per	L	Str-UA
37.	*Cucumis trigonus* Roxb.	Cucurbitaceae	G,W, F	A	V	Td
38.	*Cuscuta chinensis* Lam.	Cuscutaceae	G, W, F	A	P	Tw
39.	*Cuscuta reflexa* Roxb.	Cuscutaceae	G, W, F	A	P	Tw
40.	*Dalbergia volubilis* Roxb.	Papilionaceae	F	Per	L	Str-UA
41.	*Derris scandens* (Roxb.) Benth.	Papilionaceae	F	Per	L	Tw
42.	*Dioscorea bulbifera* L.	Dioscoreaceae	W, F	Per	L	Tw
43.	*Dioscorea deltoidea* Wall. Ex Griseb.	Dioscoreaceae	W, F	A	L	Tw
44.	*Dioscorea echinata* R. Knuth	Dioscoreaceae	W, F	A	L	Tw
45.	*Dioscorea japonica* Thunb.	Dioscoreaceae	W, F	A	V	Tw
46.	*Dioscorea oppositifolia* L.	Dioscoreaceae	W, F	Per	L	Tw
47.	*Dioscorea pentaphylla* L.	Dioscoreaceae	W, F	Per	L	Tw
48.	*Diplocyclos palmatus* (L.) C. Jeffrey	Cucurbitaceae	W, F	A	V	Td
49.	*Embelia ribes* Burm.f.	Myrsinaceae	W, F	Per	L	Str-UA
50.	*Embelia tsjeriam-cottam* (Roem. & Schult.) A.DC.	Myrsinaceae	W, F	Per	L	Str-UA
51.	*Erycibe paniculata* F.M. Bailey	Convolvulaceae	F	Per	L	Tw
52.	*Ficus heterophylla* L.f.	Moraceae	F	Per	L	Str-UA
53.	*Gloriosa superba* L.	Liliaceae	W, F	A	V	Td
54.	*Hemidesmus indicus* (L.) R. Br. ex Schult.	Asclepiadaceae	W, F	Per	L	Tw
55.	*Ichnocarpus frutescens* (L.) W.T. Aiton	Apocynaceae	G, W, F	Per	L	Tw
56.	*Ipomoea aquatica* Forssk.	Convolvulaceae	G	A	V	Str-UA
57.	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	G, W, F	A	V	Tw
58.	*Ipomoea eriocarpa* R. Br.	Convolvulaceae	G, W	A	V	Tw
59.	*Ipomoea hederifolia* L.	Convolvulaceae	G, W	A	V	Tw
60.	*Ipomoea maxima* (L. f.) Don ex Sw.	Convolvulaceae	G, W	A	V	Tw
61.	*Ipomoea muricata* (L.) Jacq.	Convolvulaceae	G, W	A	V	Tw
62.	*Ipomoea nil* (L.) Roth	Convolvulaceae	W	A	V	Tw
63.	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae	G, W	A	V	Tw
64.	*Ipomoea pes-tigridis* L.	Convolvulaceae	G, W, F	A	V	Tw
65.	*Ipomoea purpurea* (L.) Roth	Convolvulaceae	G, W	Per	V	Tw
66.	*Ipomoea quamoclit* L.	Convolvulaceae	G, W, F	A	V	Tw
67.	*Lathyrus aphaca* L.	Papilionaceae	G	A	V	Td
68.	*Lathyrus odoratus* L.	Papilionaceae	G	A	V	Td
69.	*Lathyrus sativus* L.	Papilionaceae	G	A	V	Td
70.	*Merremia dissecta* (Jacq.) Hallier f.	Convolvulaceae	W, F	A	V	Tw
71.	*Merremia hederacea* (Burm. f.) Hallier f.	Convolvulaceae	W, F	A	V	Tw
72.	*Mikania micrantha* Kunth	Asteraceae	W, F	A	V	Tw
73.	*Milletia auriculata Baker.*	Papilionaceae	F	Per	L	Str-UA
74.	*Momordica charantia* L.	Cucurbitaceae	G, W, F	Per	V	Td
75.	*Momordica dioica* Roxb. ex Willd.	Cucurbitaceae	G, W	A	V	Td
76.	*Mucuna pruriens* (L.) DC.	Papilionaceae	W	A	L	Tw
77.	*Mukia maderaspatana* (L.) M. Roem.	Cucurbitaceae	W, F	A	V	Td
78.	*Naravelia zeylanica* (L.) DC.	Ranunculaceae	F	Per	L	Td
79.	*Operculina turpethum* (L.) Silva Manso	Convolvulaceae	G, W, F	Per	L	Tw
80.	*Oxystelma secamone* K. Schum.	Asclepiadaceae	G, W, F	A	V	Tw
81.	*Paederia foetida* L.	Rubiaceae	W, F	A	L	Tw
82.	*Passiflora foetida* L.	Passifloraceae	W, F	A	V	Td
83.	*Pentatropis spiralis* (Fox.) Druce.	Asclepiadaceae	W	A	V	Tw
84.	*Pergularia daemia* (Forssk.) Chiov.	Asclepiadaceae	W, F	Per	V	Tw
85.	*Piper longum* L.	Piperaceae	F	Per	L	Str-UA
86.	*Porana paniculata* Roxb.	Convolvulaceae	F	Per	L	Tw
87.	*Rhynchosia minima* (L.) DC.	Papilionaceae	G, W	A	V	Tw
88.	*Rosa clinophylla* Redout & Thory	Rosaceae	F	Per	L	Str-A
89.	*Scindapsus officinalis* (Roxb.) Schott	Araceae	F	Per	L	AR
90.	*Smilax perfoliata* Lour.	Smilaceae	F	Per	L	Td
91.	*Smilax zeylanica* L.	Smilaceae	F	Per	L	Td
92.	*Solena heterophylla* Lour.	Cucurbitaceae	W, F	A	V	Td
93.	*Spatholobus parviflorus* (DC.) Kuntze	Papilionaceae	F	Per	L	Tw
94.	*Stephania japonica* (Thunb.) Miers	Menispermaceae	W, F	A	V	Tw
95.	*Tecoma capensis* (Thunb.) Lindl.	Bignoniaceae	G, W	Per	L	Str-UA
96.	*Telosma pallida* (Roxb.) W. G. Craib	Asclepiadaceae	W	Per	V	Tw
97.	*Teramnus labialis* (L.f.) Spreng.	Papilionaceae	G, W	A	V	Tw
98.	*Tetrastigma lanceolarium* (Roxb.) Planch.	Vitaceae	F	Per	L	Td
99.	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.	Acanthaceae	W, F	Per	L	Tw
100.	*Tiliacora racemosa* Colebr.	Menispermaceae	G,W, F	Per	L	Tw
101.	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	G, W, F	Per	L	Tw

