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DISTRIBUTION AND VARIATION IN MULBERRY GERMPLASM

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A total of 183 mulberry germplasm resources have been collected through 13 explorations covering 38 districts in 13 states and one union territory to assess their variability. The wild collections of *Morus serrata* were confined to North West India. *M. laevigata* and *M.alba* are available mostly in cultivated forms. The natural resources of *M. laevigata* in North East had a wide variation. The natural genepool reserves of *M.laevigata* with large tree population at Lamia bay, Doomarnalli, Havelock and John Lawrence Islands (Andamans) are identified and reported for the first time which serve as new locations of mulberry resources availability. The extent of variation in the developed genepool reserves at Central India and introduced European mulberry varieties in tea/coffee estates in Kerala in South India were identified. The variability of the *Morus* germplasm collected, its scope of utilization and necessity for long term conservation have been stressed.

Key words : *Morus*, exploration, variability, conservation

Mulberry (*Morus* sp.) is the only food plant of silkworm (*Bombyx mori* L.). The natural distribution of the genus has considerably changed because of its extensive cultivation for silkworm rearing in tropical, sub-tropical and temperate zones, most of it to the north of equator and ranging from 50° North latitude to 10° South latitude (Yokoyama, 1962). Vavilov (1926) while reviewing the centres of origin of crop plants placed the genus *Morus* in "China-Japan" region which includes East China, Korea and Japan. Hooker (1885) and Brandis (1906) have reported 4 species viz., *M. indica, M. alba, M. serrata* and *M. laevigata* occurring in India. Parkinson (1923) reported the occurrance of *M. laevigata* from Andaman and Nicobar Islands. Gamble and Fischer (1957) in the Flora of Madras Presidency recorded 2 *Morus* species viz., *M. alba* and *M. indica.* Nair (1977) documented the occurrance of *M. serrata* from Bushahr Himalayas. Kanjilal *et al.* (1940) enumerated 3 species from Assam and North East viz., *M. serrata, M. laevigata* and *M. acidosa.*

Survey and exploration of mulberry genetic resources were undertaken in Central Himalayas (Balakrishnan and Ramesh, 1989), North eastern India

(Jain and Kumar, 1989), North-western Himalayas (Dhar and Ashan, 1989) and Central India (Omachan, 1976). Osmoston (1927) and Dandin *et al.* (1993; 1995) reported the distribution of *M. indica, M. serrata* and *M. laevigata* in forest flora of Kumaon region and Northeastern India respectively. Sreekumar *et al.* (1995) have extensively explored for mulberry resources in Kerala and collected 134 accessions from 525 locations, mostly from house- hold and cultivated gardens/estates.

Mulberry is mainly cultivated for sericultural purposes. It is also exploited for multipurpose utilization of its fruits, timber in furniture making and branches for basket weaving, fire wood besides medicine. The wide spread incidence of shifting agriculture or *jhum* cultivation is rapidly eroding the forest habitats especially in Northeastern India and mulberry is threatened with wide spread destruction thereby necessitating an urgent need to survey and collect the potential mulberry resources from natural habitat, and the primitive and obsolete varieties (Sanjappa, 1989). Further, forestry resources are getting destroyed to convert land for agricultural use and urbanization (Chauhan and Thakur, 1995). Systematic documentation however, on the distribution of mulberry resources availability in India is meagre. Hence, exploration and survey were planned to identify the locations of availability of mulberry resources either under natural habitat or in cultivated forms and in different parts of the country so that long term conservation strategy could be suggested.

MATERIALS AND METHODS

In order to plan the survey and exploration throughout the country, published literature and herbarium records of Botanical Survey of India at Shillong, Dehradun, Port Blair, Pune and Coimbatore, Forest Research Institute herbarium at Dehra Dun, the Institute of Forest Genetics and Tree Breeding herbarium at Coimbatore, the State Forest Research Institute herbarium at Itanagar and the North-eastern Hill University herbarium at Shillong were consulted which indicate that the genus *Morus* is naturally distributed in the Sub-Himalayan regions upto an altitude of 2100 m with climate varying from temperate to sub-tropical and extending between Indus and Brahmaputra rivers. Thus, to expedite the process of exploration in different regions, 4 teams were formed to cover the various geographical regions of the country in two different seasons every year viz., spring (February to April) when natural flowering occurs accompanied by sprouting of buds and autumn (September to October). The regions covered are indicated in Fig. 1.

