S Y N O P S I S

OF THE THESIS ENTITLED

TAXONOMIC REVISION OF THE SUBTRIBE *DIMERIINAE* HACK. OF ANDROPOGONEAE (PANICOIDEAE – POACEAE) IN PENINSULAR INDIA

Submitted to the
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BY

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CERTIFICATE

This is to certify that the thesis entitled **Taxonomic revision of the subtribe Dimeriinae** Hack. **of Andropogoneae (Panicoideae - Poaceae) in Peninsular India** submitted to the University of Calicut by Mr. M. S. Kiranraj, in part-fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Botany is a *bona fide* record of the research work carried out by him under my supervision and guidance. No part of the present work has formed the basis for the award of any other degree or diploma previously.

Prof. (Dr.) M. Sivadasan

(Supervising teacher)

C. U. Campus

15. 07. 2008

DECLARATION

The thesis entitled **Taxonomic revision of the subtribe Dimeriinae** Hack. **of Andropogoneae (Panicoideae - Poaceae) in Peninsular India** submitted by me in part-fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Botany has not been submitted earlier either in part or in full for any degree or diploma of any University and it represents the original work done by me.

Kiranraj, M. S.

C. U. Campus

15. 07. 2008

dedicated to

My Parents & Ravi Sir

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Chapter 1. INTRODUCTION

THE GRASS WORLD

"Grass is the forgiveness of Nature – her constant benediction". The importance of grass is concealed in this famous quote from Senator John Ingalls (1864). It is true that grasses have an important role both in man's economic activity and in ecological regime of Mother Nature. Grasses belong to Poaceae, the most important of all plant families to mankind. Humans discovered cereal grains over 10,000 years ago and explored their unparalleled use as food, which turned out to be a prerequisite for civilizations in time. All of the grains, we grow today were grown by Stone Age men (Moore, 1960). The word 'grain', the unique seeds of grasses where seed coat is fused to the ovary wall, comes from the Latin word '*granum*' meaning seed and 'cereals' after '*Ceres*', the Roman goddess of grain and agriculture. Out of the 7000 plant species cultivated for food, the three 'king makers' of grasses – Wheat, Rice and Maize – supply 50 % of the world food and in the global production of crops they comes first together with sugarcane (*Saccharum officinarum*) (Wilson, 1988). Wheat (*Triticum aestivum*), the 'queen of cereals' is considered as the first cultivated crop which together with Barley (*Hordeum vulgare*) sustains near Eastern cultures. Corn or Maize (*Zea mays*), the 'king of crops', maintains the New World civilizations and the Rice

(*Oryza sativa*) sustains the far Eastern populations, which also feeds half of the people in the planet in daily basis (Simpson & Ogorzaly, 2001).

The crop species of Poaceae provide 80% of the annual global food (FAOSTAT, 1999). Now, 70 % of the earth's farmland is utilized for grain production and about 35 species have been cultivated as cereals. The family also includes less familiar minor grains (Millets), which feed the poor people, mainly cultivated in the Old World. Grasses are also used as livestock food and sugar source; for erosion control and turf production; bamboos used for paper-making, rayon production, as construction materials, etc. Ultimately, grass becomes the 'stuff of life' and it is also found intervening with cultural history of man from time immemorial.

Grass diversity, distribution and significance

Grasses comprise approximately 15 % of monocot species diversity (Clark, 2004) and places it as the fifth largest flowering plant family (Hilu, 2007). In the number of species, Poaceae (ca. 10,000 spp.) together with Orchidaceae (ca. 20,000 spp.) forms half of the total monocots (ca. 65, 000 spp.) (Judd *et al*., 2002). The family encompasses tremendous ecological, morphological, physiological, and generic diversity and is divided into 651 (Clayton & Renvoize, 1986) to 765 genera (Kellogg, 1998). *Poa* L. (ca. 500 spp.), *Festuca* L. (ca. 450 spp.), *Panicum* L. (ca. 470 spp.) and *Paspalum* L. (ca. 330 spp.) are the leading genera in the family

(Mabberley, 1997), which together constitute about 20 % of the grass species of the world. The first two pooid genera (*Poa* L. and *Festuca* L.) are mainly concentrated in the temperate regions and the rest two panicoid genera (*Panicum* L. and *Paspalum* L.) to tropical regions. Grasses are unique among flowering plants due to the extreme reduction, profound modification, complexity of microscopic reproductive parts and parallel evolution of various morphological characteristics, which cause difficulties in grass taxonomy and becomes ‘marginalized’ in systematic studies especially in countries like India.

Grasses exhibit cosmopolitan distribution, ranging from polar regions to the equator, except in some forest types and they form almost 25% of the earth vegetation (Heywood, 2007). They constitute the dominant species in major biomes such as grasslands, steppes and savannas, while the woody bamboos play an important role in Tropical forest ecology (Judd *et al.,* 2002). Other Grass dominated ecosystems are North American prairie and plains - “the bread basket of the world”, the South American pampas; the Eurasian steppes, and the African veldt. Grasses and large grazing herbivores have evolved together (de Wet, 1981), and are observed that evolution of horses played a central role in interpreting the origin of grass dominated ecosystems (Stebbins, 1981; Jacobs *et al.,* 1999). The fertile grasslands of the world are considered as the ‘bread baskets’ and are primary genetic resource center of most of the cultivated crops. Conservation of these natural grasslands are now overwhelmed as it holds ecological diversities, species variabilities and genetic resources and have been protected under “warm spots” which overlap some of the Vavilovian centers (Nayar, 1998). Unfortunately, many of the tropical countries including India have treated these virgin lands with hostility and efforts have been started to convert grasslands to monoculture plantations (“green deserts”). This type of human impact on the natural vegetation may interfere with natural succession caused by global Climate-change.

The occurrence of polyploidy is the main cause of the high species diversity in grasses, and Stebbins (1972) pointed out that about 80-90% species of the family have undergone polyploidisation. The nature of polyploidy is related to hybridization and apomixes which are frequently observed in the family and they together have played an important role in the evolution of grasses (Kellogg, 1990). Grasses also vary in their photosynthetic pathways and the presence of C_3 and C_4 mechanism enables them to adopt wide range of habitats. C_3 pathway is most efficient in temperate regions whereas C_4 grasses are mostly concentrated in tropical and subtropical regions of the world (Cerling *et al.*, 1997).

Climate change & Grass distribution

The Climate change have altered the global distribution of C_3 and C_4 grasses, which affects the global carbon cycle and leads to differing effects on agricultural production and the diversification of C_4 grasses in particular (Ehleringer, 1991). An ecological study reported that fluctuating climate and vegetation has influenced the structure and composition of montane grass dominated ecosystem of southern India (Sukumar *et al.*, 1995). In recent years, the ecophysiological aspects of C_4 grasses (approximately half of the total grass species) have attracted much attention of researchers and mainly they worked out to know, whether the C_4 grasses are adaptive to the environment comprising of rising temperature and CO_2 level due to global warming, when compared to C_3 grasses (Ehleringer *et al*., 2002).

Grass Classification

Owing to economic and ecological importance of the family many attempts have been made for obtaining a useful classification for the grasses. It is seen that there are four successive revolutionary periods, which is marked by the introduction of anatomical, physiological and molecular characters to supplement gross morphology in classification.

The first period started with Adanson's (1763) grouping of grasses into several sections which was purely based on morphological characters. Jussieu (1789), was the first who introduced the name 'Gramineae' to the grasses and his classification was primarily based on reproductive features of spikelets. Beauvois and Palisot (1812) examined arbitrary characters for his treatment and grouped accordingly into cohorts and tribes, which lead to the proper knowledge of the grass family. Later Brown (1814) made the first scientific division, and he classified grasses into two 'tribes' (subfamilies), viz. 'Poaceae' (Pooideae) and 'Paniceae' (Panicoideae), which was based on nature of spikelet characters. In 1883, Kunth identified tribes under the family, many of them still in current use, and later his treatment was followed by Steudel (1855). Other outstanding contributions were made by Hackel (1887), Hayek *et al*. (1925) and various tribes recognized by those workers were grouped into two subfamilies, *viz.* Panicoideae and Festucoideae. These classifications exclusively depended on morphological characters of the spikelet and inflorescence types (Campbell, 1985).

Avdulov (1931) developed a better system with the incorporation of chromosome morphology and anatomy of leaf epidermis in his classification. Later Prat (1932), Stebbins (1956), and Brown (1958) have made useful contributions to this system. These 'New systematics' which are primarily based on size of chromosomes, orientation and size of the first seedling leaf, as well as anatomical features eventually lead to the separation of chloridoid grasses from the pooids. During this period, Reeder (1957) proposed a new classification based on four characteristics of embryo and grouped them into 6 groups, including pooid and panicoid groups. Major changes were the subdivision of old

Festucoideae (or Pooideae) into several subfamilies and the additional treatment of Arundinoideae and Bambusoideae.

Stebbins and Crampton (1961) suggested a new classification system, and it has been mostly set up on the basis of anatomical, cytological and physiological features rather than traditional morphological characters such as the nature of the inflorescences and spikelets, and it has recognized into 6 subfamilies. During this time, internal leaf anatomy provided the best characters to recognize subfamilies and tribes. Occurrence of bicellular micro-hairs, as well as the shape and distribution of silica bodies on leaf epidermis were considered as useful diagnostic features (Metcalfe, 1960; Clifford & Watson, 1977; Dahlgren, 1985). The taxonomic treatments of Clayton and Renvoize (1986), and Watson and Dallwitz (1992) are the modifications of the above classifications. During this period, the number of subfamilies established ranged from 2 (Tsvelev, 1989) to 12 (Caro, 1982) in which Brown's (1814) Panicoideae was still retained without any modification. Currently, the classification of Clayton and Renvoize (1986) is widely used (Table 1). It has presented predictive evolutionary relationships at the tribal and generic level, which have been relied upon by subsequent workers for their studies on evolution and phylegenetic reconstructions (Hilu, 2007). The phenetic analyses have made to recognize 5 (Watson & Dallwitz, 1992) to 8 (Hilu & Wright, 1982) subfamilies under Poaceae.

In 1990 s, an extensive use of molecular data has modified the systematics considerably, which marked the 4th revolutionary period in grass classification. Davis and Soreng (1993) used plastid DNA restriction site variations, which resulted in obtaining expanded Pooid clade and suggested that Bambusoideae were not monophyletic. Many workers like Hilu and Johnson (1991), Barker *et al.* (1995), Clark *et al.* (1995), etc. were engaged to develop a better classification for the family by using molecular characters. Soreng and Davis (1998) combined morphological, anatomical, chromosomal, and biochemical characters as well as the molecular features to analyse phylogeneic relationship within the family. Later, Mathews *et al.* (2000) used nuclear sequence data to resolve phylogenetic position of the group. Recently, the Grass Phylogeny Working Group (GPWG, 2000; 2001) proposed a revised subfamilial classification and recognized 12 subfamilies (Table 1), and as many as 41 tribes within the family based on a combined analysis of molecular as well as morphological characters. These studies have shown that the family is strongly monophyletic in origin, which is supported by morphological (bracteate inflorescence, reduced perianth, fruit a caryopsis, embryo and pollen wall features) as well as molecular characters (*rbcl* and *ndhf* sequences).

Hilu (2007) summarized the progress in grass systematics during the century and recognized two distinct periods, *viz*. Predictive period and Analytical period with two sub-phases

Predictive Taxonomy & Predictive Phylogenetics and Phenetic analyses & Phylogenetic approaches respectively.

Table 1. Comparison of the subfamilial classification of Poaceae by Clayton and Renvoize (1986) and GPWG (2001)

Clayton & Renvoize (1986)	GPWG (2001)
Subfamily Bambusoideae (includes Anomochloideae Pharoideae Puelioideae & Ehrhartoideae)	**Subfamily** Bambusoideae
	Anomochloideae
	Pharoideae
	Puelioideae
	Ehrhartoideae
Centothecoideae	Centothecoideae
Pooideae (includes Danthonioideae & Aristidoideae)	Pooideae
	Danthonioideae
	Aristidoideae
Arundinoideae	Arundinoideae
Chloridoideae	Chloridoideae
Panicoideae	Panicoideae

The emerged picture of the grass phylogeny revealed the following elucidations (Pohl, 1987; GPWG, 2001; Judd *et al*., 2002).

(1) Poaceae are monophyletic and primitive members are broad-leaved tropical forest grasses.

(2) Similarities to sedges (Cyperaceae) in habit and spikelets represent convergent evolution.

(3) The family Joinvilliaceae of Pacific regions is a sister group to Poaceae.

(4) Subfamilies like Anomochloideae (native to Brazil) Pharoideae (Old & New World tropics), and Puelioideae (West Africa) are the earliest diverging lineages which together include only 0.25 % of total species of the family.

