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RESEARCH COMMUNICATION

An overview of the genus *Dioscorea* L. (Dioscoreaceae) in India

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ABSTRACT
The present paper depicts an overview and elucidated assessment of published data and herbarium records on the diversity, distribution pattern, endemism and threat status of *Dioscorea* spp. to get availed with extant stature and design strategies for its effective conservation. *Dioscorea* nested under family Dioscoreceae is a pantropical genus comprising about 682 species. In India, the genus is known to possess 42 taxa (41 species and one variety). *Dioscorea* L. is highly regarded for its nutritional and medicinal values having a significant role in pharmaceutical and nutraceutical industries. Several species of *Dioscorea* contain various biologically active molecules that show anti-arthritic, anti-inflammatory and anti-fertility effects and thereby known for alleviating medicinal curses.

Introduction

Dioscorea L. commonly known as Yam is the type genus of the family Dioscoreaceae comprising about 682 species distributed across the world with higher diversity in Southeast Asia, Africa, Australia and tropical America (1). The genus is named after Pedanius Dioscoriodes, a Greek physician, who authored *"De Materia Medica"*. The species of *Dioscorea* are either climbing herbs or shrubs with rhizomes and tubers, bear alternate leaves with reticulate venation and possess unisexual flowers. *Dioscorea* shows a number of anatomical, morphological and embryological characters which are reminiscent of dicotyledons (2). The genus is represented by dioecious plants inhabiting hot and humid areas. Nature of twinning and occurrence of prickles in the plants are the diagnostic features of the genus, which can be used to distinguish the species. The occurrence of dicotyledonous characters like reticulate venation in leaves, simultaneous type of development in pollen grains, the arrangement of vascular bundles and presence of second rudimentary cotyledon in some species of the genus render it as an interesting monocotyledon. The genus prefers wet climate for flowering and fruiting, and in the dry season, tubers persist (2). Dioscoreaceae is considered to be categorized among the families of the earliest angiosperms, which might have originated in Southeast Asia (3). Being a pantropical genus, *Dioscorea* occurs in tropical regions but a few species are also known to exist in temperate zones of the world (4). As per previous reports, Indomalesia region is considered to be the centre of origin for *Dioscorea* (5). The genus was first published in '*Species Plantarum*' in 1753 (6). He placed *Dioscorea* in the family Sarmantaceae in *Philosphica Botanica.* Later, *Dioscorea* was placed along with *Smilax* L. in the section II of the order Asparagi (7). Finally, It was separated from Smilacaceae and nested it under Dioscoreaceae (8). *Dioscorea* shows close resemblance with *Smilax* and can be differentiated by the presence of inferior ovary, capsular fruit and large cavity of the albumen in the former. The genus *Dioscorea* was divided into four subgenera which were further divided into 60 sections (9). Later, several workers provided different treatments to the genus (10-12). Hooker. There are 150 species of *Dioscorea* from Indian sub-continent as well as Southeast Asian countries (13). Records are there on the occurrence of 50 species of the genus from India (14). These inhabits 33 species and 24 varieties belonging to *Dioscorea* from Indian subcontinent (15).

Yams, undoubtedly are one of the potential plant resources being used both as food and medicine. Due

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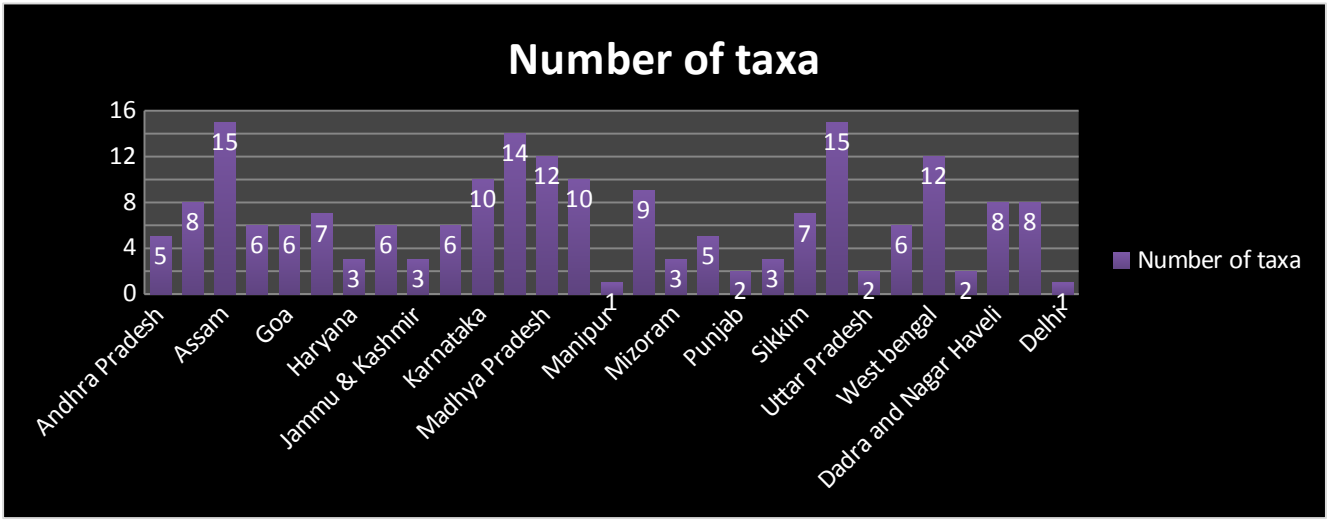