102.	*Tragia involucrata* L.	Euphorbiaceae	W, F	Per	V	Tw
103.	*Trichosanthes cucumerina* L.	Cucurbitaceae	G, W, F	A	V	Td
104.	*Trichosanthes nervifolia* L.	Cucurbitaceae	G, W, F	A	V	Td
105.	*Tylophora indica* (Burm. f.) Merr.	Asclepiadaceae	W, F	Per	L	Tw
106.	*Vallaris solanacea* (Roth) Kuntze	Apocynaceae	W	Per	L	Str-UA
107.	*Ventilago maderaspatana* Gaertn.	Rhamnaceae	W, F	A	L	Str-UA
108.	*Vicia hirsuta* (L.) Gray	Papilionaceae	G, W	A	V	Td
109.	*Wagatea spicata* Dalzell	Caesalpiniaceae	F	Per	L	Str-A
110.	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae	W, F	Per	L	Str-A
111.	*Ziziphus xylopyrus* (Retz.) Willd.	Rhamnaceae	W, F	Per	L	Str-A

Supplementary Table 2. List of tendrilar climbers based on their branching across the terrestrial landscape of north-eastern Uttar Pradesh

S. N.	Species	Family	S.N.	Species	Family
A.	Simple tendrilar climbers		B.	Branched tendrilar climbers	
1.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae		a. Bifid	
2.	*Cucumis trigonus* Roxb.	Cucurbitaceae	1.	*Ampelocissus latifolia* (Roxb.) Planch.	Vitaceae
3.	*Gloriosa superba* L.	Liliaceae	2.	*Bauhinia vahlii* Weight & Arn.	Caesalpiniaceae
4.	*Lathyrus aphaca* L.	Papilionaceae	3.	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae
5.	*Lathyrus odoratus* L.	Papilionaceae	4.	*Cardiospermum halicacabum* L.	Sapindaceae
6.	*Lathyrus sativus* L.	Papilionaceae	5.	*Cayratia trifolia* (L.) Domin	Vitaceae
7.	*Momordica charantia* L.	Cucurbitaceae	6.	*Cissus adnata* Roxb.	Vitaceae
8.	*Momordica dioica* Roxb. ex Willd.	Cucurbitaceae	7.	*Diplocyclos palmatus* (L.) C. Jeffrey	Cucurbitaceae
9.	*Mukia maderaspatana* (L.) M. Roem.	Cucurbitaceae	8.	*Trichosanthes nervifolia* L.	Cucurbitaceae
10.	*Passiflora foetida* L.	Passifloraceae	9.	*Solena heterophylla* Lour.	Cucurbitaceae
11.	*Smilax perfoliata* Lour.	Smilaceae		b.Trifid	
12.	*Smilax zeylanica* L.	Smilaceae	1.	*Antigonon leptopus* Hook. &Arn.	Polygonaceae
13.	*Tetrastigma lanceolarium* (Roxb.) Planch.	Vitaceae	2.	*Naravelia zeylanica* (L.) DC.	Ranunculaceae
14.	*Vicia hirsuta* (L.) Gray	Papilionaceae	3.	*Trichosanthes cucumerina* L.	Cucurbitaceae