(5) The remaining species fall into two large groups namely BEP clade (includes subfamilies Bambusoideae *s.s.*, Ehrhartoideae & Pooideae) and PACCAD clade (includes Panicoideae, Arundinoideae *s.s.*, Chloridoideae, Centothecoideae, Aristoideae & Danthonoideae).

One of the key theories regarding the origin of grasses stated that primitive grasses may be small, low-growing perennials, somewhat tufted, with short leaves and probably forest-loving groups (Stebbins, 1972).

Indian scenario

Located in a tropical region, India is blessed with variety of environmental regimes from the warm humid tracts of Southern Western Ghats to the cold dry cliffs of Northern Himalayas and the western hot Thar desert to moist wet tracts of Khasi and Jaintia Hills in the east. It is situated at the tri-junction of three realms – Afro-tropical, Indo-malayan and Palaeo-artic – which interestingly include Peninsular India, the historical part of southern Gondwanaland. The country is broadly divided into Peninsular and Extra-peninsular regions, which are again subdivided into 12 biogeographic regions with 25 biotic provinces (Mani, 1974; Singh *et al*., 2002). India is one of the biologically richest tracts in the World and ranked 6^{th} among the 12 Global mega-biodiversity countries (Nayar, 1996). Though, the land surface covers 2.2 % of the global area, the country exhibits 5-6 % of the known living organisms, which include 10% of the World flora. The country is also ranked fourth in Biodiversity richness and Cultural diversity together and having vast Indigenous Knowledge systems (Cunnigham *et al.,* 2003). Traditionally, biodiversity conservation is found profoundly intertwining with the Indian philosophy and the Indians esteemed the spiritual fulfillment through the external and internal environment of man.

Roughly, Indian flora comprises an estimated 17,000 species of flowering plants under 2,250 genera in 315 families with nearly 5000 endemics (Singh *et al.*, 2002). Some plant families that show enormous species diversity are Poaceae, Orchidaceae, and Balsaminaceae (Hajra & Mudgil, 1997). Mitra and Mukherjee (2007) estimated that 121 genera, inclusive of 94 monotypic ones, are endemic to the country, out of which 42 genera are exclusively endemic to Peninsular India. Poacecae represents the largest flowering plant family in India with highest number (15) of endemic genera in the country; all except one genus (*Cyathopus* Stapf) are confined to Peninsular India.

The family Poaceae has been poorly documented in many Indian floras and a comprehensive systematic study on grass flora of India has not been made yet. Only few revisionary studies (Jain, 1967a; 1967b; 1970; 1972; Ved Prakash & Jain, 1979; Deshpandae, 1984; Ved Prakash & Jain, 1984; Sur, 2001, 2004) were carried out in India. Roughly, the family is represented by about 1350 species belonging to 249 genera (Nair & Thomas, 2001). *Poa* L. (ca. 56 spp.), *Ischaemum* L. (ca. 52 spp.) and *Dimeria* R. Br. (42 spp., based on present study) are the dominant genera of the family, of which the first is mainly concentrated in temperate Himalayan grass domain and the rest two are confined to the tropical peninsular grass domain (Kiran Raj *et al.,* 2003). More than about 350 species are endemic to the present political boundary of the country, of which about 220 species (approximate figure) are strictly endemic to Peninsular India.

Recently, the traces of grass found in fossilised dinosaur dung from Peninsular India (Prasad *et al.,* 2005) proved that grass orginated on earth much earlier than previously thought, and changed believes about dinosaurs' diets. This work was the first evidence to show that dinosaurs ate grass and that Poaceae had originated and diversified during the Cretaceous period (Pipermo & Sues, 2005). A preliminary observation on diversity and distribution of primitive and advanced grass-tribes, occurrence of isolated endemic genera, monotypic taxa, degree of endemism, etc. also suggested that Peninsular Indian grasses played a major role in the grass evolution as a whole.

Subfamily Panicoideae Link

Panicoideae are the largest of the grass subfamilies, represented by 237 genera (Kellogg & Campbell, 1987) and about 3270 species (GPWG, 2001). They are mostly warm-season grasses distributed mainly in tropical (especially Old World and Gondwanan), extending to humid warm temperate regions (Watson & Dallwitz, 1992). The subfamily includes largest grass tribes in the family, *viz.* Paniceae (101 genera/ca. 2200 spp.) and Andropogoneae (Clayton & Renvoize, 1986). Panicoideae is represented by economically important crops like Porso millet (*Panicum miliaceum*), Little millet (*P. sonorum*), common millet (*P. sumatrense*), Foxtail millet (*Setaria italica),* and Pearl millet (*Pennisetum glaucum*) of the tribe Paniceae; Maize (*Zea mays* L.), Giant millet (*Sorghum bicolor* (L.) Moench), Sugar cane (*Saccharum officinarum* L.), Job's tear grass (*Coix lacryma-jobi* L.), Vetiver grass (*Chrysopogon zizanioides* (L.) Roberty) and Lemon/Citronella grass (*Cymbopogon* spp.) of the tribe Andropogoneae. The C_4 photosynthetic pathway (C_4PS Type with PCK/NAD-ME as Decarboxylating enzyme and C_4 MS Type with NADP-ME as Decarboxylating enzyme) is common in the subfamily, rarely with C_3 and some with C_3/C_4 intermediates (GPWG, 2001). Most of the species with Chromosome base number x = 5, 9 or 10

(Watson & Dallwitz, 1992). Morphological and molecular data supported the monophyletic origin of the subfamily (Kellogg, 2000).

Taxonomically, 7 tribes are recognized under the subfamily (Clayton & Renvoize, 1986), and they are also recognized and maintained in the classification of GPWG (2001) (Table 2).

All tribes of Panicoideae are well represented in India except the Steyermarkochloeae (1 genus, 1 species), which is exclusively found in Tropical America. The tribe Hubbardieae is endemic to Peninsular India, which is also monotypic with one species (*Hubbardia heptaneuron* Bor). In India, the subfamily is represented by 105 genera and about 1200 species. Among these, 12 genera (all endemic to Peninsular India) and ca. 200 spp. are endemic to the country. The exact diversity of Panicoideae in Peninsular India is not known due to the paucity of grass systematic studies in this region.

Table 2. Comparison of the tribal classifications of the Panicoideae proposed by Clayton and Renvoize (1986) and GPWG (2001).

Clayton & Renvoize (1986)	GPWG (2001)
Tribe Steyermarkochloeae	**Tribe** Steyermarkochloeae
Eriachneae	**Insertae Sedis** *
Hubbardieae	Hubbardieae
Isachneae	Isachneae
Paniceae	Paniceae
Arundinelleae	Arundinelleae
Andropogoneae	

	Andropogoneae

***** Eriachneae, Micraireae, Streptogyneae, *Cyperochloa, Gynerium*

Tribe Andropogoneae Dumort.

Andropogoneae constitutes one of the two major tribes in the subfamily Panicoideae, which includes about one-third of grass species in the World (Mathews *et al.,* 2002). The tribe includes economically important genera like *Coix* L., *Chrysopogon* Trin., *Cymbopogon* Spreng., *Saccharum* L., *Sorghum* Moench, *Zea* L., etc. and dominates tropical grasslands of Africa, South America, South East Asia, Australia and India. All members of the tribe exhibit C_4 photosynthetic pathway and the tribe is represented by about 1,000 species and 85 genera (Clayton & Renvoize, 1986). Andropogonoids are widely distributed in the tropics, particularly in the savannah zone extending into warm temperate regions. Clayton (1981a) observed that the members mostly found in seasonal rainfall zone have major centers in India and South East Asia. Hartely (1958) have made significant contribution in the phytogeographical study of Andropogonoids and observed that Indo-Malayan region has relatively rich species diversity with zones of high concentration in Western India and in Southern Indonesia. He also found that rich species diversity occurred in tropics when compared to temperate regions and is lower in Western than in Eastern hemisphere. Earlier, a cytotaxonomic study of Andropogoneae suggests that “the tribe is comparatively recent origin; that it probably originated in the tropical forests of the Indo-Malaya area, and radiated from there to the tropical savannahs" (Celarier, 1956: 272).

Traditionally, Andropogoneae are well-defined tropical grasses and makes up about one third of the grass subfamily Panicoideae. The tribe is considered as "natural" because of many shared morphological characters (Clayton, 1981b; Clayton, 1987). The most characteristic feature of the tribe is the presence of fragile racemes bearing spikelets. Most of the taxa have paired spikelets that are arranged in digitate racemes; one sessile and other pedicelled, but in some, one spikelet appears to be suppressed (see Chapter 5). Due to the morphological variations found in the inflorescences and the raceme segment (internode, fragile or tough rachis, sessile spikelet, pedicel, pedicelled spikelet), the tribe is considered as one of the most complex groups in Poaceae.

Adaptation and evolution

Most andropogonoids have a peculiar disarticulation pattern for mature spikelets, in which 'spikelet pair' is the dispersal unit rather than individual spikelet, floret or caryopsis. This seems to allow frequent establishment of geographically isolated populations (Doyle & Donoghue, 1986). Hartely (1950) observed that climatic factor including winter temperature; summer moisture and seasonal rainfall are of great importance to the distribution of andropogonoids. Hartely (1958) also found some remarkable link between high midsummer rainfall and relative abundance of species of andropogonoids in the tropics and subtropics. His geographical survey on the study of grass flora of about 300 regions, which combined both taxonomic and cytological evidences revealed that climate plays a significant role in the origin and evolution of the tribe and concluded that Andropogoneae have a long evolutionary history in Eastern hemisphere. They have spread towards the Western hemisphere very recently where they haven't attained a full development.

The phylogeny of the tribe has been studied by Kellogg (2002) based on morphological as well as molecular characters and it revealed their monophyletic origin. The studies have shown that *Arundinella* Raddi, is sister to Andropogoneae and the putative morphological synapomorphies are C_4 NADP-ME photosynthesis, a single bundle sheath, spiral phyllotaxy, and spikelet-pairing (?). Many taxa under the tribe have a disarticulating rachis, which is responsible for the world-wide distribution of the group (Clayton, 1987). In majority of the andropogonoids, only the distal floret of the spikelet is fertile and this appears to be a derived condition in the tribe (Kellogg, 2000). It is also found that the glumes of most Andropogoneae, a single lignified layer ('keel'), appears in the center of the glume, which is unique and shared with other Panicoids. Kellogg (*l.c.*) also observed that the inflorescence structure especially in branching pattern and timing of branching, drives the rapid radiation of Andropogoneae.

Classification

The delimitation of the sub-tribes in the tribe Andropogoneae is problematic (Vegetti, 1998). Clayton and Renvoize (1986) recognized 11 subtribes in the tribe, which is primarily based on the characters of the inflorescence and spikelet morphology, while some others have recognized 5 (Hackel, 1889), to 8 (Keng, 1939) subtribes under Andropogoneae. The inclusion of the subtribe Maydeae *s. l*. in the tribe is doubtful (Simon, 1990; Kellogg, 2002). In a numerical analysis, the genera of the tribe were grouped into two - ‘awned’ (Clayton, 1972) and ‘awnless’ taxa (Clayton, 1973). The distinction between these groups was largely supported by the phylogenetic analysis of Kellogg and Watson (1993) and by phenetic study (Watson & Dallwitz, 1992). Major subtribal treatments of the tribe by different authors, are shown in the Table 3. According to Kellogg (2000, 2002), a robust system of subtribal classification and their phylogenetic relationships is still ambiguous due to insufficient molecular data from several members of Andropogoneae including the subtribe Dimeriinae.

Systematic study of andropogonoids in India

Andropogoneae are well represented in India and possess about 329 species under 67 genera (Mehrotra & Jain, 1980). Revised estimate has shown that about 360 species and 63 genera are represented in India, which constitutes about 40 % of the species and about 75 % of the genera of the tribe. It is found that the area of high concentration of andropogonoids in India lies in peninsular region. Mehrotra and Jain (1980) studied the phytogeographical significance of the tribe in India and estimated that among the 139 widely distributed species (occurring in India and world), 52 species are endemic confined to India and Africa. They also estimated that 46% of the total Indian andropogonoids are strictly endemic to the country.

A recent survey estimated that out of the 63 Indian genera of the tribe, 49 are represented in peninsular India which includes 6 exclusively endemic genera, viz. *Bhidea, Glyphochloa, Pogonachne, Pseudodichanthium, Trilobachne, Triplopogon*. About 230 species are represented in this region, out of which ca. 105 species are endemics (Kiran Raj *et al*., 2003). It is also found that in addition to the above, genera like *Bothriochloa, Chrysopogon, Glyphochloa,* and *Heteropogon* have high concentration of species in peninsular India especially in Western Ghats region. All these observations were merely based on synoptic accounts (Bor, 1960; Moulik, 1997) and enumerations (Ahmedullah & Nayar, 1987; Karthikeyan *et al*., 1989; Nair & Thomas, 2001).