Fig. 1. Diversity of *Dioscorea* in different states of India.

to the presence of essential dietary nutrients, *Dioscorea* has been an important source of food for various tribal communities and serves as a dietary staple for poor people in several areas. In addition to carbohydrates, fats, fibres and proteins, the plant possesses an ample amount of mineral nutrients including sodium, potassium, phosphorus, calcium, copper, magnesium, iron and manganese. Nutritional value of yams makes them a potential source of food being used by several indigenous groups of people living in local areas. Several medicinally important chemical constituents form a major portion of the plant rendering it as one of the most valuable drug yielding plants. Attributed to the presence of various secondary metabolites including alkaloids, carotenoids, flavanoids, glycosides, phenolics, steroidal saponins and sapogenins, tannins, terpenoids and certain volatile oils, *Dioscorea* shows broad spectrum of medicinal properties and is being used in the cure of different diseases. Tubers and leaves are the most widely used parts of the genus with anti-oxidant, anti-bacterial, anti-inflammatory activities. Various chemical constituents form the major proportion of *Dioscorea* content of which Diosgenin is the most important steroidal sapogenin responsible for the broad spectral medicinal properties of the genus and about 50% of the total steroid drug output in the world is contributed by the species of *Dioscorea* (16). Other important chemical constituents like botogenin, kryptogenin, dioscin, dioscorin etc. enhance the credibility of the genus in pharmaceutical industries. It is worthy of knowing that *Dioscorea* has been the centre of attraction for cytologists to study the mechanism of sex determination in plants as revealed by cytological studies in the genus (17).

But with the advent of modern technology, rapid urbanization, increasing population, the natural habitats of the plants are being disturbed which results in long term decline of *Dioscorea* population. Earlier studies (18) suggest that the unsustainable collection of the plant for its medicinal properties coupled with habitat degradation increased the risk of threat for the species of *Dioscorea* as revealed by the inclusion of *D. deltoidea* in the Red List of IUCN (19). Therefore, the present study has been set up with an aim to document the diversity, distribution pattern and endemism of *Dioscorea* of India so as to take necessary steps prioritizing its conservation.

Materials and Methods

The present study is based on extensive literature scrutiny and herbaria consultation. To assess the diversity of the genus in India, literature was surveyed followed by consultation of herbaria *viz.* BSD, CAL, CDRI, CIMAP, KASH, LWG, MH and RRLH, published floras and various plant database websites (IPNI, POWO, The Plant List, Tropicos, WCVP). Thereafter, Indian taxa of *Dioscorea* are enumerated alphabetically with elevation, phenology and distribution in India as well as at the world level. Further, economic potential, cytological data and threat status of the species of *Dioscorea* have been provided.

Results and Discussion

In India, the genus *Dioscorea* is represented by 42 taxa (41 species and one variety) occurring in different regions of the country displaying about 6% of the total diversity found across the globe (Table 1). Of the total taxa found in India, two species viz. *D. vexans* Prain & Burkill and *D. serpenticola* Hoque & P.K.Mukh. have been found to be endemic to the country occurring exclusively in Andaman and Nicobar Islands (Table 1). Our data analysis depicts that the southern part of the country possesses maximum diversity of *Dioscorea* with about 37.5% of the total taxa occurring in Tamil Nadu, 35% in Kerala and Assam (Fig. 1). Warm and humid climatic conditions prevailing in the southern region of the country favour luxuriant growth of the genus over there. Distribution pattern of *Dioscorea* plotted against the elevational gradient revealed that species richness is affected by increase in elevation, highest in mid-ranges and then decreased with further increase in elevation (Fig. 2). Though, the genus occurs along a wide range of elevation lying

Table 1. Distribution of the taxa of *Dioscorea* L. in India and world.

