REVIEW OF LITERATURE

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Review of literature

II. REVIEW OF LITERATURE

II.1. HISTORICAL BACKGROUND

In Indian taxonomic literature the first direct reference to bamboo is as old as Rig-Veda (Circa 5000 BC) and it is written as *bestow upon as a hundred bamboo culms* (Vinookaley, 2000). Theophrastus, Greek philosopher, mentioned the bamboos in his work *Enquiry in to plants* (Kumar & Stephen, 1999). Another early record of bamboo in Western literature was in a letter from Alexander the Great to Aristotle and referred to by Pliny in his Encyclopaedic natural history (Soderstrom, 1987).

In Arthashastra written by Chanakya (300 BC) mentioned the trade of bamboo craft as an important source of state revenue. He also described the names of different species of bamboos growing in his country. They are *Utaja, Cimaya, Chapa, Venu, Sathina, Kantaka* and *Bhalluka.* This classification was based on different characters like hollowness and solid nature of culms, presence and absence of thorns and internodal length of the culms (Vinookaley, 2000; Sensarma, 1993).

The Persian scholar and physician of 11th century Avicenna (Iben-Sina, 980-1037), in his work *Qanun of medicine* referred about Tabaxir (Soderstrom, 1987). In the same book he also referred to *Mambu* which later subsequent authors took to be a reference to bamboos.

In India, the modern floristic studies were started during the colonial period. In the 16th century, Garcia da Orta, a physician, wrote an important treatise called *Coloquios dos Simples e Drogas da India.* This work was about the native plants and their uses, and it was published in 1653. This was the first publication on Indian plants. In this book he mentioned about *Tabaxir,* which was exported during that period to Arabia, Persia and Turkey as a medicine. Merchants called it *Tabaxir Mambu.*

The famous physician and botanist Casper Bauhin published his book *Pinax* in 1623 (Soderstrom, 1987). In this book several pages were utilised for discussing reed grasses. He used the name *Arundo* for the reed and first name he used was *Arundoarbour,* which is a woody or tree like reed. It was the

source of Tabaxir and the Indians named it as *Mambu*. He also referred to Avicenna and Garcia da Orta. Later in his list of reference to this plant, Bauhin give the following *Cana Tabaxir* and *Arundo*, which the Indians call *Bambus*. According to him, they are reeds of very pleasing aspect, are very tall, black, round, thick and grows spontaneously all over the Malabar coast and especially near Coromandel. The word *Bambus* later used by Linnaeus in 1753 on the basis of his *Arundo bamboos* from which the genus name *Bambusa* was later adopted (Soderstrom, 1987).

In the 17th century, the Malabar Coast came under the Dutch rule. The Dutch commander Hendrik Adrian Van Rheede tot Draakestein realised the importance of the medicinal plants of Malabar with the help of local physicians. He described and illustrated these medicinal plants. The work that eventually consisted of 12 volumes and the first volumes was published in the year 1678 from Amsterdam. It was the great classic the *Hortus Indus Malabaricus* that later became the basis for many floristic works. Three species of bamboos were described and illustrated in the 5th volume (1685). They were Illy, *Bambusa bambos;* Beesha, *Ochlandra scriptoria* and Nolla Illy, which is *Ochlandra travancorica* (Nicolson *et al.,* 1988).

In 1737, Linnaeus's *Hortus Cliffortianus* was published. In this work he listed an Arundoarbour. Rumphius (1743) published a book *Herbarium Amboinense* in which some bamboos were mentioned. He divided the then bamboos under eight classes and these classes were again classified into various subdivisions. In 1753, the masterpiece of Linnaeus, the *Species Plantarum* was published. He mentioned a bamboo, the *Arundo bambos*. This is the first validly published name of a bamboo in scientific literature. Schreber (1789) published the generic name *Bambusa*. Another botanist Retzius (1789) published *Bambus arundinacea*. Schreber cited the generic name *Bambos* published by Retzius (1789) as a synonym under *Bambusa*. Retzius is the man who first described scientifically *Bambusa bambos*.

In 1790, Joaode Loureiro described another bamboo species *Arundo multiplex* now recognised as *Bambusa multiplex*. In 1791, Gmelin from the island of Reunion described *Nastus borbonicus*. Walter (1788) described *Arundo gigantea* and was elevated to the genus *Arundinaria* by Michaux (1803).