Based on the preliminary observation on the diversity of Andropogoneae combined with taxonomic and phytogeographic considerations, the present study also put forth a hypothesis that Peninsular India could be the centre of diversity of andropogonoid grasses (see Chapter 4).

Subtribe Dimeriinae Hack.

Dimeriinae Hack. (1887) is strictly a palaeotropical subtribe, coming under the tribe Andropogoneae Dumort., with hitherto recognized one genus and herein recognized additional one more genus (proposed and added during the present study). The subtribe is considered as an enigmatic group of the family Poaceae and occupies a somewhat anomalous position in the subtribal classification of the family (Clayton & Renvoize, 1986). It is strictly a palaeotropical subtribe, largely distributed in Tropical Asia and chiefly confined to the Indian peninsula (Hackel, 1889; Hooker f., 1896; Bor, 1953; Roberty, 1960). Most species are endemic to or centred in this region (Jain, 1986; Nair & Thomas, 2001; Kiran Raj *et al.*, 2003). Approximately, the genus comprises 65 recognised species (Bor, 1960; Watson & Dallwitz, 1980; Clayton 1994; Moulik, 1997; Ravi *et al*., 2001; Clayton *et al.,* 2002; Chen *et al*., 2006), which are mainly adapted to humid or semi-arid habitats and occur in the tropical region of Asia and West Pacific islands, with some species extending to Northeast Australia and Madagascar. It is to be noted that the Dimerias are generally oriented along tropical and subtropical region. The natural vegetation is mostly found between the Tropic of Cancer (latitude 23.5° N) and Tropic of Capricorn (latitude 23.5° S) and between longitude 180° E and 40° W (Map 1).

The genus *Dimeria* R. Br. dominates the herbaceous stratum of western peninsular regions of India during the period of retreat-monsoon (September–November). Much of the plateau, hills and mountain slopes are covered by the gregarious growth of this genus. In certain places, they form quite a dense cover, making the place to resemble cultivated paddy fields. The genus usually appeared as a last vegetative element in the ‘post-monsoon succession’ of the herbaceous strata of ghat region.

In the genus *Dimeria,* the species delimitation is highly complicated. The genus is typically homogeneous with too many narrowly defined species (Clayton & Renvoize, 1986) and is one of the least studied groups in the world, with a distribution largely confined to the Indian peninsula.

Justification of the present study

Dimeria is one of the largest genera in the grass family in India, and is represented by about 50% of the world taxa of the genus (Jain, 1986). Though a large genus, it has not received much attention in systematic studies. It has not been revised as a whole, except Bor's preliminary work (1953) on the genus for India, Myanmar and Sri Lanka. He pointed out that detailed study on the genus based on more specimens can only reveal the full extend of variation within the genus. So, his treatment was incomplete and unsatisfactory for understanding the taxonomic diversity of the genus in peninsular India.

It is widely accepted that a meaningful taxonomic monograph for a given taxa should always rely on biogeographic regions irrespective of the political boundary of the country. The present revision is confined to peninsular India where *Dimeria* attained the maximum species diversity and is considered as center of origin of the genus. Peninsular India is an ancient tableland of Indian subcontinent and was a part of historic Gondwanaland in Cretaceous period of Mesozoic era. It is a compact natural unit of geomorphological and biogeographical evolution (Mani, 1974) and so a natural study of this region has great relevance. It is also found that 80% of the C_4 grasses (including *Dimeriinae*) of India are concentrated in peninsular Indian grass domain compared to Himalayan grass domain, where C_3 grasses attain maximum diversity.

As on today, taxonomy of *Dimeriinae* is quite unsatisfactory because of the morphological complexities and similar exomorphic characters. The subtribe occupies an anomalous position in the grass classification due to the very distinct morphological features, which afford no hint of affinity within the group. The difficulty is compounded by the very poor representation of the taxa in the international herbaria like Kew (pers. comm.) and regional herbaria including those of the Botanical Survey of India (BSI). An extensive and exhaustive exploration and collection, and detailed analysis of the subtribe are the very essential for proper identification and solving nomenclatural problems existing and hence the present study.

Table 3. Comparison of major subtribal classification systems of Tribe Andropogoneae

Hackel (1889)	Keng (1939)	Celarier (1956)	Clayton & Renvoize (1986)	Kellogg (2000)
Dimerieae	**Dimerieae**	**Dimeriinae**	**Dimeriinae**	? In Saccharinae
Sacchareae	**Sacchareae**	**Saccharinae**	**Saccharinae ***	$
(*See* Sacchareae)	**Apocopeae**	(*See* Saccharinae)	**Germainiinae ****	**Saccharinae**
Ischaemeae	**Ischaemeae**	**Ischaeminae**	**Ischaeminae**	**Germainiinae**
(*See* Euandropogoneae)	**Bothriochloeae**	(*See* Sorginae)	(*See* Sorghinae)	**Ischaeminae**
Rottboellieae	**Rottboellieae**	**Rottboellinae**	**Rottoboelliinae**	(*See* Sorghinae)
(*See* Euandropogoneae)	**Sorgheae**	**Sorginae**	**Sorghinae**	**Rottoboelliinae**
(*See* Euandropogoneae)	(*See* Euandropogoneae)	(*See*	**Anthistriinae**	**Sorghinae**
Euandropogoneae	**Euandropogoneae**	Andropogoninae)	**Andropogonina**	**Anthistriinae**
		Andropogoninae	**e**	**Andropogonina**
		Maydeae	**Tripsacinae**	**e**
		(*See* Maydeae)	**Chionachninae**	**Tripsacinae**
		(*See* Maydeae)	**Coicinae**	**Chionachninae**

	Coicinae

* Includes 4 genera of Keng's "Apocopeae" ** Represented by 3 genera of Keng's "Apocopeae" $ Data not available

Chapter 2. REVIEW OF EARLIER WORKS

DIMERIINAE *s. str.*

In 1810, Robert Brown established the genus *Dimeria* in his *Prodromus Florae Novae Hollandiae* and described the first species *D. acinaciformis*, based on an Australian plant. In fact, this specimen was originally collected by Joseph Banks and Daniel Carl Solander in 1770, when they together with Captain James Cook traveled the world in the H. M. S. Endeavour (Bertel & Wagner,1998). During this trip, they explored many Asian countries including Southern Australia and deposited the massive plant collections from these regions at Banks herbarium (Stafleu, 1967). Later these specimens were distributed to many European herbaria including British Museum, London (BM), which now houses the type specimen of the genus. Trinius (1820) described another species from India, *viz. D. ornithopoda*, which is the species only widely distributed.

Nomenclatural history

Dimeria has two tough racemes of spikelets, from which the name of the genus is presumably derived. The structure of the inflorescence and spikelets is more or less uniform in almost all taxa of the genus. In 1830, Presl described the genus *Haplachne* C. Presl with the species *H. pilosissima* C. Presl which was later recognized as *Dimeria chloridiformis* (Gaudich.) K.Schum. & Lauterb., a species from Marianas. Zollinger (1854) proposed another name *Didactylon* Zoll. & Mort. for two Javanese species, *viz. D. simplex* Zoll. and *D. ramosum* Zoll. & Mort., both of them now synonymed under *Dimeria ornithopoda* Trin. var. *ornithopoda*. Steudel in his *Synopsis Plantarum Glumacearum* (1855) raised another genus *Pterygostachyum* Nees *ex* Steud. with the species *P. lehmannii* Nees ex Steud. for an Indian species, which was found to be conspecific to *Dimeria lehmannii* (Nees) Hack. In the same work, he also proposed another genus *Psilostachys* Steud., transferred from *Arthraxon hohenackeri* Hochst. (= *D. hohenackeri* Hochst *ex* Miq.). The generic name *Psilostachys* was also superfluous as it was earlier recognized under the family Amaranthaceae. Steudal (1855) also mentioned six species under *Dimeria* R. Br. separately for Tropical Asia and Australia, of which four species are recognized today. All these names were later treated by Hackel (1889) as congeneric to *Dimeria*. Stapf (1896) established another genus viz. *Woodrowia* Stapf under the tribe Agrostideae, with the species *W. diandra* Stapf, which was later treated as *Dimeria diandra* by Bhide (1911). But, this name was also a superfluous one and later it was found to be conspecific to *D. stapfiana* C. E. Hubb. *ex* Pilger.

Systematic treatments

Systematic studies in India

The increased botanical exploration in various parts of Asia during the beginning of 19th century, lead to several collections of the genus particularly in the South Indian region. Botanists like Bourne, Gardner, Thwaites and Meebold make extensive collections and later workers described several taxa based on their collections. Hackel (1889) had made the first meaningful work on the genus and described 12 species and 10 infraspecific taxa from Tropical Asia and Australia. Most of the species are reported from Indian region, of which some of them have doubtful identity. Among those, only 12 taxa (including infraspecific) are recognized today. He used the number of raceme in the inflorescence, spikelet length and the texture of upper glume as the main characteristics for the identity and classification. He has been greatly influenced by the works of Hook. f. (1897), Camus and Camus (1923), and Pilger (1940).

Hook. f. (1897) described 12 species from India and Myanmar, and 10 among them were accepted later. He described three new taxa, *viz*. *Dimeria kurzii* Bor, *D. pusilla* Thw. var*. pallida* Hook.f. (= *D. thwaitesii* Hack.) and *D. pusilla* Thw. var. *lawsonii* [= *D. lawsonii* (Hook. f.) C. E. C. Fisch.], of which the first species was from Myanmar and the two varieties were from South India. He classified the taxa based on their number of racemes and rachis texture, but did not give much attention for the treatment and made many nomenclatural errors (Bor, 1953).

Fischer (1935) recognized 10 species in his *Flora of Presidency of Madras*. His treatment included two new combinations of names (*D. lawsonii* (Hook.f.) C. E. C. Fisch. and *D. avenacea* (Retz.) C. E. C. Fisch.) and the classification was primarily based on texture of the rachis.

Jacob (1947) described two species as new from central Kerala. Raizada (1948) reported a new species from Orissa State (*D. mooneyi* Raiz.), but name is not accompanied by a Latin diagnosis. Later, Mooney (1950) effectively published the same.

The first significant change in the concept of characters of *Dimeria* appeared in Bor's treatment (1953). Bor presented a detailed account of *Dimeria* based on the species known to him. He modified the species concept of Hackel (1896) by adding more reliable morphological features for the diagnosis and his treatment have been more significant in the classification of the genus today. Bor had found that the shape of rachises, type of pedicels, the orientation and time of disarticulation of spikelets, are of great significance in the subdivision of the genus. He grouped the species of India, Myanmar and Sri Lanka under three sections, *viz.* *Dimeria* sect. *Loriformes, Dimeria* sect. *Capillares,* and *Dimeria* sect. *Annulares.*

Cooke (1958) had reported three species from former Bombay Presidency. Later, Raghavan *et al.* (1981) had accounted 6 species from this region.

Bor (*l.c.*) had obtained 25 species from India, Myanmar, and Sri Lanka including 8 novelties. Among those, 20 species including 5 novelties were described from peninsular India. He also stressed the need for a detailed study of the genus in Indian region, based on more specimens which would lead to a better under standing of the diversity of the genus.

In 1960, Roberty treated 27 species of *Dimeria* as infraspecific category under *D. avenacea* C.E.C.Fisch. He believed that all the species described under *Dimeria,* including 16 taxa from peninsular India, could be treated under the sub varieties of *D. avenacea.* But he worked on limited specimens, and all the names given by him are not valid due to the lack of appropriate type specimens. Subsequent workers rejected this proposal.

Almeida (1970) described a new species - *Dimeria santapaui* - based on the specimens collected by L. J. Sedgwick and T. R. D. Bell from southern Western Ghats in Karnataka State. A critical morphological analysis during the present study revealed that *D. santapaui* M. R. Almeida is having many unique characteristics that differed from that of the genus *Dimeria* R. Br., and is therefore considered here as belonging to a new genus, viz. *Ravia* Kiran Raj et Sivad. gen. nov. (*ined*.) under the subtribe *Dimeriinae* with only one species viz., *Ravia santapaui* (M. R. Almeida) Kiran Raj & Sivad., comb. nov. (*ined*.).

Sreekumar and Nair (1991) had reported 15 species from Kerala State, which included 5 novelties (Sreekumar *et al*., 1981, 1982, 1983; Nair *et al*., 1983; Nair *et al*., 1984). During the present study, 13 species are maintained under the genus and one name (*Dimeria borii* Sreek. *et al.*) has been treated as *D. mooneyi* Raiz. var. *borii*. Another species (*D. keralae* N. C. Nair *et al.*) has been transferred to the new genus proposed here, viz. *Ravia*.

