

FORAGE DESMODIUMS : ECOLOGY AND POTENTIALS

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The *Desmodiums* belong to a large genus *Desmodium* comprising 450 species, distributed all over the world. In India, 49 species are reported from tropical, subtropical and temperate regions. Almost all the species are important pasture legumes and being palatable and nutritious are considered as alfalfa of the tropics. Research attention on the forage value of desmodiums is rather low in comparison to other pasture legumes. In this paper, the ecology and potentials of *Desmodium* of forage value are highlighted.

Key words: Forage Desmodiums, grazing preference, legume persistence, stress tolerance, environmental adaptations

INTRODUCTION

The *Desmodiums* are highly palatable and nutritious and are considered as alfalfa of the tropics (Allen and Allen, 1981). Almost all the species are important pasture legumes having diploid chromosome number $2n = 22$. Most of the species are in wild state and await discovery. Due to biotic interferences, many species are on the verge of extinction. Several species such as *D. heterocarpon*, *D. triflorum*, *D. gangeticum*, *D. tortuosum*, *D. diffusum*, *D. heterophyllum* are extensively used as fodder and pasture crop in India. This paper presents the state of research information particularly on the ecology and potentials of *Desmodiums* and highlights the prominent species and future research areas.

Taxonomy

Most *Desmodiums* are perennial herbs and shrubs but rarely trees and are distinguished by jointed, usually indehiscent pods. The approaches to taxonomic classification of the genus *Desmodium* vary and so also the estimates of the number of species. Most likely, there are 450 species distributed all over the world. The Asiatic species of *Desmodium* (Ohashi, 1973) defy division into smaller ones due to continuity of the main character. Schubert (1963), who has published widely on the taxonomy of American and African species of *Desmodium*, has recognized three subgenera in the Mexican *Desmodium* and is of the view that inflorescence and loment characters serve the strong basis for classifying *Desmodiums*.

Ohashi (1973) placed *Desmodium* in the tribe Caronilleae, subtribe Desmodiinae together with 24 other genera including the closely related *Codariocalyx*, *Dicerma*, *Dendrolobium*, *Hegnere*, *Phyllodium* and *Tadehagi*. Huthinson (1964) elevated the subtribe to the range of tribe viz., Desmodieae.

Origin and Distribution

South-east Asia (India, Thailand, Malaysia and China) is considered as the primary centre of diversity in *Desmodium*. The second major centre of diversity is Mexico, the Mexican species being distinct from Asian counterparts. According to Index Kewensis about 160-180 species of *Desmodium* are reported from equatorial region (0-10°Lat), 180 species from tropical and subtropical regions (10-250° Lat) and 110 species from the temperate regions (above 250°Lat) (Jackson, 1895). Most of the *Desmodium* species are distributed within the altitude range of 1500-2200 m above m.s.l. (Singh *et al.* 1988).

D. uncinatum and its two cultivars viz. *D. uncinatum* cv. green leaf and cv. silver leaf are native to South and Central America and are distributed in humid and subhumid tracts (Bogdam, 1977). *D. canum*, a woody trailing perennial is widespread in the wet tropics, common in Fiji, Hawaii, North and Central America (Bermudez *et al.* 1968). *D. scorpiuras* is distributed in tropics but has originated in America, whereas *D. discolor* is widespread in subtropics of Brazil, Argentina and Paraguay (Boelcke, 1964). *D. intortum*, a trailing perennial is native to Panama and Columbia and is widespread in South America specially eastern slopes of the Andes and Brazil (Whiteman, 1968). *D. tortuosum*, a perennial herb is native to West Indies and is spread over Florida, Central and South America and tropical Africa (Bogdam, 1977), whereas *D. barbatum* is widely distributed in Florida, USA, Argentina and tropical Africa (Burkart, 1952).

D. heterocarpon and *D. heterocarpon* var. *heterocarpon* are native to South-east Asia, Sri Lanka and India (Bermudez *et al.* 1968). *D. gyroides*, a fodder in India is indigenous to South East Asia (Bryan, 1966). *D. heterophyllum*, a perennial prostrate creeper is native to and distributed in Eastern Hemisphere, Mauritius, South-east Asia and Malaysia, whereas *D. biarticulatum*, an erect herbaceous annual is a very good fodder in coastal ecosystem and *D. capitatum* is a browse species. Both of these species are distributed in India, Sri Lanka and Malaysia (Farinas, 1965).