Therefore, the first described bamboo genera are *Bambusa, Nastus and Arundinaria.* Wendland (1808) described *Bambusa vulgaris.* William Roxburgh (1814) was the Director of East India Company's Calcutta Garden described *Dendrocalamus strictus* and *Bambusa bambos* in Plants of the Coast of Coromandel (1778) and 7 species of bamboos in his *Hortus Bengalensis* (1814). Kunth (1815) recognised bamboos as one of his ten natural groups of genera and referred to the group as *Gramina Bambusacea.*

Nees (1834) for the first time recognised the relation between woody and herbaceous species. In *Bambusacea Brasiliensis,* he included *Streptochaeta* as one of the bamboo groups. Nees (1834) classified the bamboos into three groups, *Bambuseae, Arundinariae and Streptochaete.* The first monograph on bamboo taxonomy was Ruprecht's (1839) *Bambuseas Monographice exponit.* He included 67 taxa under 9 genera among which 55 species were described with flowers. Munro (1868) published a world *Monograph of the Bambusaceae.* It is one of the most useful original references on bamboos. In this treatise, 170 species of bamboos were described under 20 genera. All the groups and subgroups that Munro had recognised are accepted even now, though under different names or included under different ranks with recent concepts.

Kurz (1876) published a paper on *Bamboo and its Uses.* He was the first man who studied special type of proliferation in bamboo spikelets. Another important work of Kurz was the *Forest Flora of British Burma* (1877) in which 30 species of Burmese bamboos were included.

Colonel Beddome (1873) included 18 South Indian bamboo species in *Flora Sylvatica for Southern India.* Subsequently, in *Genera Plantarum* of Bentham (1883) 18 genera of South Indian bamboos were described.

In 1887, Franchet described some herbaceous bamboos from French Congo. Later, Gamble the Director of the imperial Forest School, Dehra Dun during 1890-1899, wrote several books on the forests of India and Burma. In 1896, *The Bambuseae of British India,* his monumental work on Indian bamboos was published. He included 15 genera under 115 species with 119 illustrations. This work still remains as the foundation for the subsequent studies on Indian bamboos. He also studied the taxonomy of the genus *Arundinaria* and Burmese bamboos (Gamble, 1888, 1894). In his book, *A Manual of Indian*

Timbers (1902) he described the species of *Arundinaria, Bambusa, Dendrocalamus, Oxytenanthera* and *Ochlandra.*

Brandis (1899) in *Biological Notes on Indian Bamboos,* described bamboos from both south India and northeastern part of India. In 1906, Brandis published a book, *Indian Trees.* In this book the general characteristics of the tribe Bambuseae are given along with descriptions of the genera *Arundinaria, Bambusa, Oxytenanthera, Dendrocalamus* and *Ochlandra.* His remarkable work appeared in 1907 on the structure of bamboo leaves.

In Forest Flora of the Bombay Presidency and Sind, Talbot (1912) described *Bambusa bambos, Dendrocalamus strictus, Oxytenanthera stocksii, O. monostigma* and *Ochlandra talbolti.*

II.2. INTERNATIONAL STATUS

In the beginning of 20th century Camus (1913) published a monograph of bamboos, *Les Bambusees.*

The British Botanist, Agnes Arber (1926, 1927, 1928, 1929, 1934) conducted studies on the flower structure and organisation of different species of bamboos such as *Dendrocalamus strictus, Bambusa bambos, Cephalostachyum* sps., *Oxytenanthera* sps., *Schizostachyum* sps. and *Ochlandra* sps.

South America is rich in bamboos and considerable work on bamboo taxonomy has been carried out. One of the earlier descriptions of American bamboos was in *Flora Brasiliensis* by Doell (1880). Parodi (1936, 1941, 1961) studied the bamboos of Argentina and Chile. McClure and Smith (1967) revised the Brazilian bamboos. McClure (1973) also published another work on new world bamboos. Among the studies of South American bamboos the work of Soderstrom is estimable. Soderstrom (1981a) described a new genus *Olmeca* from Mexico. It has with fleshy fruits similar to that of *Ochlandra.* Some of the important publications on American bamboos are Calderon and Soderstrom (1973), Soderstrom (1981b, 1987, 1988), Soderstrom and Ellis (1982, 1987, 1988), Soderstrom and Calderon (1974, 1978, 1979), Soderstrom and Young (1983, 1989), Soderstrom and Londono (1987, 1988) and