Mohanan and Rao (1984) described a new species from Tamil Nadu. Ravikumar *et al.* (1990) had obtained yet another species (*D. balakrishnaniana*) from Tamil Nadu, which has shown extended distribution in Kerala region.

Later, Ravi and his co-workers (1992, 1995, 1996, 1997, 2001) described 11 new species from Southern Western Ghats of Kerala and one species (*D. mahendragiriensis*) from the Eastern Ghat region of Orissa (Ravi *et al.,* 1995). Ravi, who encouraged to do the present work, commented that a thorough systematic study based on more specimens would reveal the exact diversity of *Dimeria* in Western Ghats (pers. comm.)

Few reports on rediscoveries and new records have been published from time to time which included some misidentifications like *D. acutipes* (Mishra *et al*., 1983; Britto, 1989), and *D. kanjirapallillana* (Gayathri & Pullaiah, 1996).

State floristic accounts (Roy & Shukla, 1983; Salunkhe, 1995; Bhat & Nagendran, 2001; Ravi & Mohanan, 2002), State floras

(Rao, 1986; Pullaiah, 1997; Saxena & Brahmam, 1996) and State flora analyses (Henry *et al*., 1989; Sharma *et al.*, 1984; Sasidharan, 2004; Nayar *et al.,* 2006) have mentioned the occurrence of the genus in their respective regions, majority of which are based on the old type collections.

Some Indian enumerations (Karthikeyan *et al.*, 1989; Moulik, 1997; Sharma *et al*., 1996; Nair & Thomas, 2001) have also mentioned the diversity of the genus, and are merely based on protologues or earlier works, without any verification of the exact number of taxa described from the country.

Studies in other regions

Reeder (1948) recognized 5 species, including 2 new species and one new variety, from New Guinea during his study on panicoid grasses of the region.

The diversity of *Dimeria* in Sri Lanka, were first treated by Senaratna (1956). At that time, he obtained 11 species, but now only 8 names are referred. Later, Clayton (1994) revised the Sri Lankan taxa and obtained 9 species. All of them are occurring in peninsular India except two (*D. leptorhachis* and *D. ballardi*). Interestingly, Clayton (*l.c.*) observed that some species, including three peninsular Indian taxa (*D. acutipes* Bor, *D. trimeni* Hook.f., *D. ceylanica* Bor *s. l*.) should be merged – the first with *D. avenacea* (Retz.) C. E. C. Fisch. and the rest two with *D. pubescens* Hack. His observations are mostly based on the study of limited specimens from Sri Lanka alone. The above names are reinstated during the present study.

Cheng *et al.* (1997) studied the genus for China and recognized 7 species and 5 infraspecific taxa. Later, Chen *et al*. (2006), during the study of *Flora of China*, accounted only 6 species and one variety in Chinese region.

A preliminary study of the genus *Dimeria* in Malesian region has been recognized 6 species and 3 infraspecific taxa. A detailed revisionary study of the genus in this region especially in Papua New Guinea is much needed, where the genus shows enormous diversity (Veldkamp, pers. comm.).

The details on the diversity of *Dimeria* in extra Peninsular Indian regions are given in Table 4.

Anatomy and physiology

Metcalfe (1960) gave a detailed account of the leaf anatomy of *Dimeria*. He identified that the plant exhibits C_4 (Kranz) photosynthetic pathway of Mestome Sheath (MS) type. Leaf blades are having conventional arc of bundles with adxial colourless mesophyll tissue. Chlorenchyma cells of mesophyll tissue are radially arranged. Bulliform cells are irregularly grouped in the epidermal layer. Sclerenchyma cells are associated with vascular bundles (Watson & Dallwitz, 1992).

Cytology

Mehra and Kalia (1975) were the first to study the chromosome number in taxa of *Dimeria*. They counted the chromosome number of *Dimeria ornithopoda* var. *ornithopoda* (2n=14), *Dimeria ornithopoda* var. *khasiana* (2n =14) and *D. fuscescens* (2n=50). Later, Christopher (1978) got a different chromosome number for *Dimeria ornithopoda* var. *ornithopoda* (2n= 32). Gould and Soderstrom (1974) reported 2n to be 32 or 46 in *D. lehmannii*. All these works have been later compiled by Virendra Kumar and Subramaniam (1989). All of the cytologically studied species were diploids or polyploids. There is no other cytological information on any other species of the genus.

Table 4. Comparison of systematic studies of *Dimeria* in extra Peninsular Indian region.

Sl. No.	**Region/Country**	**No. of Taxa**	**Reference**
1.	Malay Peninsula	4	Ridley, 1925
2.	Sri Lanka	9	Clayton, 1994
3.	China	12	Chen *et al.*, 2006
4.	Taiwan	2	Clayton, 2002; IPNI
5.	Japan	3	Clayton, 2002; IPNI
6.	Vietnam	3	Clayton, 2002; IPNI
7.	Russia	3	Clayton, 2002; IPNI
8.	Myanmar	5	Clayton, 2002; IPNI
9.	Malesia (*including* Malaysia, Fiji, Indonesia, Philippines, Pacific islands, Micronesia, New Guinea)	13	Clayton, 2002; IPNI
10.	Australia	2	Clayton, 2002; IPNI
11.	Madagascar	3	Clayton, 2002; IPNI

During a preliminary cytotaxonomic survey, Celarier and Harlan (1956) had commented, "It is already obvious that several genera especially *Dimeria* R. Br. and *Ischaemum* L. of Andropogoneae are in need of much more detailed study"., and he later suggests that the subtribe Dimeriinae is a primitive group under the tribe Andropogoneae (Celarier, 1956).

Studies on other aspects of the members of Dimeriinae are completely lacking.

Chapter 3. MATERIALS AND METHODS

THE STUDY AREA

Physiographically, India can be divided into 3 well-marked regions, *viz*. Peninsula, Indogangetic plains, and Extra peninsula (Murthy *et al*., 1996) Among these, Peninsular region is considered as a compact natural unit and is a ‘shield’ area extending from Vindhya-Satpura ranges in the North and Chota Nagpur plateau in the North-East. It is an ancient tableland of Indian subcontinent and constitutes rocks of different age group including Archean gneisses. Its mountains are of relict type, which composed of geologically ancient rocks of diverse origin (Krishnan, 1968). Peninsular India (Map 2), lies between the latitudes 22^{o} N and 8^{o} N, and is covering an area of approximately 39,000 km^2 with an average elevation of 460–600 m above MSL.

According to the continental drift theory (cf. Wagener, 1924), the peninsular India represents the Indian part of the Gondwanaland which on breaking some 1000 million YBP during Cretaceous period moved north wards and crushed against Laurasia causing the upliftment of the Himalayan and obliteration of the former Tethys sea. In the process of movement of Indian plate over 5900 km, passing through different climatic regions followed by volcanic eruptions causing the flow of deccan lavas, major groups of the Gondwanaland floristic stock became extinct (Rao, 1994).

Physiography

The Peninsula India is flanked on the east by Bay of Bengal, South by Indian Ocean and west by Arabian sea. The North-western part of the Indian peninsula is called ‘Deccan trap’ and the great triangle of the Deccan plateau is stretching southwards, which dominated the Peninsular region. Southwest of the peninsula is the Nilgiri Hills. The Deccan Plateau is a vast plateau in India, encompassing most of Central and Southern India. It comprises the whole of peninsular India south of the Vindhya range and has an elevation which ranges from 450 to 750 m. Maharashtra covers most of the northern plateau, and Chhattisgarh the north-east corner. Andhra Pradesh covers the east-central portion of the Deccan, and Karnataka the west-central and most of the southern portion of the plateau, with the southernmost portion in Tamil Nadu. In the northern fringes of the Deccan lava tableland are the rugged plateaus of Malwa, Bundelkhand and Rewa.

The Western Ghats lies along the western side of the Indian peninsula, which is one among the 10 biogeographic zones of India, and is responsible for the biodiversity richness of Peninsular India. Western Ghats together with Sri Lanka is considered as hottest hotspots of the world (Mayers *et al.*, 2000). It is home of about more than 4000 species of higher plants, including an approximately estimated 2000 endemic species (Nayar, 1991). The

West Coast region (Konkan coast) is bounded on the west by the Arabian Sea and on the east by Western Ghats.

The eastern side is composed of a series of disconnected ranges collectively called as Eastern Ghats, from Orissa State down to Nilgiri in Tamil Nadu where they meet the Western Ghats. The chief mountains of the peninsula are Aravallis in the northwest (average height 1500m) Nilgiris (average height 450m), Anamalai, Cardamom and Palani hills in the south.

The physiographic diversity of the peninsula has produced all possible types and extremes of climatic conditions suitable for supporting varied types of ecosystems. It is believed that the peninsula is a compact natural unit of geomorphological and biogeographical evolution (Murthy *et al*., 1996).

Peninsular India is drained by five major river systems: Mahanadi, Godavari, Krishna, Periyar and Kavery. The Mahanadi, Godavari, Krishna and Kaveri are east flowing rivers in the region whereas the Periyar is the only west flowing one. The geology and climate of Peninsular India are the two overriding factors effecting the nature of the rivers of the region. By effecting the soils and vegetation the geology and climate determine the sedimentological characteristics and the whole process of erosion, transportation and deposition within each drainage basin. The sparse vegetation of the highlands contrasts with the moderately luxuriant vegetation of the river valleys (Meher Homji, 2001).

Phytogeographical divisions

For the purpose of this study, a general frame work of the phytogeographic zones recognized by Botanical Survey of India, which was adopted from Balakrishnan (1996) is followed. The zones identified for India are as follows:

1. North-West Himalayas
2. Indo-Gangetic plains
3. Eastern Himalayas:
    a. Sikkim
    b. Arunachal Pradesh
4. North-Eastern India and North Bengal
5. Central India
6. Arid zone
7. Northern Western Ghats and northern West Coast
8. Southern Western Ghats, West Coast & Lakshadweep
    a. Southern Western Ghats
    b. Southern West Coast
9. Deccan
10. Eastern Ghats – Coromandel coast
    a. Eastern Ghats
    b. Coromandel Coast
11. Andaman & Nicobar Islands

Phytogeographically, Peninsular India falls under the following five regions, *viz.* Central India, Northern Western Ghats and northern West Coast, Southern Western Ghats and West Coast, Eastern Ghats and Coromandel Coast, and Deccan (Map 3).

The present study area encompasses the above five regions, which can be collectively considered as the Peninsular Indian Grass domain. Earlier, Clayton and Cope (1980) recognized it as “Deccan region” (*s.l.*) and during their chorological study of Old World grasses suggested this phytochorion as an important centre of diversity of grasses with high degree of endemism.

Peninsular Indian Grass domain

Many authors supported the view that Peninsular India is an ancient tableland of Indian subcontinent and a compact natural unit of geomorphological and biogeographical evolution (Krishnan, 1968; Nayar, 1996; Daniels, 1997). Phytogeographic study on Peninsular Indian flora is very interesting, as this relic region is built-in the historical southern part of Gondwanaland (Schuster, 1976). Also, many workers tried to explain the past gondwanic connections of Peninsular India based on the present day pattern of biodiversity distribution (Hora, 1937; Inger & Dutta, 1986).

Earlier studies on the Indian grasses (Hartely, 1958; Jain, 1986; Nair & Thomas, 2001; Kiran Raj *et al.,* 2003) have pointed out that two grass domains occur in India, viz. Temperate Himalayan domain (including Indo-Gangetic plains), and the Tropical Peninsular Indian domain.

Climate

The climate of Peninsular India is generally called as Monsoon climate (Meher Homji, 2001). The weather in this region remains humid during summer and dry during winter. Instead of four seasons, it basically has two main seasons, the wet and dry. The monsoon climate favours the cultivation of jute, tea, rice, and various vegetables in this region.

The larger part of the Peninsular India represents a tropical climate with a strong seasonality. Climatically, Peninsular India can be divided into 4 zones, viz. Semi-arid zone of Deccan plateau, Tropical wet zone of Western Ghats and West Coast region, Tropical wet and dry zone of Eastern region and some parts of Deccan region and Humid sub-tropical zone of Central India (Map 4).

Annual rainfall in the Peninsular India is determined by seasonal changes of the South-West monsoon with an extended dry season of 6–9 months depending on the locality. Most rainfall in this region is associated with South-West monsoon between June and September. Every year the moisture-rich South-West monsoon, originating from the Indian Ocean, together with Arabian Sea-branch, passes over the Indian subcontinent via Kerala region, producing heavy rainfall in Western Ghats, whereas the Eastern Ghats receive moderate rainfall. The coastal districts of eastern Tamil Nadu (Carnatic region), usually receives rainfall with North-East monsoon (retreat or post monsoon) between October–November. Here the rain occurs more or less throughout the year with the temperature and humidity remaining high during the monsoon. This causes the dramatic changes in the ecology of the peninsular region.