Recent survey of *Desmodium* lists 33 species and 14 sub-species from India (Hussain and Kapoor, 1990). Most of the species occur in humid regions of Assam, West Bengal mountains and Eastern Himalayas. The species occurring in Assam regions are *D. griffithianum*, *D. khasianum*, *D. econum* and *D. racemosum*. The species viz. *D. oxyphyllum*, *D. podocarpum*, *D. laburnifolium* and *D. floribundum* are mostly confined to the Western Himalaya (Table 1).

Table 1. Habitat and distribution of forage Desmodiums

Species	Habit	Distribution
<i>Desmodium adscendens</i> (SW) DC.	Er, H, P	Eastern Himalaya, Sikkim
<i>Desmodium bakeri</i> Balakr.	Tr, H, A	Plains of Mysore, Western Ghat
<i>Desmodium barbatum</i> (L.) Benth. Subsp. <i>saulierei</i> (Sch.) Ohashi	Er, H, P, E	N.E. Himalayas, Sikkim
<i>Desmodium benthami</i> Balakr.	Tr, H	Nilgiri, Western Ghats
<i>Desmodium biarticulatum</i> (L.) Muell	Tr, S	Coastal saline soil A.P. Tamil Nadu, Orissa, India,
<i>Desmodium caudatum</i> (Thumb.) DC.	Er, H/S, P	Bengal,
<i>Desmodium concinnum</i> DC. var. <i>concinnum</i>	Er, H/S, P	Khasi hills, Eastern Himalaya
<i>Desmodium concinnum</i> DC. var. <i>retusum</i> (D.Don) Ohashi	Er, S	Upper Punjab, Simla, Khasi hills
<i>Desmodium dichotomum</i> (Klein ex Willd.) DC.	St, H, P	Bundelkhand, Bengal Plains, Western peninsula
<i>Desmodium dolabriforme</i> Benth.	Er, H/S, P.E	Western peninsula
<i>Desmodium elegans</i> DC.	Er, S	Punjab, Western Himalayas
<i>Desmodium ferruginum</i> Wall. ex Thw Subsp. <i>wynaadense</i> (Bedd. ex Gamble) Ohashi	Er, S	Tamil Nadu, Nilgiri
<i>Desmodium ferruginum</i> Wall exthw. Subsp. <i>ferruginum</i>	Er, S.	--
<i>Desmodium gangeticum</i> (L.) DC.	Er/Pr,H/S,P	Orissa, A.P., M.P., Bengal
<i>Desmodium griffithianum</i> Benth.	Tr.H	Upper gangetic plains
<i>Desmodium gyroides</i> (Link) DC.	Er, S	Central and Eastern Himalaya, Khasi hills, Upper Bengal
<i>Desmodium heterocarpon</i> (L.) DC. var. <i>heterocarpon</i>	Er/De, H/S,P	Throughout Eastern tropics Tamil Nadu, A.P. Orissa
<i>Desmodium heterocarpon</i> (L.) DC. var. <i>strigosum</i> Van Meeuwon	Er, S	M.P., West Bengal N.E. India
<i>Desmodium heterophyllum</i>	Tr, H, P	Throughout India, Malaysia, China, Philippines
<i>Desmodium khasianum</i> Prain	Er, S	Khasi hills, Assam, Eastern Himalaya
<i>Desmodium kulhaitense</i> Clarke ex prain	Er, S	Sikkim, Khasi hills, Bengal
<i>Desmodium laxiflorum</i> DC.	Er, S	Assam, Garhwal, Kumaon hills
<i>Desmodium laxum</i> DC.	Er, S	Western Peninsula, Sri Lanka
<i>Desmodium likabalicum</i> Bennet and Chandra	Er, S	Nilgiri, South India

(Contd. to next page)