Soderstrom and Zuloaga (1985). The taxonomy, systematics and diversity of South American bamboos were studied by Clark (1985, 1987a, 1987b, 1993, 1996), Clark and Londono (1990, 1991), Londono and Clark (1998), Londono and Davidse (1991), Sendulsky (1992, 1995), Tucker (1988), Young and Judd (1992) and Zuloaga *et al.* (1993). Judziewicz (1992) revised the South American bamboo genus *Atracantha* with keys, descriptions, illustrations and maps of all five recognised taxa. Recently, Judziewicz *et al.* (1999) published a detailed treatise on American bamboos.

There are a lot of valuable taxonomic publications from China by different workers. Accounts of bamboos of China appear in many works of McClure between 1919 and 1940. Other important taxonomic work on Chinese bamboos are of Chao and Chu (1981), Chao and Renvoize (1987), Keng (1982a, 1982b, 1983a, 1983b, 1984a, 1984b, 1986, 1987, 1991), Keng and Wen (1991), Li (1998), Stapleton and Xia (1997), Wang and Ye (1991), Wen and Chou (1985), Xia (1996), Xia and Jia (1996), Yi (1993a, 1993b, 1996, 2000), Yi and Yang (1998) and Zhang and Chen (1991).

South East Asia has rich genetic diversity of bamboos. Recently lot of explorations was done in this area and lot of scientific data on bamboos came out. The contributions of Holttum, Dransfield and Widjaja on the taxonomic studies of south east Asian bamboos are of great significance (Holttum, 1946, 1954, 1956a, 1956b, 1956c, 1956d, 1958, 1967; Dransfield, 1980, 1981, 1983a, 1983b, 1989a, 1989b, 1994, 1996, 1998a, 1998b; Widjaja, 1990, 1994, 1998). Chao and Renvoize (1989) revised *Arundinaria* in South East Asia and Africa. Widjaja (1987) revised the genus *Gigantochloa* of Malaysia. Dransfield and Widjaja (1995) done a notable work with complete descriptions, illustrations of south east Asian bamboos. Wong (1995a) published a book on Malaysian bamboos. His other important contributions are Wong (1981, 1982, 1986, 1991, 1992, 1993a, 1993b, 1995b). Other workers also done important taxonomic works on south east Asian bamboos (Chialiang-Chi *et al.*, 1983; Susiarti & Soedjito, 1996; Sumantera, 1996; Rudall and Dransfield, 1989). Chua *et al.* (1996) wrote a detailed taxonomic account of bamboos of Singapore.

In Japan the bamboos are very important both economically and culturally. Makino, Nakai and Koidzumi, Usui and Aoki made significant contributions to Japanese bamboo taxonomy (Makino, 1900, 1923, 1932a, 1932b; Makino and Shibata, 1901; Nakai, 1925; Koidzumi, 1936, 1937, 1940a, 1940b; Usui, 1985, 1987; Aoki, 1987).

McClure in the field of world bamboo taxonomy made exceptional contributions. He published a number of papers on Chinese and American bamboos. In 1966, he published an excellent book on the morphology, taxonomy and cultivation of bamboos. He reported lot of new species, made new combinations and typified a number of genera and species (McClure, 1936a, 1936b, 1936c, 1946, 1956, 1957, 1959, 1960, 1961, 1962, 1963a, 1963b, 1973).

Ohrnberger and Gorrings (1983) published the bamboos of the world. This treatise is with the nomenclature and distribution of the herbaceous and woody bamboos. Ohrnberger (1999) released a detailed annotated nomenclature and taxonomic literature on the bamboos of the world.

Bangladesh has a very good natural resource of bamboos. Alam (1982, 1994), Alam *et al.* (1997) and Banik (1998) studied the taxonomy, distribution and genetic resources of bamboos in Bangladesh. Parker (1928, 1931, 1932) worked on the taxonomy of Burmese bamboos.

Sri Lankan flora has a lot of affinities with south Indian flora. Six species of bamboos are common in South India and Sri Lanka. De Zoysa studied various aspects of bamboos of Sri Lanka (De Zoysa, 1994; De Zoysa *et al.*, 1990). Soderstrom and Ellis (1988) published detailed taxonomic and anatomical studies on Sri Lankan bamboos.