Temperature variation in different regions and during different seasons is also very great. The average annual temperature is lower in Western Ghats and Nilgiris than the Deccan plateau and coastal regions. The summer temperature in most of the regions rises to above 37–39^{o} C. The minimum winter season temperature in southern India rarely goes below 20^{o} C.

Geology and soil

Mostly, the soil of peninsular region is derived from ancient crystalline rocks of Gondwana, which forms red sandy and loamy soil (Krishnan, 1968). The Deccan plateau consisting of volcanic rock with a thickness varying from 1,200 to 1,500 m that reaches a good 3,000 m near Mumbai, covers a million square kilometres. It is composed of black volcanic basalt soil. The largest meteorite crater in the world – the Lonar Crater, measuring 1,800 m across and 170 m deep – is situated right here in the Vidarbha region of Maharashtra. The vast volcanic basalt beds of the Deccan were laid down in the massive Deccan Traps eruption, which occurred at the end of the Cretaceous period, 65 million years ago. Some paleontologists speculate that this eruption may have caused the extinction of the dinosaurs. Layer after layer was formed by the volcanic activity that lasted many thousands of years, and when the volcanoes became extinct, they left a region of highlands with typically vast stretches of flat areas on top like a table. Hence it is also known as ‘Table Top’ (Krishnan, 1968).

Mainly 4 types of soil are predominant in Indian Peninsula, *viz.* Alluvial, Black, Red, and Laterite soil (Ray Chaudhary *et al*., 1963). Red soil comprising of red loam and sandy soils are distributed in Peninsular India including the states of Tamil Nadu, Karnataka, Andhra Pradesh, Chhattisgarh, and Orissa (Singh *et al*., 2002). Eastern Peninsular India and parts of Kerala consists of coastal alluvial soils of high fertility. The soil of western slopes and peaks of Western Ghats is generally lateritic. Lateritic soil, which is rich in hydrated oxides of aluminium and iron, is distributed in Maharashtra, southern Karnataka, Kerala, Chhattisgarh, and Orissa. This soil is distributed in areas receiving high rainfall with alternating wet and dry periods (Anonymous, 1961).

Vegetation

In addition to the Mangrove forests that occur naturally along both coasts of Peninsular India, there are six major forest types, viz. Tropical thorn forests, Tropical dry deciduous forests, Tropical moist deciduous forests, Tropical dry evergreen forests, Tropical wet evergreen forests, and Tropical semi-evergreen forests. Of these, Tropical thorn forests, Tropical dry and moist deciduous forests cover most of the geographical area of Peninsular India (Parrotta, 2001). Once being a part of Gondwanaland, the Indian peninsula was covered by evergreen forests. Later it occupied a more equatorial position during the Miocene. With the rise of Himalayas and Western Ghats, its climate and vegetation changed drastically with drier deciduous forests becoming the climax vegetation. However, the evergreen forests persisted in parts of Western Ghats and Eastern Himalayas retaining some plant groups.

In general, *Sehima/Dichanthium* type, the largest among the five grassland types of India, occurs on Peninsular India with many subtypes (Dabadghao & Sankaranarayan, 1973). In the Western Ghats, *Chrysopogon-Arundinella* and *Andropogon polyptychus-Eulalia phaeothrix* type are frequently seen. According to Meher Homji (2001), 5 major types of grassland vegetation are represented in Peninsular Indian region, *viz*. Shrub-savanna, Tree-savanna, Shrub pseudo-steppe, Savanna-woodland, and Clump savanna.

METHODOLOGY

The methodology and general frame work of the study is mainly in accordance with that of Radford *et al*. (1974) and Bridson and Forman (1998).

Herbaria references

The present work is partly based on study of herbarium specimens available in a number of institutions including regional herbaria of the Botanical Survey of India. During the present study, the herbarium specimens of the following herbaria (abbreviations according to Holmgren *et al.,* 1990) were studied, viz. BM, CGE, GH, K, CAL, CALI, DD, L, LWG, BLAT, MH, KFRI, AHMA, BSI, TBGT, FRC and WAG. The type specimens are obtained on loan from BM, TBGT, L and WAG and digital images of the types from GH, K and US. It is found that many regional herbaria except BSI and TBGT have poor representation of the species of the genus. A complete set of all specimens collected and examined is deposited at CALI.

Collection and field work

The present study is mainly based on the specimens collected during extensive fieldtrips to different parts of the Indian peninsula. A large number of specimens (approximately 1500 numbers from whole of Peninsular India) have been collected. The different physiographic regions of Indian peninsula were repeatedly visited during all seasons as possible and the collected specimens were processed to make herbarium according to the guidelines of Vogel (1987). The study was carried out during the period from 2000 and 2007.

The major constraint on collection of the specimens was the short span of flowering which made it is difficult to collect the flowering specimens from all regions in the same season. The genus is mostly monsoon specific and comprises 80% annuals, which start sprouting at the end of South-West monsoon (September–October) and dries off immediately during retreat of monsoon (December–January). The difficulty was compounded by the influence of seasonal variation on majority of the annual species. It was also found that about 60% of the taxa were having very limited distribution and many of them known were only from the type locations.

Measurements

The dried samples were analyzed for each species to evaluate the characters as well as to make sketches. For the measurements of floral parts, fully developed spikelets of the raceme were used. In addition the culm and leaf of the plant, width of the raceme-rachis, the spikelet parts like pedicel, callus, upper glume, lower glume, lemma, palea and stamen were also measured for comparison. They were usually measured after softening in water. Some times spikelets were studied after they were soaked in boiled water or soaking in water overnight if necessary. Measurement of spikelet length excluded that of the awns. Glume length and lemma length excluded that of the callus. Some measurements of vegetative and reproductive features can be obtained from the figures 4 and 6 and also from Plate 2 (see Chapter 4).

Measurements and drawings of the spikelet parts have been made using Stereo microscope (WILD) fitted with a camera lucida. For the correct measurement of the spikelet and its parts, a dissecting microscope (LABOMED) is used.

Photomicrographs of the raceme and spikelets were taken with the help of digital camera fitted to a Stereo microscope (LEITZ). For the field photographs, SLR NIKON FM-10 and SONY Digital Camera are used whenever necessary.

Opaque slide preparation

The spikelets and a portion of rachis of each species have been mounted on an opaque sheet of size 2.5 X 8 cm and are used for study the range of spikelet variation of the taxa concerned. It is very useful for ready reference of the diagnostic morphological features.

Identification

Identification has been done through examination of the type specimens and mainly referring to the works of Hackel (1889), and Bor (1953, 1960) and confirmation of identification by consultation with the experts on grasses available at Royal Botanical Garden (Kew), The Nationaal Herbarium (The Netherlands) and other centers, where grass systematic research is being carried out seriously.

Nomenclature & citations

Bibliographic details of all taxa so far published have been obtained form Index Kewensis (IK) and IPNI (2005). The citations of periodicals and books are abbreviated and their abbreviations are in accordance with *Botanico-Periodicum-Huntianum* (B-P-H)

(Lawrence *et al*., 1968) and *Taxonomic Literature* (Stafleu & Cowan, 1976-1978). Authors' names are given following to *Authors of Plant Name Index* by Brummitt and Powel (1992). Acronyms of herbaria are used according to that given in *Index Herbariorum* (Holmgren *et al.,*1990) and Holmgren & Holmgren (1998).

The specimens cited in this work are exclusively those collected from Peninsular India only. The details of the specimen cited are given in the sequence of the names of States (in bold), the names of district, collection locality, collection date, name of collector and the acronym of depository (herbaria). Each species is provided with a distribution map.

Terminology

The terminology used in the species description is mainly in accordance with Stearn (1992).

Distribution map & Illustrations

Habitat and distribution data from national and international herbaria were compiled and integrated from which distribution maps of all taxa are generated in accordance with Holmgren and Angell (1986). The generation of distribution dot maps is a very effective way of showing plant distribution and is useful to interpret the phytogeography and ecology as well. Micro-tip pens (ROTRING Variant) equipped with 0.1 and O.2 points were used for preparation of illustrations.

PRESENTATION OF THE TAXONOMIC TREATMENT

A bracketed key to the genera and sections is provided first, which have been constructed using readily observable characters. Under each sectional keys, the respective species key is given followed by species, which is alphabetical order. Each species is treated with updated nomenclature, typification, relevant synonymy, complete description, distribution, ecology and habitat along with flowering and fruiting period. Notes on nomenclature, interrelationships and taxonomy are given wherever relevant. List of additional specimens examined from the area of study are given at the end of each species treatment and are cited by State, District, and place of collection starting from South to North. The infraspecific taxa are treated under the respective species following a key to the infraspecific taxa. The species are provided with number which is continuous irrespective of the sections.

The synonyms if any are given, taking into account the entire distribution and pertinent literature related to each species. For each name, the type is mentioned. The synonyms are given in chronological order respective to the type.

During the present study, all the type specimens of the representative taxa in Peninsular India except two are studied. The depository of the type specimens are specified using the abbreviations of the *Index Herbariorum* (Holmgren *et al.,* 1990) and the examined specimens are indicated with the sign ‘ !’ .

The detailed descriptions of all taxa are provided with illustrations except that of *Dimeria acutipes* Bor. are provided. The colour photographs of some taxa and the type specimens are given wherever necessary.

The distribution maps have also been furnished. All relevant data on ecology and phenology have been summarized and given under each taxon.

Relevant notes on nomenclature and variations whenever necessary have also been provided.

The representative specimens available in all the herbaria of Botanical Survey of India and the important herbaria attached to the academic and research institutions in Kerala and other parts of India have been studied and cited under each species treatment.

Details of the main abbreviations used in the text are given below.

Acc. No.	:	Accession number
alt.	:	Altitude
cf.	:	*confer* (compare)
ca.	:	*circa* (about)
GOA	:	Goa University Herbarium, Goa
Ibid.	:	*Ibidem* (In the same place)
l. c.	:	*loco citato* (at the place cited)

MSL	:	mean sea level
s. coll.	:	*sine collector* (Without collector's name)
s. n.	:	*sine numero* (Without collection number)
s. l.	:	*sensu lato* (In broader sense)
s. str.	:	*sensu stricto* (In strict sense)
SNCH	:	Herbarium, Sree Narayana College, Kollam
YBP	:	years before present

Chapter 4. GENERAL OBSERVATIONS AND ANALYSIS

COMPARATIVE MORPHOLOGY

Bor (1953) has given a general account on the morphology of Indian and Myanmarese (Burmese) species of the subtribe Dimeriinae *s. str*. The subtribe is mostly with majority of the species having uniform morphological characteristics except some species display seasonal variations within and among populations.

A detailed account on morphology of Dimeriinae is presented here, which is largely based on the study of Peninsular Indian taxa, where it exhibits maximum diversity. This is the first comprehensive study on the taxonomy and morphology of the subtribe.

Vegetative features

In general, vegetative features are very uniform among the species of Dimerias and provide few useful taxonomic characters.

Habit

Veldkamp (1973) pointed out the importance of the life-span of the species in grass taxonomy. Of the 42 taxa of Dimeriinae (under two genera) treated here, 34 are more or less annuals and 9 species are perennials.

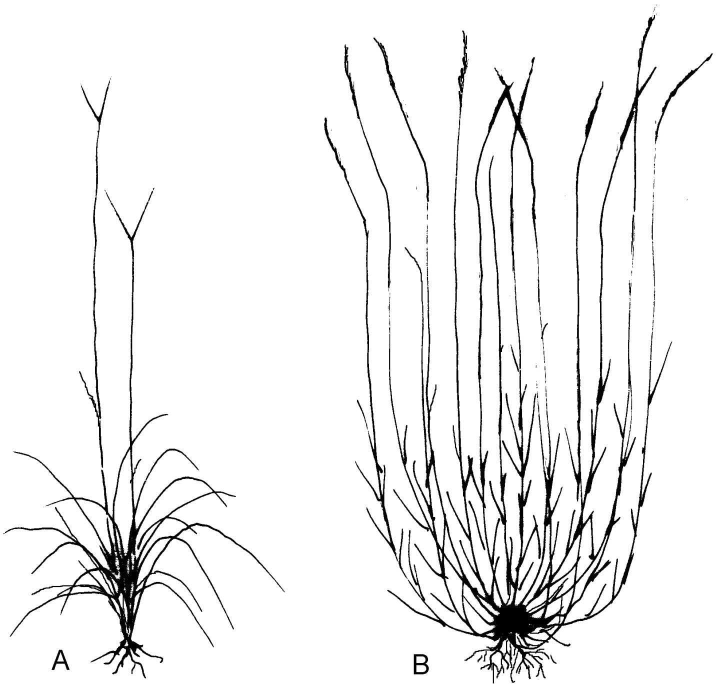
In Peninsular India, true annuals grow along drier parts of the region, mostly in lateritic soil or rocky substrata. They are more or less erect but sometimes geniculate at lower nodes (*D. connivens*). They do not have roots at lower nodes, stolons, and rootstocks. Most species are with gregarious or sub-gregarious flowering habit and some are with mat-forming (*D. hohenackeri* var. *kodagensis*). Culms are usually slender and, solitary or few, sometimes tufted (*D. raizadae*). Culm length may vary from 15 cm (*D. woodrowii*) to 60 cm in height.