<i>Desmodium microphyllum</i> (Thunb.) DC.	Pr, H, P	Eastern Himalayas Ceylon
<i>Desmodium motorium</i> (Houtt.) Merrill	Er, H/S,P	Himalaya, Assam, Ceylon, Tamilnadu, Orissa, A.P.
<i>Desmodium multiflorum</i> DC.	Er, S	Khasi hills, Eastern Himalayas
<i>Desmodium neomexicanum</i> A. Gray	St, H, P	Eastern Himalayas, Sikkim, Khasi hills
<i>Desmodium oblongum</i> Wall. ex Benth.	Er, S	South India, Nilgiri, Tamil Nadu
<i>Desmodium oojeinense</i> (Roxb.) Ohashi	T	West Bengal, Tamil Nadu, A.P., Orissa, M.P.
<i>Desmodium oxyphyllum</i> DC. Subsp. <i>oxyphyllum</i>	Er, S	Tropical Himalaya, Simla, Garhwal
<i>Desmodium podocarpum</i> DC. subsp. <i>podocarpum</i>	Er, H/S, P.	Khasi hills, Sikkim
<i>Desmodium pryonii</i> DC.	Er, H, P	Western Himalayas, upper Punjab
<i>Desmodium pulchellum</i> (L.) Benth.	Er, S	M.P. West Bengal, Orissa, A.P. and Tamil adu
<i>Desmodium renifolium</i> (L.) Schindl	Tr, H, A	Eastern Himalaya, Western Peninsula
<i>Desmodium repandum</i> (Vahl) DC.	Er H/S, P	Nilgiri, South India, Malaysia
<i>Desmodium sequax</i> Wall.	Er, S	Sikkim, Himalayas, Simla, Kumaon
<i>Desmodium spirale</i> DC.	Er, H, A	Himalaya, Sikkim, Upper Punjab
<i>Desmodium styracifolium</i> (Obeck) Merrill	Er, S	Assam, Eastern Himalaya
<i>Desmodium tortuosum</i> (SW.) DC.	Er, H, A	Eastern Himalaya
<i>Desmodium triangulare</i> (Retz.) Merrill Var. <i>triangulare</i>	Er, S	Tamilnadu, Nilgiri, A.P. Orissa
<i>Desmodium triangulare</i> (Retz.) Merril Var. <i>congestum</i> (Wall. ex wt. & Am.)	Er, S	North Bengal, N.E. India
<i>Desmodium triflorum</i> (L.) DC.	Pr/Tr, H, P	Throughout India
<i>Desmodium velutinum</i> (Willd.) DC. Var. <i>velutinum</i>	Er, H/S, P	Dry regions, West Bengal, Assam, Orissa
<i>Desmodium velutinum</i> (Willd) DC. Var. <i>longibracteatum</i>	Er, H, P	Sikkim, Khasi hills, North-East India
<i>Desmodium velutinum</i> (Willd.) DC. Var. <i>Sikkimense</i> (Sch.) Ohashi	Er, H, P	Sikkim, N.E. India
<i>Desmodium lonatum</i> Mig	Er, S	Hills of South India, Tamil Nadu

Er = Erect

H = Herb

P = Perennial

Tr = Trailing

A = Annual

S = Shrub

E = Endemic

St = Straggling

Pr = Prostrate

De = Decumbent

T = Tree

The western Ghats are rich in species of *Desmodium*. In the Nilgiris and surrounding areas, *D. gardneri* and *D. rufescens* are present. Species occurring in Eastern and Western Himalayas are *D. laxiflorum*, *D. pulchellum*, *D. cephalotes*, *D. gyrans* and *D. parviflorum*.

• Only a few peninsular species occur in Assam and the Western Himalaya viz. *D. heterophyllum* and *D. inerme*. In addition to these, *D. triflorum* is a very common species all over India. *D. cephalotes*, reported for the first time from India, confined to the hilly tracts of Assam (Datta and Babu, 1968). Beside this, *D. salvifolium*, *D. tortuosum*, *D. neomericum*, *D. macaraguense*, *D. canum*, *D. rigidum*, *D. perflexum*, *D. distortum*, *D. heterophyllum*, *D. uncinatum* are the introductions (Paroda and Arora, 1986).

Environmental adaptations

Desmodium species grow on a wide range of soils viz. clay loam, light clay, sand, ferruginous acid soils and red basaltic loams, wide range of annual average rainfall from 900-3000 mm and rather low ambient temperature range from 25-30°C (Table 2).