On locating the mulberry resources in natural habitats, following data were recorded uniformly by all teams : bark colour, leaf characters such as lobation, texture, shape, margin, surface and size (l × b), phyllotaxy, internodal

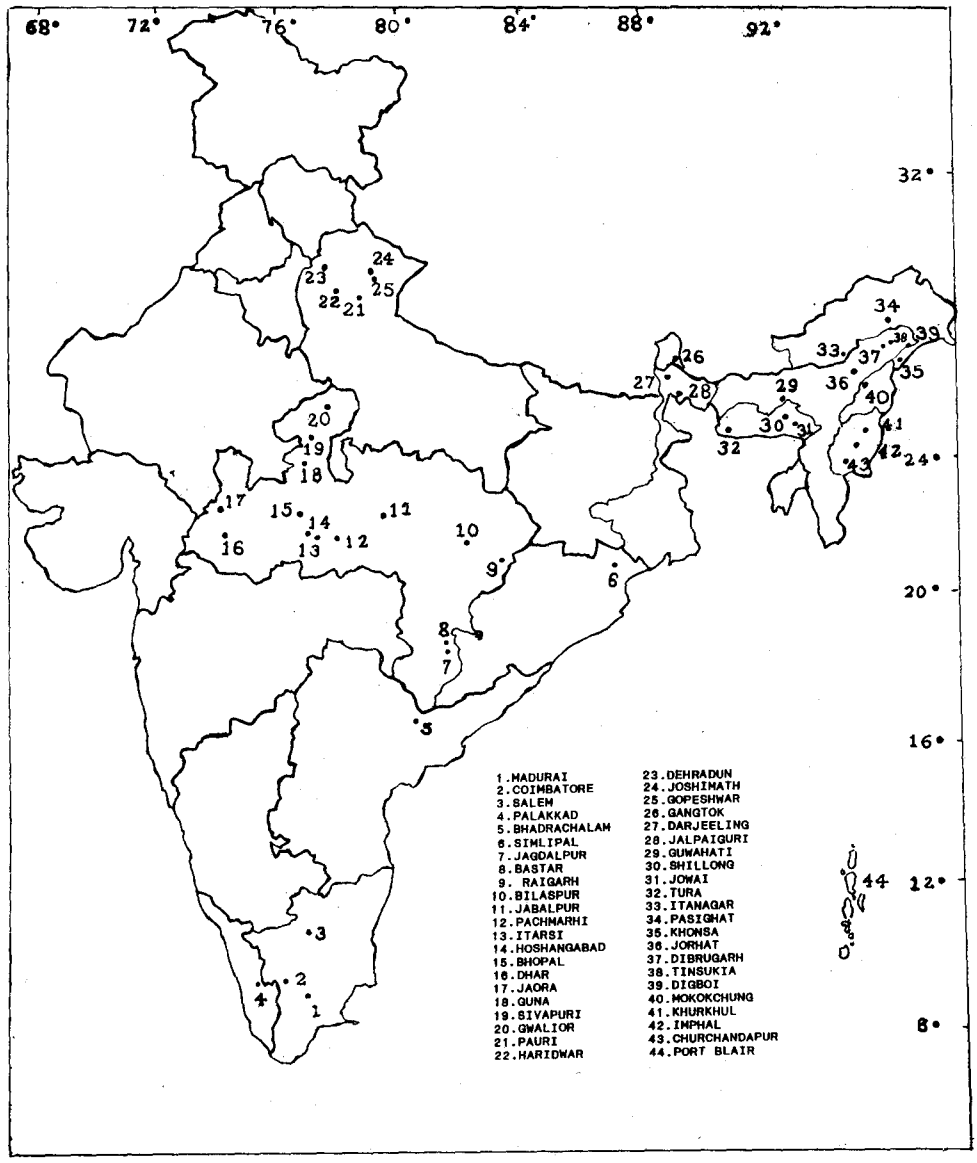

Fig. 1. Exploration sites for collection of *Morus* spp. in India

distance, sex, catkin length, fruit length. A portion of the shoot with leaves, inflorescence and fruits were collected and herbarium specimens made. The plants were sampled based on distinct morphological variability. Sufficient cuttings were collected having 4-5 dormant, healthy buds/cutting for further propagation through grafting/cutting to ensure survival and later transplanted from nursery to field gene bank for *ex situ* conservation.