True perennials have cataphylls and may have stolons (*D. mahendragiriensis*) but are usually erect with rootstocks. Most of the species show rooting at lower nodes. They are usually found along forest margins of the Western Ghats region and sometimes the sandy soils along river margins with thick rootstocks (*D. fuscescens*). They do not have gregarious growth and are sporadic in their habitat.

Some species are neither true perennials nor annuals but possess thick rootstocks. Based on the nutrient availability, they usually grow exhibiting tufted habit and up to 1.5 m in height (*D. kurumthotticalana s. l.*).

Rarely, culms bent at uppermost node (*Ravia santapaui s. str.*).

Some of the representative habits and culm types in Dimeriinae are shown in the figures 1 and 2(i).


A
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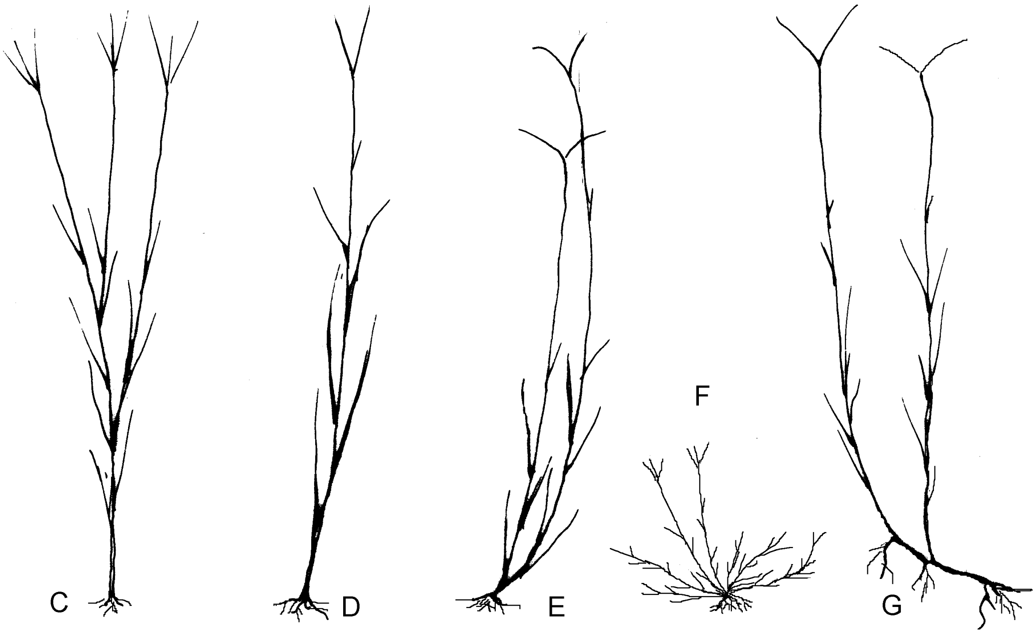

Fig. 1. Diagrammatic representation of different habits in Dimeriinae. A. Caespitose, Annual or Perennial (*D. trimeni*); B. Tufted, Annual (*D. lawsonii*); C. Slender, single, branched (*D. ornithopoda*); D. Slender, single, not branched *D. pubescens*); E. Geniculate, few culms from the base *(D. connivens*); F. Procumbent, Annual (*D. hohenackeri* var*. kodagensis*); G. Stoloniferous, Perennial (*D. namboodiriana*).

Indumentum

Conveniently, terms like ‘ciliate’, ‘bearded’, ‘scabrid’ and ‘bulbous-based hairs’ etc., have been here refereed under indumentum, whereas sometimes ‘pubescent’ has also been included rarely. Attempts were made to group the indumentum studied here. There are two types of hairs are present among the species of Dimeriinae.

1. Thin and uniseriate type. 2. Thick and multiseriate type.

The uniseriate hairs are fine with smooth walls and are often appressed. These simple hairs usually occur on nodes, callus, margins of the raceme-rachis and along the keel/surface of the glumes. These hairs are more hyaline along the margin of the glumes and lower lemma.

The multiseriate hairs are bulbous-based and are known as bulbous-based or tubercle-based hairs (tbh), and usually occur on the leaf surfaces mainly at the junction of leaf-sheath and lamina (Plate 1).

Leaf morphology

Leaves are usually arranged all along the culm or rarely grouped at the base of the culms. The leaf blades in all species of Dimeriinae found in Peninsular India are usually linear-lanceolate.

In general, the blades of the upper leaves shorter. There is also variation in absolute leaf blade size, from short leaves of *D. woodrowii* (4–6 cm x 0.2–0.3 cm) to the long wide leaves of *D. fuscescens* (25–30 cm x 0.5–0.8 cm). The surface of leaf blade is usually glabrous and margin scaberulous. Sometimes, scattered bulbous-based hairs are present along the surface as well as margins. Rarely, leaves are pubescent throughout the culm and leaf surface (*D. pubescens*). The junction of the leaf-sheath and lamina (Collar) is usually ornamented with bulbous based hairs in most species and sometimes without (*D. agasthyamalayana*). The different collar types are shown in figure 2(ii).

Ligule is found at the collar region and is continuous with the hyaline margins of the sheath. It is membranous, and ranges from 0.5–1 mm in length. It is truncate in shape, and lacerate or fimbriate along the margins.

The sheath is closely enclosing the culm and usually shorter than internodes. The leaf sheath is of interest only in those few species (*D. pubescens*) which bear bulbous-based hairs throughout the surface. In some species like *D. fuscescens*, the sheath is much longer than internodes. Rarely, the culm may slip away from the sheath (*D. lehmannii*).

Reproductive features

Inflorescence

The inflorescence is composed of racemes, consisting of rachises, bearing numerous pedicelled spikelets on their adaxial surface. The raceme structure of Dimeriinae is unique in the tribe

Andropogoneae due to the absence of 'spikelet-pairing'. They are with only pedicelled spikelets on tough raceme-rachises. Spikelets are usually packed compactly arranged and are alternately in 2-rows on each raceme (Fig. 3).

Each peduncle terminate with usually two racemes but it may vary from 1 (*D. fischeri*), to 3 (*D. connivens*) and up to 11 (*D. gracilis*). Rarely, the number of racemes may also vary within a species (e.g., 1 to 4 in *D. raizadae*). The number of racemes occurring within the Peninsular Indian taxa is shown in the table 5. The racemes are comparatively larger in perennial species (8–12 cm) and shorter in annuals (3–5 cm). The number of spikelets present in each raceme usually ranges from 30 to 80. But in *Dimeria* sect. *Capillares,* it ranges from 10–25 and in *Ravia*, number of spikelets varies between 6 and 8.

The racemes are usually sub-digitately arranged, rarely digitately (*D. gracilis*) but solitary racemes are also found in some annual species (*D. fischeri, D. lawsonii,* etc.). The raceme pair is usually divergent, but in species like *D. agasthyamalayana, D. trimeni,* they appear as forked (or V-shaped). In *D. connivens*, non-divergent racemes hardly exert from the sheath of the peduncle (Fig. 4, G). Rarely, the divergent racemes may be with erect apical portion grow again upward towards the apex and exhibiting an U-shaped appearance (*D. kanjirapallilana*).

Table 5. Number of racemes per peduncle among various species of different sections of *Dimeria* in Peninsular India.

Number of raceme	Sect. *Annulares*	Sect. *Capillares*	Sect. *Dimeria*	Sect. *Loriformes*
Raceme 1			*D. acutipes* *D. avenacea*	*D. kurumthotticalana* var. *kurumthotticalana* var. *idukkiensis* *D. mooneyi* var. *mooneyi* *D. balakrishnaniana* var. *balakrishnaniana* *D. thwaitesii* *D. kurzii* *D. lawsonii* *D. mahendragiriensis* *D. fischeri* *D. bialata* var. *sivarajanii*
2	*D. woodrowii* *D. veldkampii*		*D. agasthyamalayana* *D. aristata* *D. connivens* *D. deccanensis* *D. fuscescens* *D. kanjirapallilana* *D. orissae* *D. trimeni* *D. lehmannii* *D. ornithopoda* var. *gracillima*	*D. copei* *D. bialata* *D. deccanensis* *D. ravii* *D. josephii* *D. pubescens* *D. kurumthotticalana* var. *kurumthotticalana* *D. mooneyi* var. *mooneyi* var. *borii* *D. raizadae* *D. namboodiriana* *D. jainii* *D. balakrishnaniana* var. *balakrishnaniana* var. *sahyadricum*
3	*D. woodrowii*	*D. hohenackeri* var. *kodagensis*	*D. ornithopoda* var. *ornithopoda* var. *khasiana*	*D. raizadae* *D. pubescens* *D. copei*
4 or 5		*D. hohenackeri* var. *hohenackeri* *D. gracilis* *D. stapfiana*		
6 to 11		*D. gracilis*		

In *Dimeria* sect. *Annulares*, the racemes coiled or rolled to form a 'globule' (*D. woodrowii*) (Fig. 4, I) or 'ringlet' (*D. veldkampii*) (Fig. 4, H) at maturity. In some species, having more than two digitate racemes, they are widely divergent (*D. raizadae*).

In *Ravia,* the racemes are usually intertwined (when 2 racemes present), because of the twisted raceme-rachis.

Different types of racemes structures are shown in the figure 4.

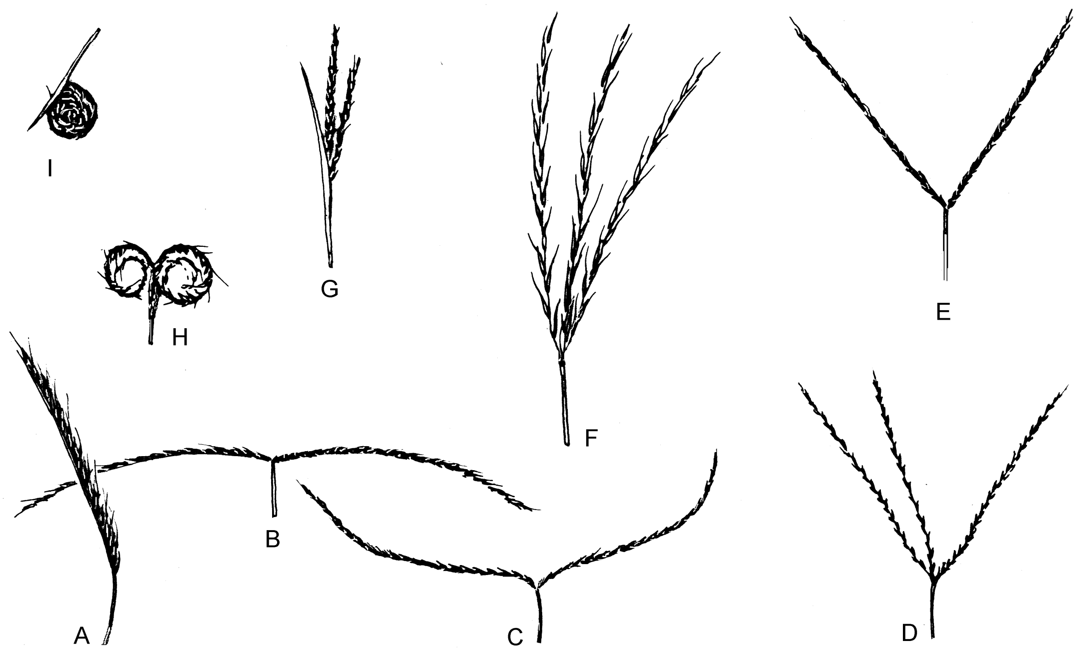

Fig. 4. Diagrammatic representation of different raceme types in *Dimeria*. A. Raceme solitary, long exerted (*D. fischeri*); B. Racemes widely divergent (*D. raizadae*); C. Raceme U-shaped (*D. kanjirapallilana*); D. Raceme digitate, hardly divergent (*D. pubescens*); E. Raceme fork-shaped (*D. trimeni*); F. Raceme sub-digitate, not divergent (*D. gracilis*); G. Raceme hardly exerted, not divergent (*D. kurzii*); H. Raceme ringlet-shaped (*D. veldkampii*); I. Raceme globule-shaped (*D. woodrowii*).