Table 2. Environmental adaptations of forage *Desmodium*s

Species	Soil texture	Soil pH	Rainfall (mm)	Temperature (°C)	Altitude (m)	References
<i>D. uncinatum</i>	Sandy, Clay loam red basaltic loam	5.0	900-3000	25-30	1500-1800	Mears <i>et al</i> 1964
<i>D. intortum</i>	Wide range of soil	5.0	875-3475	25-30	600-2500	Bryan, 1969
<i>D. sandicense</i>	Sandy, clay soil	6.0	750-1075	25-30	-	Andrews and Norris 1961
<i>D. discolor</i>	Acid to sandy loam	6.5	-	-	-	-
<i>D. heterocarpon</i>	Wet, mineral soil	5.0	1250-1500	15-25	-	Kretschmer, 1974
<i>D. heterophyllum</i>	Sandy, clay acid soil	5.0	15-4000	15-25	200-700	Whiteman, 1968
<i>D. gyroides</i>	Acid and alkaline soil	6.0	2000-4000	15-25	1000	Andrews and Norris 1961
<i>D. canum</i>	Wide range of soil sandy, light clay	6.5	1250-1500	25-30	900-1700	Kretschmer, 1974
<i>D. barbatum</i>	fertile acid soil	6.5	1000-2000	25-30	-	Otero, 1952
<i>D. biarticulatum</i>	Saline, sandy soil	5.0	1500-2000	30-40	-	Otero, 1952

Persistence and tolerance

Most of the species of *Desmodium* withstand adverse environmental conditions such as high temperature, drought, flood, shade, overgrazing, burning etc. (Table 3).

Table 3. Stress tolerance of forage *Desmodiums*

Species	Cold	Shade	Flood	Drou- ght	Cutting and overgrazing	Fire	Salinity	Reference
<i>D. uncinatum</i>	M	-	H	H	H	-	-	Wang <i>et al.</i> 1985
<i>D. intortum</i>	M	M	-	L	H	-	L	Rortar, 1970
<i>D. sandwicense</i>	-	-	H	H	M	M	-	Whiteman 1968
<i>D. triflorum</i>	L	M	H	H	M	-	L	Wang <i>et al.</i> 1985
<i>D. heterophyllum</i>	L	M	M	H	H	L	L	Kelly, 1964
<i>D. gyroides</i>	-	-	M	H	H	L	-	Bryan, 1966
<i>D. canum</i>	H	-	-	-	L	L	-	Thro and Shock 1987
<i>D. barbatum</i>	H	-	M	-	M	M	-	Bermudes <i>et al.</i> 1968
<i>D. biarticulatum</i>	M	H	L	H	H	H	H	Farinas, 1965
<i>D. heterocarpon</i> var <i>heterocarpon</i>	-	M	H	H	-	L	-	Kretschmer <i>et al.</i> 1976
<i>D. discolor</i>	M	-	M	H	-	-	-	Farinas, 1965
	H= High		M = Medium			L = Low		

Palatability

Leaves, terminal shoots and stolons of *D. uncinatum* are grazed by cattle. It shows profuse growth during autumn and spring. *D. heterophyllum* is less palatable but resistant to heavy grazing (Huang, 1967). Leaves and shoots of *D. canum* are highly preferred by livestock (Milford, 1967). *D. barbatum* is preferred by cattle and it makes good hay and crop at 20-30 cm height before flowering (Bermudez *et al.* 1968). *D. triflorum* is recommended for poultry, specially for baby chicks (Farinas, 1965). *D. intortum* is an excellent fodder for baby chicks and in deforested highlands, it is used as a hedge plant (Squibb *et al.* 1978). *D. velutinum* is highly palatable with high dry matter and crude proteins (Mzamane and Agishi, 1986). *D. cinereum*, *D. distortum* and *D. discolor* have higher percentage of green leaves during dry season (Labri *et al.* 1993).

D. tortuosum is used as green chop and hay in tropics but it tends to disappear under prolonged grazing stress. *D. ovalifolium* has relatively poor palatability (Brumbu, 1980). *D. distortum* and *D. gyroides* produce massive crop of fodder preferred by cattle. *D. discolor* is highly palatable to livestock and it makes useful supplement in late summer when grasses have turn dry. Its foliage can be grazed or made into an excellent silage or hay.