RESULTS AND DISCUSSION

Distribution of mulberry resources

The explorations so far conducted revealed that 2 species under natural conditions i.e., *Morus laevigata* and *M. serrata* are available whereas under developed genepool, mostly *M. laevigata* is represented. Cultivated forms observed belonged to *M.indica* and *M. alba*. *M. laevigata* is widely distributed in different regions having no specificity of plants growing in particular types of soil or forest. In North-western India, it is found in natural habitats in Dehra Dun (30.19°N and 78.03°E), Hardwar (29.58°N and 78.09°E) and Laxman-Jhula (Pauri-Garhwal, 30.08°N and 78.48°E). In Andaman and Nicobar Islands (11.40°N and 92.44°E), wild trees of this species were observed along streams in the moist deciduous forest of Doormanalli and littoral forest of Lamia bay growing in close proximity from the sea (100 m). Wild form of *M. laevigata* was recorded earlier in Andaman by Parkinson (1923). Its availability has also been recorded by Vasudeva Rao (1986) but no specimen was examined. In North-eastern India, exploration in Sikkim was conducted for the first time as earlier explorations undertaken in North-east did not include Sikkim (Jain and Kumar, 1989; Dandin *et al.* 1995). Natural distribution of *M. laevigata* trees were observed in Eastern Himalayan wet temperate forests of namely, Rhenock, Tarpin (East Sikkim, 27.3°N and 88.51°E), Manring, Turung, Sipshu (South Sikkim 27.2°N and 88.39°E),. June, Chakung and Phuncheybong (West Sikkim, 27.1°N and 88.12°E).

Naturally occurring but scattered *M. laevigata* trees were observed in West Bengal in Eastern sub-montane semi-evergreen forests of Lava and Alghara situated in Kalimpong (27.02°N and 88.34°E). It also occurs in sub Himalayan secondary wet mixed forests of Murthy and Imdong in Jalpaiguri (26.30°N and 88.50°E). In Assam, it is found to occur in forested areas of mixed deciduous type in Pengaree, Dibrunadhi near Digboi (27.22°N and 94.34°E). In Meghalaya, trees of this species were located in tropical evergreen forests of Umpling, Nongpoh (Ribhoi district 25.54°N and 91.54°E), Sung Valley, Mynso and Jowai (25.26°N and 92.14°E). In Manipur, *M. laevigata* trees with dissected leaves were observed in Khurkhul and unlobed leaves in Churachandpur and the forest type in this region was tropical semi-evergreen.

In Arunachal Pradesh, trees were scattered in tropical semi-evergreen forests of Drupong and Harmutty (27.02°N and 93.38°E). The occurrance of this species in North-east have also been reported by Jain and Kumar (1989) and Dandin *et al.* (1995). In Central India, trees of *M. laevigata* are grown for its sweet fruits which have a good market value. Thus, developed genepool reserves of this species were located in tropical moist deciduous forests of Jaora (23.40°N and 75.10°E), Dhar (22.32°N and 75.24°E), Shivpuri (25.26°N and 77.39°E), Gwalior (26.12°N and 78.09°E), Bilaspur (22.03°N and 82.12°E), Pachamarhi (22.29°N and 78.26°E), Jabalpur (23.10°N and 71.59° E) and Raigarh (21.53°N and 83.28°E). In South India, Yadav and Pavan Kumar (1996) identified population of *M. laevigata* trees in Yercaud, Shevaroy hills, (11.44°N and 78.11°E). So far this developed genepool seems to be the largest with the trees in slopy terrain over a two km radius covered with deciduous semi-evergreen vegetation.

M. serrata resources were found to be distributed in natural habitats of North-western India in Salna (700 m), Urgam valley, Joshimath (30.33°N and 79.35°E) and Chakrata (30.42°N and 77.52°E) situated at an altitude of 2200m. The mulberry tree of Joshimath is perhaps the oldest and almost 1220 years old (Rau, 1967). This species grows in association with oak, pines and conifers. Watt (1891) reported that this species is found at higher elevations between 1200 to 2750 m in North-west growing in association with oak (upto 1800 m). Dandin *et al.* (1993) have reported their distribution in Rajouri, Sundarbani, Poonch and Batote regions of Jammu Division; Kangra, Chamba, Nahan and Kullu districts of Himachal Pradesh and Garhwal Himalayas of Uttar Pradesh at an elevation of 1100 to 2200m.