Sl. No.	Name of Taxa	Fl. and Fr.	Elevation (m asl)	Distribution	
				India*	World
1.	*D. alata* L.	Aug–Oct	1000–1200	AR(20,21), AS(22), DD(23), DN(23), GA(23), GJ(24), JH(25), KA(26),KL(27) MH(28), MP(29), MZ(30),OD(31) TN(32), WB(33,34)	Bangladesh, Bhutan, China
2.	*D. arachidna* Prain & Burkill	Jul–Oct	500–1500	AS(22), OD(31), ML(34)	Myanmar, Thailand, Vietnam
3.	*D. belophylla* (Prain) Voigt ex Haines	Sep–Jan	850–1500	AR(20,21), GJ(35), HP(36,37), HR(38), JK(39,40), JH(25), KA(26), MH(28), MP(29,41), SK(34), TN(42), UP(43), UK(44,45)	Bangladesh, Bhutan, Myanmar, Pakistan
4.	*D. brandisii* Prain & Bukill	Sep–Jan	200–500	AR(24)	Myanmar
5.	*D. bulbifera* L.	Aug–Dec	200–1800	AP(57), AS(22), CG(25), DD(23),DN(23), GA(23), GJ(24,35), HP(36,37,46,47), HR(38), JH(25), JK(39,40), KA(26,48), KL(27,49), MH(28), ML(34), MP(29,41), MZ(30), RJ(50,51), SK(34), TN(32,52,53), UK(44,45), UP(43), WB(33,34)	Afghanistan, China, Myanmar, Nepal, Sri Lanka
6.	*D. cumingii* Prain & Burkill	Apr–Feb	500–1400	AR(20), AS(22)	China, Philippines, Taiwan
7.	*D. daunea* Prain & Burkill	Sep–Feb	600–1000	AR(20), AS(22)	China, Malaysia, Thailand
8.	*D. decipiens* Hook.f.	Sep–Jan	500–2200	AS(22)	China
9.	*D. deltoidea* Wall. ex Griseb.	May–Sep	1800–2500	JK(39,40), HP(36,54), UK(44,45)	Afghanistan, Bhutan, China, Nepal,
10.	*D. esculenta* (Lour.) Burkill	Jun–Oct	700–900	KL(27,49), MH(28), MP(29,41), SK(34), TN(32,52,53), WB(33,34)	Bhutan, China, Nepal, Indonesia
11.	*D. floribunda* M.Martens & Galeotti	Jun–Sep	200–800	AS(22), KA(26,48)	Central America, Myanmar
12.	*D. glabra* Roxb.	Sept–Jan	1000–1500	CG(25), DD(23), DN(23), GA(23), KA(26,48), MH(28), ML(34), SK(34), TN(32,52,53), UK(44), WB(33)	China, Myanmar, Nepal
13.	*D. hamiltonii* Hook.f.	Sept–Jan	500–1000	KL(27,49), TN(32,52,53), WB(33,34)	Bhutan, China, Nepal
14.	*D. hispida* Dennst.	July–Oct	500–1300	AP(57), DD(23), DN(23), GA(23), GJ(24,35), KA(26,48), KL(26,48), MH(28), ML(34), MP(29,41), RJ(50), SK(34), TN(32,52,53), UP(43), WB(33),	Bhutan, China, Malaysia, Nepal
15.	*D. intermedia* Thwaites	Sep–Jan	1000–1500	KA(26,48), KL(27,49), MP(29,41), TN(52,53),	Sri Lanka
16.	*D. japonica* Thunb.	Sep–Dec	500–1200	AS(22)	China, Japan, Myanmar, Taiwan
17.	*D. japonica* var. *nagarum* Prain & Burkill	Aug–Nov	500–1200	AS(22)	China, Korea, Japan, Taiwan, Thailand
18.	*D. kalkapershadii* Prain & Burkill	Sept–Dec	700–2500	OD(31,55), TN(32,53,53)	Bangladesh
19.	*D. kamoonensis* Kunth	Aug. –Oct.	1200–1800	HP(36,54), ML(34), MP(29,41), UK(44)	China, Nepal, Myanmar
20.	*D. laurifolia* Wall. ex Hook.f.	Jul–Sep	500–1200	AR(20), AS(22)	Malaysia, Thailand
21.	*D. lepcharum* Prain & Burkill	Jun–Oct	1000–1800	AR(20), AS(22), MH(28), ML(34), SK(34), WB(33,34)	Myanmar
22.	*D. longipedicellata*	Aug	500–1500	AS(56), ML(56)	Bangladesh
23.	*D. listeri* Prain & Burkill	Jun–Oct	1000–1500	AR(20), AS(22)	Myanmar
24.	*D. melanophyma* Prain & Burkill	Jul–Nov	1500–2200	HP(36,54), ML(34), UK(44)	Nepal, Pakistan
25.	*D. nummularia* Lam.	Sep–Nov	1800–2700	OD(31,55), WB(33,34)	China, Indonesia, New Guinea, Vietnam
26.	*D. oppositifolia* L.	Aug–Nov	1000–1250	AP(57), CG(25), DD(23),DN(23, GA(23), GJ(24,49), KA(26,48), JH(25), KL(27,49), MH(28), MP(29,41), TN(32,52,53), UP(43), WB(33,34)	Bangladesh, Myanmar, Sri Lanka, Thailand
27.	*D. orbiculata* Hook.f.	Aug–Nov	100–300	AS(22), KL(27,49), ML(34), OD(31,55), TN(32,52,53)	Indonesia, Malaysia, Thailand
28.	*D. pentaphylla* L.	Sep–Jan	700–1500	AP(57),AR(20), AS(22), CG(25), DD(23), DN(23),GA(23), GJ(24,35), HP(36,54), HR(38), KA(26,48), KL(27,49), MH(28), ML(34), MP(29,41), MZ(30), RJ(50), SK(34), TN(32,52,53), UK(44), UP(43), WB(33,34),	Australia, China, Myanmar, Sri Lanka, Thailand
29.	*D. polystachya* Turcz.	Jun–Nov	500–2500	UK (57)	China, Taiwan
29.	*D. polystachya* Turcz.	Jun–Nov	500–2500	UK (57)	China, Taiwan