Forage yield and quality

Forage yield of different species of *Desmodium* varies considerably depending on the soil type and fertility status (Table 4). *D. discolor* produces

Table 4. Forage quality of *Desmodiums*

Species	Crude protein (%)	Crude fibre (%)
<i>Desmodium adscendens</i>	15.3	19.42
<i>D. canum</i>	15.6	-
<i>D. aparines</i>	22.1	-
<i>D. intortum</i>	17.8	31.0
<i>D. sandwicense</i>	11.9	-
<i>D. scorpiuros</i>	15.5	29.3
<i>D. tortuosum</i>	18.6	44.6
<i>D. triflorum</i>	13.6	35.0
<i>D. uncinatum</i>	14.4	42.0
<i>D. varians</i>	12.3	37.9
<i>D. barbatum</i>	15.6	31.1
<i>D. discolor</i>	15.5	-
<i>D. gangeticum</i>	12.95	-
<i>D. cephalotes</i>	30.2	-
<i>D. heterocarpon</i>	32.9	-
<i>D. triquetrum</i>	29.6	-
<i>D. nicaraquense</i>	22.0	-
<i>D. distortum</i>	22.5	-

24-30 t/ha green foliage in Zimbabwe (Whyte *et al.* 1969). *D. canum* yields 5.0-6.5 t DM/ha with crude protein content 15-60% (Whitney, 1970). Forage yield from *D. sandwicense* is very low (3.75 t DM/ha). The Green leaf desmodium is a high yielder giving several cuts but increased cutting frequency reduces the yield. The forage yield of *D. discolor* ranges from 6.3-7.5 t DM/ha. The

yield of pure silver leaf sward is reported as 6.43 t DM/ha (Clatworthy, 1977). After 3 months planting, 2nd harvest yield 2.8 t DM/ha. *D. intortum* produces 19 t/ha of green matter (Benge, 1987). In South Western islands of Japan *D. intortum* and *D. uncinatum* produce 11.41 t DM/ha and 6.38 t DM/ha respectively (Soji *et al.* 1987).

Seed production

Environmental conditions influence seed production in desmodium. Seed yield is 330 kg/ha in *D. uncinatum* and 18-20 kg/ha in *D. barbatum* (milford, 1967). *D. discolor* and *D. intortum* produce 200 kg/ha and 80-100 kg/ha of seeds respectively (Otero, 1952). The recommended seed rate for sowing is 4-8 kg/acre in *D. intortum* and 4-16 kg/acre in *D. uncinatum*. In general, seed rate for desmodiums is 5-8 kg/ha (Kanodia and Patil, 1981). The seed yield is 20-80 kg/ha in *D. canum*. Seed requirement for broadcast is very high (20-40 kg/ha) in *D. intortum* and very low (3-5 kg/ha) in *D. heterocarpon* var. *heterocarpon* (Young *et al.* 1964).

Seed germination

Seed germination of *Desmodiums* varies in different environmental conditions. The seeds of *D. tortuosum* shows 65-86% germination when treated with zinc solution (Paramathama and Surendran, 1990). The germination is 70-97% at 50°C in *D. cephalotes* and *D. gyrans* except *D. pulchellum* which has very poor germination. At 20°C, the germination of *D. cephalotes* and *D. gyrans* gradually decreased and finally ceased altogether and increased salinity from 0.125-0.2 m NaCl increased germination from 37-45% (Datta and Sen, 1987).

Green seeds have better germination percentage than brown seeds irrespective of their method of scarification, when both type of seeds of *D. velutinum* are stored in hot water having 80°C and conc. H₂SO₄ to increase germination. The seeds treated with acid have lower percentage of germination (Akinola and Afolayam, 1961). The seeds of *D. intortum* show 95% germination (Risopoulous, 1966) but the seeds of *D. biarticulatum* are moderately viable (Farinas, 1965).

Propagation methods

Desmodiums spread well by creeping stem which root at the nodes. The segmented pods break up when matured and seeds are scattered. In suitable soil it can spread vigorously.