M. alba, a deciduous, monoecious tree is cultivated in Punjab, North-west Himalayas and western Tibet ascending to 3350 m. Watt (1891) and Parkar (1956) are of the opinion that this species is indigenous to China and extensively cultivated throughout the plains of India and in Himalayas upto an elevation of 3300 m. It is also grown as a roadside and as avenue tree. In the present report, a tree belonging to this species was located in Surari Garhwal, (30.08°N and 78.48°E) at an altitude of 1365 m. This area was earlier covered under forest. In Central India a developed genepool of *M. alba* was observed in Guna (24.39°N and 77.18°E).

M. indica is commonly distributed in the sericultural areas extending from temperate to sub-tropical Himalayas from Kashmir to Sikkim ascending to 2100 m. Presently most of the cultivated forms belonging to this species are commonly distributed in Uttar Pradesh, West Bengal, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Karnataka, Tamil Nadu, Kerala and Andhra Pradesh. Trees of this species are found growing in the backyards for utilization as firewood and timber. Thus, in Sikkim small trees of these species are found growing in the backyards in Sipshu and Budong. In West Bengal small trees

are found growing along the road sides and backyards in Jhorpukhari (Kalimpong), Mangalbari, Farabari and Churaimahal (Jalpaiguri) as also fringe areas of forest in Lataguri and Nagarkhata (Jalpaiguri). This species was observed growing in the backyard as a medium size tree in Tingrai near Tinsukia and Pengaree off Digboi. In Madhya Pradesh, the Forest Department have planted trees of this species in Katghora as part of social forestry programme. The present survey undertaken indicated that the distribution of natural resources of *M. indica* might have become rare due to widespread introduction of improved varieties and intensive farming practices.

In South India, the Britishers selectively introduced female mulberry varieties from Europe/Australia in tea estates of Coonoor and Munnar mainly for their ornamental value. Some of these varieties are selectively cultivated by sericulturists in Marayoor and Guhanathapuram. In Kerala, mulberry resources are commonly found growing in backyards of houses.

Variability

A total of 183 mulberry resources have been collected from different parts of the country (Table 1) representing four species. The variability in

Table 1. Mulberry resources collected during explorations (1993-98)

	North-East India	North-west India	Central India	South India	Andaman & Nicobar Is.	Total
M. laevigata	33	4	8	4	2	51
M. serrata	-	12	-	-	-	12
M. indica	32	8	5	-	-	45
M. alba	-	2	2	-	-	04
Unidentified	5	20	-	46	-	71
Total	70	46	15	50	2	183

M. laevigata resources collected from different parts of the country are presented in Table 2. The leaf is unlobed to different lobations with dissected leaves observed in a collection from Khurkhul (Manipur). The leaf shape is mostly wide ovate but narrow ovate leaf was also observed in a collection from Jowai (Meghalaya). The leaf surface is usually rough in Northeastern collections and smooth in Northwestern and Central Indian collections. Very big sized leaves (32.6 × 26.8 cm) were observed in *M. laevigata* trees occurring in Andamans as compared to mainland forms where the leaf size varied from 15 × 11 cm to 22 × 15 cm (L × B). The internodal distance varied from 4.0 to 10.9 cm.

Table 2. Comparative characteristic features of *M. laevigata* collected from different regions of India

Sl. No.	Characters	North-West India	North-East India	Central India	South India	Andaman & Nicobar Is.
1.	Bark colour	Brown, Grey, Greenish-grey, grey blackish	Pale brown, Grey brown	Grey brown	Brown/ Grey brown	Grey white
2.	Leaf location	Lobed, Unlobed dissected	Lobed, Unlobed dissected	Lobed, Unlobed	Unlobed	Unlobed
3.	Leaf Texture	Coriaceous	Coriaceous	Coriaceous	Coriaceous	Coriaceous, Membr-anous
4.	Leaf shape	Wide ovate, ovate, long ovate, ovate lanceolate	Widely ovate, ovate, narrow ovate	Wide ovate, ovate	Ovate	Ovate, widely ovate
5.	Leaf margin	Serrate	Serrate	Serrate	Serrate	Fine serrate
6.	Leaf surface	Smooth, rough	Rough very rough	Smooth, Rough	Rough	Slightly rough
7.	Leaf size (L × B cm)	15×11 - 18×12	22×11 - 22×15	15 × 12	-	22.6 × 22.1 to 32.6 × 26.8
8.	Phyllotaxy	1/2	1/2	1/2	1/2	1/2
9.	Internodal distance (cm)	6.0-7.0	4.0-8.5	5.0-7.0	4.0-7.0	4.9-10.9
10.	Sex	Male, Female	Male, Female	Female	Female	-
11.	Catkin length (cm)	4.0-7.0 (M)	6.0-7.10.0(M)	5.5-9.8 (F)	5.0 (F)	-
		7.0-9.0 (F)	7.0-11.0 (F)			
12.	Fruit length (cm)	7.0-12.0	7.5-12.0	6.0-18.5		-