Chao and Renvoize (1988a, 1988b) conducted studies on bamboos of the Himalayan region and southern Burma. They revised the genus Arundinaria of South East Asia and Africa and made some new combinations (1989a, 1989b). In the field of modern bamboo taxonomy Stapleton has made significant contributions (Stapleton, 1994a, 1994b, 1994c). Besides these, he published several papers on bamboo taxonomy (Stapleton, 1998; Stapleton *et al.*, 1996, 1997; Xia and Stapleton, 1997a, 1997b).

II.3. NATIONAL STATUS

The studies on Indian bamboos were geared up subsequent to the publication of Gamble's monumental work *Bambuseae of British India* (1896). Parker (1929) wrote additional notes on the taxonomy of Indian bamboos. In the famous publication *Wealth of India* (1948, 1952, 1966) the importance and uses of the genera *Arundinaria, Dendrocalamus, Ochlandra* and *Oxytenanthera* were mentioned. Kedharnath and Chatterjee (1966) reported an important species of bamboo *Phyllostachys bambosoides* from Himachal Pradesh. Qureshi and Deshmukh (1965) studied the distribution and importance of Indian bamboos. Raizada and Chatterjee (1956, 1963) studied the world distribution of bamboos with special reference to India, and also reported a new species from South India. Many workers reported new species and also studied the taxonomy and distribution of Indian bamboos (Bahadur, 1974, 1979; Bahadur and Naithani, 1976, 1983; Bahadur and Jain, 1981; Varmah and Bahadur, 1980; Bor, 1982; Majumdar, 1983; Suri and Chauhan, 1984; Gaur, 1987; Sulhan, 1991; Thangam, 1992; Vinayak Kelkar, 1994; Jainendra Kumar and Sinha, 1994; Das, 1994; Subramanian, 1995, 1998; Moulic, 1997; Hore, 1998; Rai and Chauhan, 1998; Adakoli, 1999).

Significant contributions were made by Biswas (1988, 1993, 1995, 2002a, 2002b) and Biswas *et al.* (1991) on the taxonomy of northeastern bamboos. Tewari (1992a, 1992b) published a monograph and a handbook on Indian bamboos. Bedell (1997) wrote an excellent book on the taxonomy of Indian bamboos. Naithani worked on bamboos of northeastern States and reported a number of new species (Naithani, 1990a, 1990b, 1992, 1993, 1994a, 1994b; Naithani and Bahadur, 1982; Naithani and Bennet, 1986, 1991; Naithani and Sumer Chandra, 1998). Bennet worked on the taxonomy and nomenclature problems of some Indian bamboos (Bennet, 1988, 1989, 1993; Bennet and Gaur, 1990a, 1990b).

Apart from classical taxonomy many workers emphasised the importance of anatomy of leaf, culm, etc. in bamboo systematics. These characters can be considered as supporting evidence for generic and specific delimitations. Epidermal anatomy of culm, leaves and nodal anatomy can also be used for the purpose of bamboo classification.

Brandis (1907) had done an excellent work on the structure of bamboo leaves. He studied the similarity in features of leaf anatomy and epidermis of different bamboos. Metcalf (1960) published a remarkable book on the anatomy of monocots. In this work he discussed the anatomy of grasses including bamboos. Grosser and Liese (1971) studied the vascular bundles of Asian bamboos. Calderon & Soderstrom (1973) studied the detailed leaf anatomy of the genus *Maclurolyra* from Panama. Alam and Dransfield (1981) did the anatomical studies of the species *Melocalamus compactiflorus*. Renvoize (1985, 1987) studied the leaf blade anatomy of bamboos. Wen and Chou (1984, 1985) conducted a detailed study of the vascular bundle arrangement of 100 species of 28 genera of Chinese bamboos. Based on vascular bundle anatomy they provided a generic key. Usui (1987) studied the phylogeny of 20 Japanese bamboo species based on nodal anatomy. Soderstrom and Londono (1988) published a paper on the morphological studies on the Brazilian bamboo genus *Alvimia*. Raechal and Curtis (1990) published a paper, which deals with the root anatomy of bamboos. Yao and Xu (1992) published the anatomical analysis of native bamboo culms of China.