In *Dimeria* sect. *Loriformes*, the spikelets are firmly appressed to the raceme-rachis at an angle of less than 45^0, and arranged distichously making the rachis adaxially visible (Fig. 5B, C). Sometimes spikelets are facing towards one side of raceme (*D. fischeri*). In *Dimeria* sect. *Capillares*, spikelets slip away from the rachis and are distantly arranged at an angle of more than 45^0 with the rachis (Fig. 5D). In *Dimeria* sect. *Dimeria*, especially perennial species, the spikelets are firmly appressed to the rachis and are arranged overlapping with one another (imbricate), making the rachis adaxially, non-visible (Fig. 5A).

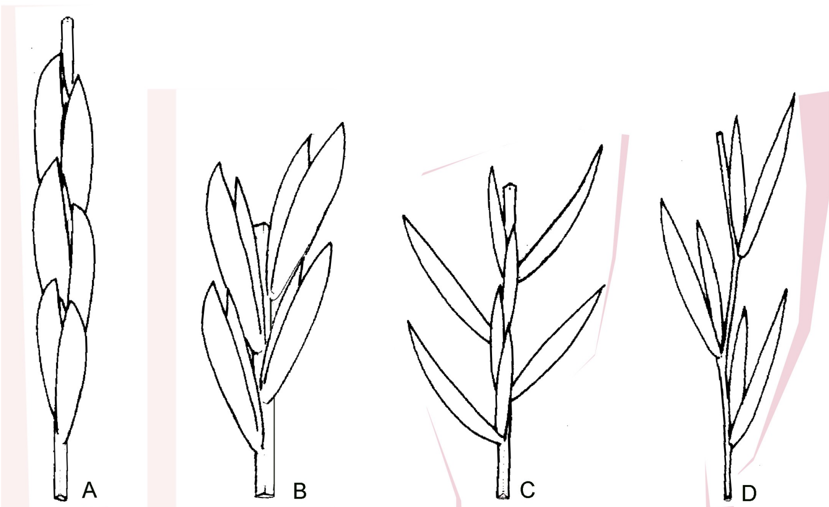

Fig. 5. Schematic presentation of spikelet-arrangement on rachises in *Dimeria*. A. Secund, close and imbricate (*D. fuscescens*); B. Secund, close but not imbricate (*D. kurumthotticalana*); C. Secund, close and glumes spread apart (*D. raizadae*); D. Secund, distant and spikelets slips away from rachis (*D. hohenackeri*).

Rachis of raceme

Bor (1953) basically used the texture of raceme-rachis in the delimitation of the sections under the genus, which is conveniently used as an important diagnostic feature. In *Dimeria,* raceme-rachis are usually tough, linear or zig-zag and bears the spikelets in its adaxial surface. Three main types of raceme-rachises can be recognized.

1. Rachis flattened (Fig. 6 D; Plate 2, D–F): The midrib of the rachis is flattened and corky or coriaceous; accompanied by a broad wing along its margins. These wings usually scabrous to ciliate, but rarely glabrous (*D. ravii*). In some species like *D. pubescens,* longitudinal nerves parallel to the rachis can be clearly seen in the wings. Rachis-internodes ca. 0.5 – 1mm long. In cross section, rachis appears flat. Rarely, rachis is convex on abaxial surface (*D. copei*). The width of the rachis may vary from 0.75 to 1.5 mm.

2. Rachis trigonous (Fig. 6 A, B; Plate 2, A): The midrib of the rachis is never flat but definitely triqueterous and coated. The angles usually scaberulous, and sometimes ciliate (*D. aristata*). Usually, abaxial angles of the rachis are minutely winged along rachis-internode. Internode ca. 0.5 mm long. In cross section, rachis appears triangular, and the width is ca. 0.5 mm in diameter. Rarely, rachis is twisted (*Ravia* sp.).

3. Rachis capillary and angular (Fig. 6, C; Plate 2, B): The midrib is filiform and usually terete or triangular in cross section, and scarious. Wing less. Usually glabrous, but rarely scaberulous along abaxial angles (*D. hohenackeri*). Rachis-internode 2.5 –

3.5 mm long. The width of the rachis may vary from 0.1 to 0.3 mm in diameter.

4. Rachis abxially and adaxially convex (Plate 2, C): This type of rachis is exclusively found in *Dimeria* sect. *Annulares.* The midrib of the rachis is neither flattened nor triqueterous but slightly compressed and corky. In transverse section, rachis appears somewhat ellipsoid, and minutely winged along the rachis-internode. Internode 1–1.5 mm long and the rachis width is ca. 0.75 mm. Margin of the rachis usually glabrous but rarely sparsely ciliate. In this type, the rachis circinately incurved or coiled at maturity. This type of rachis may adapt to the unusual coiling phenomena, and in turns helps to taxa disperse their diaspores more effective than other members of the Dimeriinae, and is considered as the advanced character in the subtribe.

In most of the species, the rachis is markedly zigzag in appearance (*D. trimeni, D. fuscescens, D. copeana,* etc.) which has little taxonomic value because this condition is variable within the species of different populations. The texture of the rachis is of great taxonomic importance, as it provides major diagnostic characters by which the sections of the genus are primarily delimited.

Pedicel

In contrast to other andropogonoids, the members of Dimeriinae do not have a distinct pedicel for the spikelets, but with a pedicel-like extension from the tough rachis are present, on which the spikelets are borne. In other andropogonoid grasses, the rachis is fragile and jointed, and get detached at the time of maturity. Here, each disarticulation unit usually consists of spikelet with rachis-joint and pedicel (e.g., *Ischaemum* spp.) or with rachis-joint only (*Arthraxon* spp.). In *Dimeria*, the rachis is tough and continuous, and disarticulation unit consists of spikelets only, leaving the pedicel in the rachis. So here, the extension of the rachis is termed as ‘pedicel’.

The ‘pedicels’ are alternately arranged on both sides of the rachis. In *Dimeria* sect. *Dimeria*, pedicels are formerly appressed to rachis where as in *Dimeria* sect. *Loriformes* it become more or less adnate to the rachis-wing. In *D. pubescens* Bor, pedicel is completely attached to the wing of the rachis. In *Dimeria* sect. *Annulares*, they are widely diverging from the rachis. The different types of pedicels are shown in the figure 6 and Plate 2.

Pedicels are usually clavate when the rachis is capillary; but usually flattened when rachis is compressed or trigonous. In *Ravia santapaui*, the pedicel is obconical in appearance.

The flattened pedicels are often ciliate on the outer margins but obconical pedicels are usually glabrous. The lip of the pedicels are best seen after the spikelet has fallen off, has some taxonomic value. Four types may be distinguished,

1. Pedicel with flat and oblique lip. (e.g., *D. avenacea, D. acutipes,* and *Ravia santapaui*)

2. Pedicel with transverse lip (e.g., *D. woodrowii*, & *D. veldkampii*)

3. Pedicel with discoid or concave lip (e.g., *D. pubescens,* etc.)

4. Pedicel with cupuliform lip (e.g., *D. stapfiana, D. gracilis,* etc.).

Spikelet morphology

The schematic representation of morphology of a single spikelet is given in the figure 7.

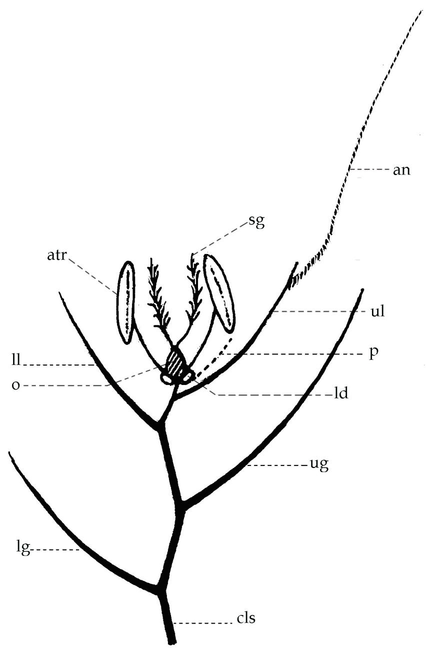

Fig. 7. Diagrammatic representation of the spikelet in Dimeriinae. (atr – Anther; cls- Callus; ld - lodicule; lg - lower glume; ll - lower lemma; o – ovary; p - palea; sg – stigma; ug - upper glume; ul - upper lemma).

Callus

The spikelets of Dimeriinae are strongly compressed, and with a definite callus at the base. The presence of callus and its structure in a few species is a useful diagnostic taxonomic character. The shape of the callus is usually compressed with truncate base (*Dimeria mahendragiriensis*), but sometimes it may be cuneate, and inserted (*Dimeria stapfiana*). In some instance, it is strongly oblique with pointed or pungent base (*Ravia santapaui*). In most of the species, length of the callus varies from 0.3–0.5 mm, but in species like *D*. *acutipes* it may go up to 1.5 mm. The callus is usually bearded, but often glabrous (*D*. *agasthyamalayana*), rarely densely hairy (*Ravia santapaui*).

Glumes

The glumes are usually coriaceous to subcoriaceous, but a crustaceous texture is found in some perennial species, rarely cartilaginous (*Ravia santapaui*). Colour of the mature spikelets varies from pale yellow to brown, often reddish-brown (*Dimeria trimeni*) or dark-red (*Ravia santapaui*). The size of the glumes, awned or unawned nature of apices, dorsal keeled nature of the glumes, and winged or wingless nature of the keels are the important diagnostic features helping species delimitation.

There is difference between the lengths of two glumes, and normally the upper is the longer. Nearly all species, the lower glume makes it an angle of 45^{o} with the upper glume during anthesis. In *Dimeria hohenackeri*, glumes widely spread apart (nearly angle of 90^{o}). The glumes are very thin along the margins, but almost coriaceous towards the middle line. Both glumes usually possess a keel on its dorsal side, which is either completely winged or winged on the upper half or it may be wingless. In *D. ornithopoda,* wing is completely absent where as in *D. deccanensis* it is minutely winged at the apex of the glume. The wings are usually papery in nature, but sometimes they are thickened and corky (*D*. *mooneyi*, *D*. *stapfiana, etc.*). This corky nature of the glume seems to be variable and it is not uniform even in the spikelets of same raceme. The presence or absence of wing is the important taxonomic value for the glumes. The winged nature of the keel may sometimes vary in the spikelets of the same raceme (*D*. *kurumthotticalana*). The distribution of upper glume features within the Peninsular Indian species are tabulated below (Table 6).

In *Ravia*, the glumes are not keeled and wingless. Here, the apical portion of both sides of the glumes has a wing like hyaline auricle.

The texture of the lower glumes has little taxonomic value and is usually wingless or minutely winged towards apex, except in *D. mooneyi* in which it is winged all along the keel.

The shape of the upper glume apices is taxonomically significant and it may vary from species to species. Mostly, the shape of apex varies from acuminate to aristate (*D. josephii*), and acute in *D*. *lehmannii*. The apex is rarely awned up to 3 mm long as in *D*. *acutipes* and *D*. *lawsonii.* Often, the apex of the glumes is recurred (*D*. *kurumthotticalana*).

The different type of spikelets and their glumes are shown in figure 6.

Table 6. The distribution of "Upper glume" features of the spikelet within the Peninsular Indian species of the sections of *Dimeria*.

Sections of Dimeria	**Upper glume wingless**	**Upper glume winged at apex only**	**Upper glume winged all along**
Sect. *Annulares* (Rachis rolled)	*D. veldkampii*	*D. woodrowii*	
Sect. *Capillares* (Rachis capillary or wiry)		*D. hohenackeri* *D. gracilis*	*D. stapfiana***
Sect. *Dimeria* (Rachis trigonous or triqueterous)	*D. acutipes** *D. ornithopoda* *D. kanjirapallilana*	*D. orissae* *D. copeana* *D. trimeni*	*D. avenacea** *D. agasthyamalayana* *D. lehmannii* *D. fuscescens* *D. aristata* *D. connivens*
Sect. *Loriformes* (Rachis flat)	*D. deccanensis*	*D. ravii* *D. josephii* *D. kurumthotticalana* *D. raizadae** *D. thwaitesii** *D. kurzii*	*D. lawsonii** *D. namboodiriana* *D. mahendragiriensis* *D. copei** *D. jainii* (wing not reached at apex)** *D. balakrishnaniana*** *D. fischeri* *D. pubescens* *D. mooneyi*** *D. bialata***

* Upper glume awned   ** Upper glume having corky wing

Florets

Each spikelet contains two florets. In Dimeriinae, the lower floret is always reduced and consists of hyaline lemma only. The lower lemma is usually oblanceolate in shape, with a rounded or acute ciliated tip. It is empty and the palea is absent.