Economic importance

The species of *Desmodium* are variously used by the local/aboriginal people in their day-to-day life. The details of uses of different species are given in Table 5.

Table 5. Economic and medicinal uses of forage *Desmodiums*

Species	Parts used as fodder	Medicinal	Others
<i>D. latifolium</i>	Stems and leaves	-	Used as broomsticks, fibres for paper making (Jain, 1963)
<i>D. tiliaefolium</i>	-	Roots carminative tonic and used in biliousness complaints (Watt, 1889-96)	Used in paper making
<i>D. cephalotes</i>	Pods are poisonous to cattle (Duthie, 1960)	-	Foliage used as food by Santals
<i>D. triflorum</i>	Foliage used by cattle	The plants are applied in scorpion sting (Singh <i>et al.</i> 1992) wounds & abscesses	Pods are eaten, used as soil stabilizer
<i>D. caudatum</i>	Foliage used by cattle (Duthie, 1960)	-	-
<i>D. diffusum</i>	Foliage used by cattle	Used to relieve cold & cough in children (Bhalla <i>et al.</i> 1992)	-
<i>D. parviflorum</i>	Foliage used by cattle, goat and camel (Duthie, 1960)	The decoction is used to cure cough & cold	Foliage is eaten by Santals
<i>D. microphyllum</i>	Used by cattle	The decoction of the plant is used in urinary trouble due to stone (Sinha, 1987)	-
<i>D. pulchellum</i>	Used by cattle	Root nodules and leaves are used in toothache (Maikhuri & Ramakrishnan 1992)	-
<i>D. triangulare</i>	Used by cattle	The decoction is used in biliousness of cattle (Jain and Tarafdar, 1970)	-
<i>D. gangeticum</i>	-	The seed smoke is used to remove insect from the body of cattle (Kapur <i>et al.</i> 1992) Smoke inhaled in crude hyper acidity (Satpathy and Oanda, 1992). The root decoction is used in fever (Bhalla <i>et al.</i> 1992).	
<i>D. laxiflorum</i>	-	Roots are used in chronic fever (Sinha, 1987)	
<i>D. capitatum</i>	-	Root decoction is given in discharge of blood from urine and it is given in respiratory trouble with <i>Solanum indicum</i> . Leaf with tobacco is applied in ulcers (Sharma and Sharma, 1992).	

Pests and diseases

The species of *Desmodium* are attacked by viral, fungal and bacterial diseases. *D. intortum* is resistant to nematode *Meliodogyne*, whereas *D. uncinatum* is least resistant to it (Kretschmer *et al.* 1980). The nematode *Meliodogyne incognita* and *Meliodogyne arenaria* cause rootknot disease in *D. heterocarpon* var. *heterocarpon*. Little leaf and *Xanthomonas* attacks have been reported in *D. canum* (Kretschme *et al.* 1980). *D. uncinatum* is highly susceptible to little leaf virus but *D. intortum* is resistant to it (Hutton and Gray, 1967). The pathogen *Colletotrichum capsici* causes severe leafblight in *D. gangeticum* having small brown spot on the leaves initially and later turning chocolate coloured (Bharadwaja and Dwivedi, 1969). Rootknot nematode occur in *D. heterocarpon* var. *florida*. *D. adscendens* and *D. intortum* cv. green leaf are resistant to *Meliodogyne* nematode and no galls are reported in the roots of these species. *D. heterophyllum* is highly susceptible to legume little leaf (Kretschmer, *et al* 1980).

Future research

Forage *Desmodium*s presently under cultivation in India are mostly exotic with a variety of diseases and pest problems. These legumes show high forage as well as seed yields under monocropping on fertile soils. For introduction of legumes in order to improve natural rangelands, there is dearth of *desmodium*s in India. On the contrary, India is a huge repository of naturally growing wild *Desmodium*s ranging from lowherbs, shrubs, to tree forms. The *desmodium*s are concentrated in humid hilly tracts and also fanout to semi-arid tracts. Therefore, in order to identify suitable *Desmodium*s for rangelands in the above areas, exploration and evaluation of *Desmodium*s of all forms should receive high priority. The Indian *Desmodium*s comprising of 49 species can also serve as genetic resources for plant improvement programmes.

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