Most of the trees were dioecious and female. Trees with male catkins were observed only in Northwestern and northeastern India. The fruit length exhibited variation ranging from 7.0 to 18.5 cm and exceptionally long fruits (18.5 cm) was observed in collections from Central India.

M. serrata resources were collected from natural habitats only from Northwestern region. The bark colour varied from red to dark brown with

heterophyllous leaves and mixed phyllotaxy rank such as 1/2 and 1/2, 1/3. The leaf surface was smooth to rough. The leaf margin was serrate. The leaf texture varied from chartaceous to coriaceous. The leaf size (L × B) varied from 15.0 cm × 10.0 cm to 20.5 cm × 20.0 cm. The internodal distance varied from 3.0 cm to 7.0 cm. The flowers were compactly arranged in catkins which were dioecious male.

Besides locating the naturally occurring tree mulberry resources, few morphologically distinct genotypes belonging to *M. indica* and *M. alba* were also collected. The rest of the collections are cultivated forms and growing in the backyard. The leaves varied from homophyllous to heterophyllous. The leaf lobation varied from one lobed to multi-lobed. Leaf base was cordate/ truncate/retuse. Leaf margin was serrate/crenate/dentate. Leaf apex varied from acute to acuminate condition. Leaf surface was smooth/slightly rough/ scabrous. Leaf texture was mostly chartaceous and few were coriaceous. The inflorescence was male/female, rarely mixed. Most of the cultivated forms had long styles and bifid errect to spreading stigmas. Few profuse fruiting varieties were also observed and collected in Central and Northeastern India.

Utilization of the resources

M. laevigata has good adaptability being distributed in diverse climatic conditions, forest and soil types including littoral habitat of Andamans. Because of its wide genetic base, characteristic features like big wide ovate leaves, long sized fruits and adaptability to diverse environments including saline habitats, it could be utilized in mulberry improvement programme. But due to constraints like sexual incompatibility, little success could only be achieved through conventional breeding programme. Hence, it is imperative to resort to biotechnological approaches like protoplast fusion in order to evolve superior hybrids by utilizing *M. laevigata* resources from diverse habitats.

M. serrata has limited adaptability having evolved in isolation and confined only in forested areas of Northwestern India. The leaves are hairy and usually not used for silkworm rearing. But there is scope to exploit the disease and frost resistant characters through biotechnology.

Among the cultivated forms collected, "Satin" variety belonging to *M. indica* is widely cultivated in Khasi and Jaintia hills of Meghalaya for rearing *bivoltine* silkworm races. It is characterised by glossy and coriaceous leaves and can straight away be introduced after initial evaluation. A few profuse fruiting varieties collected from Central and Northeast India can be exploited in breeding programmes. Further, Britishers introduced female mulberry varieties in tea estates of Coonoor and Munnar for utilizing the fruits in wine making. Some of these varieties are selectively cultivated by sericulturists in

Marayoor and Guhanathapuram areas for seed cocoon rearing resulting in good yield.

Because of shifting agriculture commonly practised in North-eastern India and also due to utilization of forest areas for agricultural purpose, there is considerable denudation of forested areas where wild trees of *M. laevigata* and *M. serrata* are available. Further, there is wide spread damage to mulberry trees especially in Sikkim, Meghalaya, North-west and Central India where the trees are exploited for various economic uses and no sustained efforts were made to propagate the resources. Only in Arunachal Pradesh, the State Govt. has enacted special legislation act to protect *M. laevigata* resources and it is an offence to cut or damage a tree. The developed genepool reserve of *M. alba* in Guna (Madhya pradesh) also deserves similar attention towards to *ex situ* conservation. As a part of conservation of biodiversity programme both in natural and developed conditions, necessary steps are required to be adopted for protecting the mulberry germplasm in *in situ* as also in *ex situ* conditions as these constitute valuable resources needed for future crop improvement programmes.