30. *D. prazeri* Prain & Burkill	Jun–Sep	1500–1600	AS(22), SK(34), WB(33,34)	Bangladesh, Myanmar, Nepal, Thailand
31. *D. pubera* Blume	Sep–Jan	500–880	AS(22), KL(27,49), MP(29,41), WB(33,34)	Bangladesh, Myanmar, Nepal
32. *D. pyrifolia* Kunth	Aug–Nov	500–1200	AR(20), AS(22)	Indonesia, Malaysia, Thailand
33. *D. scortechinii* Prain & Burkill	Jun–Jan	200–1300	AR(20), AS(22)	China, Thailand, Vietnam
34. *D. serpenticola* Hoque & P.K.Mukh.	Sep–Jan	500	AN(59)	Andaman & Nicobar
35. *D. spicata* Roth	Aug–Dec	500-1800	KL(27,49), TN(31,53),	Bangladesh, Sri Lanka
36. *D. tomentosa* J.Koenig ex Spreng.	Sep–Nov	600–1200	AP(57), KA(26,48), KL(27,49), MH(28), MP(29,41), WB(33,34), TN(32,52,53),	Sri Lanka
37. *D. trinervia* Roxb. ex Prain & Burkill	Aug–Feb	200–1000	AS(22), KA(26,50), KL(27,49), ML(34), OD(31,55)	Bangladesh, Myanmar
38. *D. vexans* Prain & Burkill	Mar	100–900	AN(60)	Andaman & Nicobar
39. *D. villosa* L.	Jul–Oct	1000–1800	AS(22), HP(36,54)	USA, Myanmar
40. *D. wallichii* Hook.f.	Oct–Feb	900–1300	AP(57), CG(25), DD(23), DN(23), GA(23), GJ(24,35), KA(26,48), KL(27,49), MH(28), MP(29,41), TN(32,52,53)	China, Malaysia, Myanmar, Thailand
41. *D. wattii* Prain & Burkill	Feb–Mar	1000–1500	AS(22), AR(20), OD(31,55)	Bangladesh, Myanmar, Thailand
42. *D. wightii* Hook.f.	Sep–Feb	1200–1500	MP(29,48), KL(27,49), TN(32,52,53)	Malaysia