Another important work is that of Ghosh and Negi (1960) on the anatomy of Indian bamboos. They studied the culm epidermis of some important species of Indian bamboos. Pattanath & Rao (1969) did an outstanding work on the epidermal and internodal anatomy of bamboos. According to them the anatomical features can be used as an aid to identification and classification of bamboos. Bisen *et al.* (1988) studied the culm and leaf epidermis of 36 species belonging to 22 genera of Indian bamboos. Agarwal and Luxmi Chauhan (1995, 1990, 1991. 1992) conducted detailed study on the leaf epidermal anatomy of Indian bamboos. Holttum (1946) proposed a classification based on the structure of ovary.

Some of the morphological characters are also useful in generic and specific delimitations. Chatterjee and Raizada (1963) reported the importance of culm sheath as an aid to the identification of bamboos. Based on the culm sheath characters they made a key for the identification of 22 species of bamboos. Guedes and Dupuy (1976) studied the morphology of lodicules. Prophylls are taxonomically important vegetative structures (Usui, 1985).

Modern molecular techniques have been applied in the field of taxonomy to study the phylogeny and affinities of bamboos. These techniques are not widely used in India to study the affinities of Indian bamboos. Some workers did some basic studies. Lalitakumari *et al.* (1985) applied the electrophorotic pattern of peroxydase isozyme of 13 species of *Bambusa* for species identification. Seethalakshmi and Preethy (1999) studied the details on the identity of some tropical bamboos using molecular techniques.

Wantanabe *et al.* (1994) applied chloroplast DNA restriction site mapping to study the phylogeny of Asian bamboos. Clark *et al.* (1995) used ndhF sequence data to analyse the phylogeny of grass family. Alam *et al.* (1997) conducted chemotaxonomic studies in peroxydase isozyme of 15 species of Bamboos of Bangladesh. Kobayashi (1997) used RFLP of chloroplast DNA to analyse the phylogeny of world bamboos. Kiew *et al.* (2000) studied the genetic variation and relationship within the subtribe *Bambusinae* using AFLP technique. Hong and Man (2002) done the enzyme electrophorosis of *Pseudosasa japonica* in Korea to estimate the genetic diversity.

II.4. SOUTH INDIAN STATUS

The first authentic reference of South Indian bamboos is in Hortus Malabaricus (Rheede, 1685). Munro (1868) and Beddome (1873) described some of the South Indian bamboos. Gamble (1896) described and illustrated all South Indian bamboos known at that time. Gamble (1902) in his publication a manual of Indian timbers described 15 species of South Indian bamboos. Bourdillon (1908) described 10 species of South Indian bamboos in *The Forest Trees of Travancore.* Rama Rao (1914) in his book, *Flowering Plants of Travancore,* included 15 species of South Indian bamboos.

The taxonomy of bamboos distributed in the South Indian States were studied by later workers (Kadambi, 1949; Andiappan and Wilson, 1963; Hussain, 1980; Nair, 1980). Nair and Ansari (1982) discussed the nomenclature problem of *Oxytenanthera monostigma.*

Matthew (1999) in the Flora of Palani Hills, South India described six South Indian bamboos. Pullaiah and his co-workers described *Dendrocalamus*

strictus and *Bambusa bambos* in the district floras of Andhra Pradesh (Pullaiah *et al.*, 1992, 1998, 2000; Pullaiah and Mohammad, 2000; Venkata Raju and Pullaiah, 1995).

Koshy and Pushpangadan (1997), Koshy and Harikumar (2001) and Koshy *et al.* (2001) studied the pollination biology of some South Indian bamboos. Seethalakshmi conducted studies on various aspects like seed storage, flowering and fruiting behaviour of some South Indian bamboos (Seethalakshmi, 1991, 1993, 2001; Seethalakshmi and Preethi, 1999; Seethalakshmi *et al.*, 1983, 1990; Seethalakshmi and Gnanaharan, 1998). Seethalakshmi and Kumar (1998) published a compendium on Indian bamboos and included all the published details of 128 species of Indian bamboos. Some of the recent publications on bamboos of this phytogeographic region are that of Kumar (Kumar, 1990, 1991, 1993, 1995; 2002; Kumar & Stephen, 1995, 1996, 1999; Kumar & Remesh, 1999, 2000, 2001, 2003; Manilal & Kumar, 1998; Kumar *et al.*, 1999, 2000, 2001a, 2001b).