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REFERENCES

Balakrishna, R and S.R. Ramesh. 1989. Mulberry species and their distribution in Central Himalaya p 33-35 *In*: K. Sengupta and S.B. Dandin (Eds.), Genetic Resources of Mulberry and Utilisation. CST & TI, Mysore.

Brandis, D. 1906. Indian trees, p. 612-613. London.

Chauhan, N.S. and S. Thakur. 1995. Conservation of plant genetic resources of Himachal Pradesh. *Indian J. For.* **18**: 226-238.

Dandin, S.B., Basavaiah, R. Kumar and H.V. Venkateshaiah. 1993. Phytogeographical studies in genus *Morus* L.I. Geographical distribution and natural variation of *Morus serrata* Roxb. *Plant Genetic Resources: Developing National Policy*, organised by the Indian Society of Plant Genetic Resources, New Delhi, Dec. 1-2, 1993 p.11.

Dandin, S.B., Basavaiah, R. Kumar and R.S. Mallikarjunappa. 1995. Phytogeographical studies in the genus *Morus* L.II. Geographical distribution and natural variation of *M. laevigata* Wall. ex Brandis. *Indian J. Pl. Genetic Resources.* **8**(1): 129-131.

Dhar, A. and M. Ahsan. 1989. Mulberry species and distribution in North-western Himalayas. p. 33-35. *In*: K. Sengupta & S.B. Dandin (Eds.). Genetic Resources of Mulberry and Utilisation. CSR&TI, Mysore.

Gamble, J.S. and C.E.C. Fischer. 1957. Flora of the Presidency of Madras. Vol. II, p. 946-958. London.

Hooker, J.D. 19885. Flora of British India. V: 491-493. (Reprinted.) Bishen Singh Mahendra Pal Singh, Dehra Dun.

Jain, A.K. and R. Kumar. 1989. Mulberry species and their distribution in North-eastern India. p. 37-42. *In*: K. Sengupta & S.B. Dandin (Eds.). Genetic Resources of Mulberry and Utilisation. CSR&TI, Mysore.

Kanjilal, U.N., P.C. Kanjilal, A. Das, R.N. De and N.L. Bor. 1940. Flora of Assam. Vol. 4, p. 272-274. Government Press, Shillong.

Nair, N.C. 1977. Flora of Bushahr Himalayas, International Bioscience Publishers, Hisar.

Ommachan. 1976. Flora of Bhopal. Angiosperms. J.K. Jain and Brothers, Bhopal.

Osmotan, A.E. 1927. A Forest Flora of Kumaon, p. 502-503. Govt. Press, Allahabad.

Parker, R.N. 1956. Forest flora for the Punjab with Hazara and Delhi. 3rd edn. p. 471-473, Govt. Printing Press, Lahore, West Pakistan.

Parkinson, C.E. 1923. A Forest Flora of Andaman Islands. p. 155. Bishen Singh and Mahindra Pal Singh, Dehra Dun.

Rau, M.A. 1967. The Scared Mulberry tree of Joshimath, U.P. *Indian Forester* **93**(8): 333-335.

Sanjappa, M. 1989. Geographical Distribution and Exploration of the genus *Morus* L. (*Moraceae*). p. 04-07. *In*: K. Sengupta & S.B. Dandin (Eds.). Genetic Resources of Mulberry and Utilisation, CSR&TI, Mysore.

Sreekumar, H., S. Kumaresan, J.C. Jose, S.K. Jaylakshmi, R. Satheesh and P.K.K. Nair. 1995. Exploration and collection of Mulberry Genetic Resources in Kerala. *J. Environ. Resour.* **3**: 14-17.

Vavilov, N.I. 1926. Studies on the origin of cultivated plants. *Trudy Byuro Prikl. Bot.* **16**:139-248.

Vasudeva Rao, M.K. 1986. A Preliminary report on angiosperms of Andaman & Nicobar Islands. *J. Econ. Tax. Bot.* **8**: 107-184.

Watt, G. 1891. Dictionary of Economic Products of India. Vol. 5, p. 279-284, Periodical Experts, Delhi.

Yadav, B.R.D. and T. Pavan Kumar. 1996. Occurrence of a new distributional range of *Morus laevigata* Wall. and its variants in South India. *Indian J. Seric.* **35**(2): 163-164.

Yokoyama, T. 1962. Synthesised science of Sericulture, p. 39-46. Japan.