SupplementaryTtable 3. List of climbing plant species showing right-handed and left-handed twining pattern across the terrestrial vegetation of north-eastern Uttar Pradesh

S. N	Species	Family	S.N.	Species	Family
A.	Right-handed Twining plants				
1.	*Abrus precatorius* L.	Papilionaceae	27.	*Ipomoea maxima* (L. f.) Don ex Sw.	Convolvulaceae
2.	*Aganosma caryophyllata* (Roxb.) G. Don	Apocynaceae	28.	*Ipomoea muricata* (L.) Jacq.	Convolvulaceae
3.	*Aristolochia indica* L.	Aristolochiaceae	29.	*Ipomoea nil* (L.) Roth	Convolvulaceae
4.	*Asparagus racemosus Willd.*	Liliaceae	30.	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae
5.	*Basella alba* L.	Basellaceae	31.	*Ipomoea pes-tigridis* L.	Convolvulaceae
6.	*Cajanus scarabaeoides* (L.) Thouars	Papilionaceae	32.	*Ipomoea purpurea* (L.) Roth	Convolvulaceae
7.	*Celastrus paniculatus* Willd.	Celastraceae	33.	*Ipomoea quamoclit* L.	Convolvulaceae
8.	*Cissampelos pareira* L.	Menispermaceae	34.	*Merremia hederacea* (Burm. f.) Hallier f.	Convolvulaceae
9.	*Clematis gouriana* Roxb. ex DC.	Ranunculaceae	35.	*Mucuna pruriens* (L.) DC	Papilionaceae
10.	*Clerodendrum splendens* G.Don	Verbenaceae	36.	*Operculina turpethum* (L.) Silva Manso	Convolvulaceae
11.	*Clitoria ternatea* L.	Papilionaceae	37.	*Oxystelma secamone* K. Schum.	Asclepiadaceae
12.	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae	38.	*Paederia foetida* L.	Rubiaceae
13.	*Cocculus trilobus* (Thunb.) DC.	Menispermaceae	39.	*Pentatropis spiralis* (Fox.) Druce.	Asclepiadaceae
14.	*Convolvulus arvensis* L.	Convolvulaceae	40.	*Pergularia daemia* (Forssk.) Chiov.	Asclepiadaceae
15.	*Cuscuta chinensis* Lam.	Cuscutaceae	41.	*Porana paniculata* Roxb.	Convolvulaceae
16.	*Cuscuta reflexa* Roxb.	Cuscutaceae	42.	*Rhynchosia minima* (L.) DC.	Papilionaceae
17.	*Derris scandens* (Roxb.) Benth.	Papilionaceae	43.	*Spatholobus parviflorus* (DC.) Kuntze	Papilionaceae
18.	*Dioscorea deltoidea* Wall. Ex Griseb.	Dioscoreaceae	44.	*Stephania japonica* (Thunb.) Miers	Menispermaceae
19.	*Dioscorea japonica* Thunb.	Dioscoreaceae	45.	*Telosma pallida* (Roxb.) W. G. Craib	Asclepiadaceae
20.	*Erycibe paniculata* F.M. Bailey	Convolvulaceae	46.	*Teramnus labialis* (L.f.) Spreng.	Papilionaceae
21.	*Hemidesmus indicus* (L.) R. Br. ex Schult.	Asclepiadaceae	47.	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.	Acanthaceae
22.	*Ichnocarpus frutescens* (L.) W.T. Aiton	Apocynaceae	48.	*Tiliacora racemosa* Colebr.	Menispermaceae

23.	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	49.	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae
24.	*Ipomoea eriocarpa* R. Br.	Convolvulaceae	50.	*Tragia involucrata* L.	Euphorbiaceae
25.	*Ipomoea hederifolia* L.	Convolvulaceae	51.	*Tylophora indica* (Burm. f.) Merr.	Asclepiadaceae
26.	*Dioscorea oppositifolia* L.	Dioscoreaceae			

B.	Left-handed Twining Plants	
1.	*Dioscorea bulbifera* L.	Dioscoreaceae
2.	*Dioscorea echinata* R. Knuth	Dioscoreaceae
3.	*Dioscorea pentaphylla* L.	Dioscoreaceae
4.	*Merremia dissecta* (Jacq.) Hallier f.	Convolvulaceae
5.	*Mikania micrantha* Kunth	Asteraceae