*References are given within brackets.
Abbreviations Used: AP = Andhra Pradesh; AR = Arunachal Pradesh; CG = Chhattisgarh; GA = GOA; GJ = Gujarat; HR = Haryana; HP = Himachal Pradesh; J&K = Jammu & Kashmir; JH = Jharkhand; KA = Karnataka; KL = Kerala; MP = Madhya Pradesh; MH = Maharashtra; ML = Meghalaya; MZ = Mizoram; OD = Odisha; PB = Punjab; RJ = Rajasthan; SK = Sikkim; TN = Tamil Nadu; UP = Uttar Pradesh; UK = Uttarakhand; WB = West Bengal; AN = Andaman and Nicobar Islands; DN = Dadra & Nagar Haveli; DD = Daman and Diu.

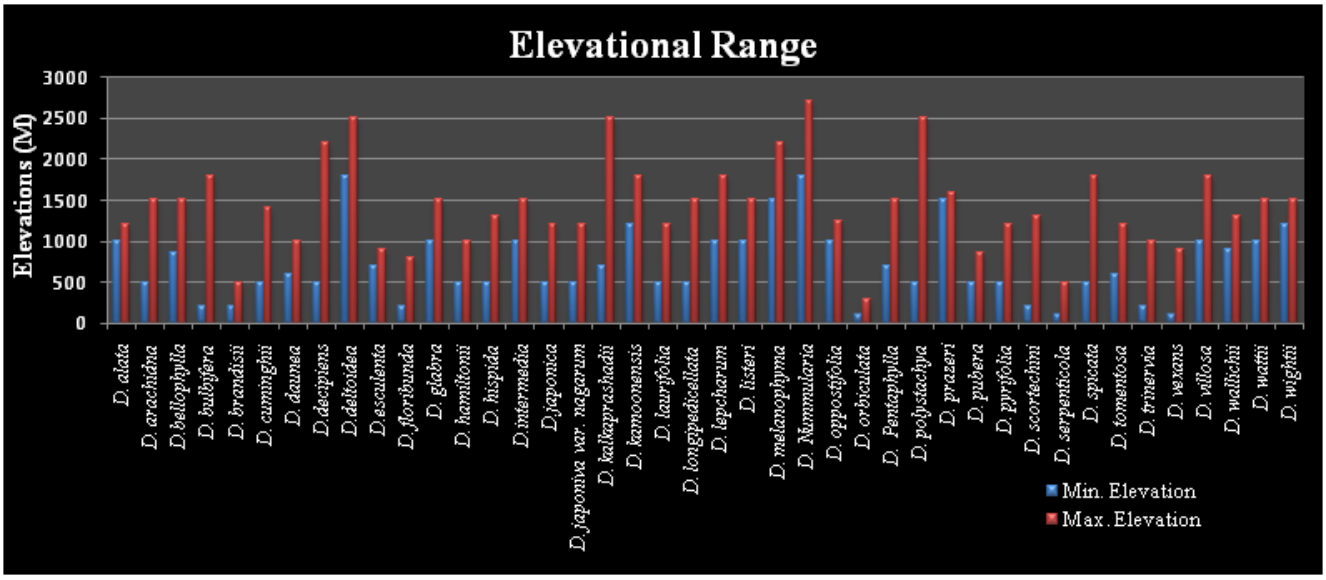

Fig. 2. Distribution of taxa of *Dioscorea* along different elevational gradients in India.

between 500–2700 m but the maximum concentration is found between elevations of 1000–1500 m with the occurrence of 27 taxa (Fig. 2). *D. polystachya* Turcz. and *D. spicata* Roth show extensive distributional range as far the elevation is concerned lying between 500–2000 m and 500–1800 m respectively. About 40% taxa of *Dioscorea* are being used in curing different kinds of ailments which include jaundice, malaria, arthritis etc. (Table 2). Cytology of the genus has been found to be very interesting as it shows remarkable variations in chromosome number ranging from 20 to 140 (2n) with 40 as the most common (Table 3). Due to its high economic potential, *Dioscorea* is being utilized unsustainably which may lead to the decline in its diversity in the near future. One species viz. *D. deltoidea* has been categorised as EN (Table 4) facing high risk of extinction which is a subject of concern for other species also which are dwelling in the similar habitat. Therefore, different conservation strategies like tissue culture, germplasm storage, setting up seed banks etc should be adopted for the conservation and sustainable utilization of this plant to prevent it from further exploitation and population decline in nature.

Conclusion

Owing to extreme nutritional and pharmaceutical values, *Dioscorea* has been considered as one of the most important plants in the agriculture sector and drug-based industries. Unsustainable exploitation by materialistic man and natural disturbances has resulted in a speedy decline of the population. Due to uncontrolled collection and unorganized cultivation, depletion of the plant is still continuing. Therefore, it is necessary to

Table 2: List of the medicinally important taxa used in the traditional healthcare system in India

Sl. No.	Species	Parts Used	Medicinal Uses	References
1.	*D. alata* L.	Tuber	Used to treat piles, gonorrhoea and leprosy	63
2.	*D. belophylla* (Prain) Voigt ex Haines	Tuber, Leaves	Used to treat jaundice, malaria, dysentery and mumps	64
3.	*D. bulbifera* L.	Tuber, Leaves, Stem	Used for abdominal pain, skin diseases, cough, asthma and also used as contraceptive, anti-inflammatory and antacid	65
4.	*D. deltoidea* Wall. ex Griseb.	Tuber, Leaves, Stem	Used as a uterine sedative, haemostatic, diuretic and wormicide	65
5.	*D. esculenta* (Lour.) Burkill	Tuber	Used to treat dysentery, swellings and act as an analgesic, anti-inflammatory	66
6.	*D. hamiltonii* Hook.f.	Tuber	Used to treat diarrhoea and stomach pain	67
7.	*D. hispida* Dennst.	Tuber	Used to treat conjunctivitis, skin disease and wound healing	68
8.	*D. kamoonensis* Kunth	Tuber	Used to treat arthritis and rheumatism	66
9.	*D. oppositifolia* L.	Tuber, Leaves	Act as antiseptic and Used for toothache, scorpion bite and increase fertility	69
10.	*D. pentaphylla* L.	Tuber	Used to treat abdominal pain, cough, cold, asthma, increase immunity and reduce swelling	66
11.	*D. pubera* Blume	Tuber	Used to treat colic pain	70
12.	*D. trinervia* Roxb. ex Prain & Burkill	Tuber	Used to cure chronic diarrhoea, diabetes, asthma and snake bite	70
13.	*D. villosa* L.	Tuber	Used to treat cramps, muscular spasm, digestive disorders and regulate female sex hormones	71
14.	*D. wallichii* Hook.f.	Tuber	Used as analgesic for stomach pain	72

Table 3. Chromosomal profile of some taxa of *Dioscorea*

Sl.No.	Name of Taxa	Chromosome no. (2n)	References
1.	*D. alata* L.	40	73
2.	*D. belophylla* (Prain) Voigt ex Haines	60	74
3.	*D. bulbifera* L.	40,60,80	73
4.	*D. deltoidea* Wall. ex Griseb.	20	75
5.	*D. esculenta* (Lour.) Burkill	80	73
6.	*D. floribunda* M.Martens & Galeotti	36	74
7.	*D. glabra* Roxb.	40	77
8.	*D. hamiltonii* Hook.f.	40	73
9.	*D. hispida* Dennst.	40	73
10.	*D. japonica* Thunb.	40	78
11.	*D. kalkapershadii* Prain & Burkill	45,54	78
12.	*D. kamoonensis* Kunth	40,60	73
13.	*D. melanophyma* Prain & Burkill	40	73
14.	*D. oppositifolia* L.	40	75
15.	*D. pentaphylla* L.	60	75
16.	*D. polystachya* Turcz.	140	73
17.	*D. prazeri* Prain & Burkill	20	74
18.	*D. pubera* Blume	40	75
19.	*D. tomentosa* J.Koenig ex Spreng.	40	79
20.	*D. villosa* L.	80	79
21.	*D. wallichii* Hook.f.	40	79

conduct research to understand the population trends and put conservational efforts towards their survival. The present study provides a baseline data of the genus *Dioscorea* which can be utilized in integrated disciplines of science in different aspects.

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Authors' contributions

PA designed the objectives and plan of work. ACS edited the manuscript and finalized it. RW reviewed the literature, collected and compiled the data. ST drafted the manuscript.

Conflict of interests

Authors do not have any conflict of interest.

Table 4. Threat status according to IUCN Red list (2020).

Sl.No	Name of taxa	Category
1.	*D. deltoidea* Wall. ex Griseb.	EN
2.	*D. hamiltonii* Hook.f.	NT
3.	*D. nummularia* Lam.	NT
4.	*D. wallichii* Hook.f.	LC

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