The upper floret is bisexual, and contains a complete flower. The upper lemma is subhyaline with two short lobes between which the awn arises. The awn is perfect or imperfect, which arises between the two lobes of upper lemma, consists of two parts (Fig. 6, E). The basal short and thick column, which is hygroscopic in nature and usually twisted in mature spikelets. The upper most, very long slender bristle is retrosely barbed. The column is always glabrous, but in *Ravia,* it is puberulent. Rarely, column is absent in some species (*D. agasthyamalayana*, *D. woodrowii, etc*.). Upper lemma is usually accompanied by a minute palea which is ca. 0.5 mm long, very hyaline in nature and rarely absent. The floret contains a hermaphrodite flower, which consists of two lodicules, two stamens and a pistil. Lodicules are usually very thin and minute, ca. 0.25 mm long and truncate, toothed at apex. The number of stamens is always two. Brown (1810) mistakenly pointed out the presence of more than two stamens, when he made the generic description of *Dimeria* based on the type species *D*. *acinaciformis* R. Br. During the present study, this specimen (*Banks & Solander, s.n.*) (Plate 3) was thoroughly examined and confirmed that only two stamens are found in the above species. Bor (1953: 554) also pointed out this correction and he suspected that “possibly Robert Brown dissected one of the abnormal spikelet of the species and gave three as the number of stamens in the diagnosis of his new genus.” Anthers are usually yellowish brown in colour and the filaments are dorsifixed. Anthers dehisce by longitudinal slits. The length of the anther varies from1 – 2.5 mm long. Styles are two in number with reddish brown coloured, stigma plumose and project laterally from the sides of the spikelet at maturity.

Grain a caryopsis, and its character seems to have little taxonomic value. It is ellipsoid but slightly compressed laterally and usually brownish red in color. The embryo is about one third or almost half the length of the grain consisting of a basal hilum.

PHYTOGEOGRAPHY

In Dimeriinae, about 90% of the known world species can be found in the following three areas, *viz.* Peninsular India, Sri Lanka and Southern China. Most of the species are having restricted distribution in one of these 3 regions.

The distribution pattern inferred from the literature and herbarium data indicates that subtribe Dimeriinae was naturally distributed in the southern erstwhile Gondwanaland region, an area composed of Madagascar, India, Sri Lanka, Australia and South East Asia especially Malesian region. Earlier, Ridd (1971) had proposed a direct connection between India and South East Asia in Gondwanaland.

Three species are restricted to Madagascar, and all of them are endemic. These geographical isolation of Malagasy species from other species of *Dimeria* by approximately 2000 km, indicate an interesting direct phytogeographical link between Peninsular India and Madagascar. Some species are also found in volcanic soils of Mascarene Islands. This distribution supports the geological data which indicated that the archipelagic connections existed between the Indian plate, the Mascarene plateau, Madagascar and Africa until 75 million YBP (Schuster, 1976).

Distribution of Dimeriinae in Peninsular India

In Peninsular India, Dimeriinae is mostly distributed from Maharashtra to Kerala (along Western Ghats region) in the west to eastern regions of Tamil Nadu, to Orissa (along Eastern Ghats region) in the North-East. Occasionally, scattered populations are seen in Deccan region. Greatest diversity and most species are found in Western Peninsular India in general, and low altitude regions of Western Ghats along Maharashtra, Goa, Karnataka, Kerala states in particular.

Species diversity and endemism

Peninsular India harbours maximum species of Dimeriinae and high percentage of endemism. Out of the 65 recognized taxa in the World, 42 are reported from Peninsular India. The subtribe shows a high percentage of endemism within Peninsular India with 24 species and 6 varieties (under two genera), which are exclusively known from this region. There are 10 species considered near-endemic to Peninsular India, of which 9 species are distributed from Peninsular India to Sri Lanka, and one species (*D. kurzii*) is with extended distribution in Myanmar.

Members of Dimeriinae are particularly abundant in the Western Peninsular India, which includes the Northern Western Ghats and its coastal zone and the Southern Western Ghats region. The highest concentration of species is found in Southern Western Ghats. In fact 28 of the 42 Peninsular Indian taxa (including 7 verities) can be found in this small region from the South of Goa, Karnataka, Kerala to Tamil Nadu states. 17 taxa are exclusively endemic to this region.

Eight species are found in Northern Western Ghats region along Maharashtra and Goa States, of which 3 species are found endemic to this region.

Three species are restricted to Eastern Ghats region and 6 taxa are found scattered over Western Ghats, Eastern Ghats and Deccan region.

The species diversity of Dimeriinae represented by the sections of *Dimeria* and the genus *Ravia* on different phytogeographic regions of Peninsular India is shown in the map 5.

Phytogeographical affinity with Sri Lanka

The biogeographical connection between the Western Ghats and the Sri Lankan hills has long been obvious (Mani, 1974). Mani (*l.c.*) divided India into five regions of which one included the Indian East Coast (Coromandel) and the eastern parts of Sri Lanka and another included Malabar and most of the hilly parts of Sri Lanka. However, Sri Lanka is often considered as a separate region or subregion. The distribution of Dimeriinae indicates that the Southern Western Ghats has close phytogeographical link with the Sri Lankan Hills, but not the Northern Western Ghats. More or less, seven near-endemic species of the Southern Western Ghats, *viz*. *D. aristata, D. lehmannii, D. pubescens, D. trimeni s. l., D. kurumthotticalana s. l., D. thwaitesii, D. avenacea,* are also found in Sri Lankan region.

The distribution of Dimeriinae along the regions of the Peninsular Indian Grass Domain and Sri Lankan region are shown in Table 7.

Widespread species

Extra-peninsular India

Thirteen species are distributed as extra-peninsular Indian taxa. *D. ornithopoda* var. *ornithopoda* is distributed throughout the Tropical Asia and Australasia. *D. aristata, D. avenacea, D. fuscescens, D. gracilis, D. lehmannii, D. trimeni, D. kurumthotticalana s. str*., *D. pubescens, D. ornithopoda,* and *D.*

thwaitesii are also reported from Sri Lanka. *D. fuscescens* is distributed along Nepal, Sri Lanka and Malaysia. *D. kurzii* is reported from Myanmar. *D. ornithopoda* var. *khasiana* is reported from Assam region, which is endemic to India.

Peninsular India

Only one taxa (*Dimeria ornithopoda* var. *ornithopoda*) is distributed in almost all regions of Peninsular India as well as India. *D. connivens* is also distributed in all regions of Peninsular India and also along the arid zone of Rajasthan State.

Table 7. Distribution of the species of Dimeriinae along different regions of Peninsular India and Sri Lanka.

Sl. No.	**Taxa**	**Peninsular Indian region**				**Sri Lanka**
		S. W. Ghats	**N. W. Ghats**	**E. Ghats**	**Deccan**	
1	2	3	4	5	6	7
	DIMERIA R. Br.					
	Dimeria sect. *Annulares*					
1.	*D. veldkampii* *	**-**	**o**	**-**	**-**	**-**
2.	*D. woodrowii* *	**-**	**o**	**-**	**-**	**-**
	Dimeria sect. *Capillares*					
	D. stapfiana *	**-**	**o**	**-**	**-**	**-**
	D. hohenackeri	**x**	**x**	**-**	**x**	**-**
5.	*var. kodagensis* *	**o**	**-**	**-**	**-**	**-**
6.	*D. gracilis*	**-**	**x**	**-**	**-**	**-**
	Dimeria sect. *Dimeria*					
7.	*D. acutipes* *	**-**	**-**	**o**	**-**	**-**
8.	*D. agasthyamalayana* *	**o**	**-**	**-**	**-**	**-**

9.	*D. aristata*	x	-	-	-	x
10.	*D. avenacea* *	x	-	x	-	x
11.	*D. connivens* *	x	x	x	x	-
12	*D. copeana* *	o	-	-	-	-
13.	*D. fuscescens*	x	-	x	-	x
1	2	3	4	5	6	7
14.	*D. kanjirapallilana* *	o	-	-	-	-
15.	*D. lehmannii*	x	-	-	-	x
16.	*D. ornithopoda*	x	x	x	X	-
17.	*var. gracillima* *					
18.	*var. khasiana* *					
19.	*D. orissae* *	x	-	x	x	-
20.	*D. trimeni*	x	-	x	-	x
	Dimeria sect. *Loriformes*					
21.	*D. balakrishnaniana* *	x	-	-	x	-
22.	*var. sahyadricum* *	o	-	-	-	-
23	*D. bialata* *	x	-	-	-	-

24.	*var. sivarajanii* *	**o**	**-**	**-**	**-**	**-**
25.	*D. copei* *	**o**	**-**	**-**	**-**	**-**
26.	*D. deccanensis* *	**x**	**-**	**x**	**x**	**-**
27.	*D. fischeri* *	**o**	**-**	**-**	**-**	**-**
28.	*D. jainii* *	**o**	**-**	**-**	**-**	**-**
29.	*D. josephii*	**o**	**-**	**-**	**-**	**-**
30.	*D. kurumthotticalana*	**x**	**-**	**-**	**-**	**x**
31.	*var. idukkiensis* *	**o**	**-**	**-**	**-**	**-**
32.	*D. kurzii*	**x**	**-**	**-**	**-**	**-**
33.	*D. lawsonii* *	**o**	**-**	**-**	**-**	**-**
34.	*D. mahendragiriensis* *	**-**	**-**	**o**	**-**	**-**
35	*D. mooneyi* *	**x**	**-**	**x**	**-**	**-**
36.	*var. borii* *	**o**	**-**	**-**	**-**	**-**
37.	*D. namboodiriana* *	**o**	**-**	**-**	**-**	**-**
38	*D. pubescens*	**x**	**-**	**-**	**-**	**x**

39.	*D. raizadae* *	**o**	**-**	**-**	**-**	**-**
40.	*D. ravii* *	**o**	**-**	**-**	**-**	**-**
41.	*D. thwaitesii*	**x**	**-**	**-**	**-**	**x**
	Genus RAVIA *(ined.)*					
42.	*Ravia santapaui**	**x**	**x?**	**-**	**-**	**-**

***** = endemic to Peninsular India. **O** = endemic to the region. **X** = regional distribution.

Distribution of allied genera

Earlier workers (Hartely, 1958; Mehrothra & Jain, 1980) suggested that Peninsular India exhibits greatest diversity of the tribe Andropogoneae. It is noticed that there are eight Andropogonoid genera endemic to the Western Peninsular India, including *Pogonachne.* The subtribe is somewhat distantly related to *Pogonachne* Bor, a monotypic genus endemic to Northern Western Ghats of Maharashtra State. The generic relationships will be discussed under Chapter 4.

Discussions

Being the first comprehensive work on subtribe the following observations and comments on the Phytogeography of Dimeriinae would be very significant.

1. Two broad centers of the species concentration in Peninsular India are evident based on observations of species distribution and area of endemism. The one is on the Northern Western Ghats zone of the Peninsular India, have a strong tendency of narrow endemism in Dimeriinae. The other is on the Southern Western Ghats zone. The taxa occurring in the Southern most region (Southern Western Ghat subzone - south beyond the 'Palakkad-gap') often have restricted distribution and have shown a strong affinity with Sri Lankan elements.

2. The main centre of diversity of *Dimeria* in Peninsular India is the Southern Western Ghats region in Kerala, Karnataka and Tamil Nadu States.

3. Among the four sections of *Dimeria*, the sect. Annulares, which is represented by two species, is exclusively endemic to Peninsular India especially to Northern Western Ghats. The section considered as near-endemic to Peninsular India is sect. *Capillares*, distributed from the Peninsular India to Sri Lanka.

4. The high degree of endemism in the Peninsular Indian region (especially in Western Ghats), both within Dimeriinae and among its allies, suggests that the subtribe originated in this area.

5. In Dimeriinae, the highest species diversity occurs in Peninsular India. The genus demonstrates a high degree of regional endemism, with 70% of the species endemic to Peninsular India. Of these, 50 % are endemic to one of the four regions of Peninsular India (Southern Western Ghats); 24 % are near-endemics with distribution in Sri Lanka and Myanmar; and 5% (*D. woodrowii & D. veldkampii*) are exclusively endemic to Northern Western Ghats region. Therefore, it is hypothesized that that Peninsular India is the centre of diversity for Dimeriinae, based on the criteria proposed by Willis (1922).

6. A further study is proposed whole country and employing molecular studies in addition to thorough systematic studies to bring out the origin and phylogenetic aspects of the group.

ECOLOGY

Habitat

The members of Dimeriinae commonly found in humid as well as wet areas of low altitude belt, i.e., from sea-level to ca. 200 m above MSL. Some species are found in areas with its natural situation from 500m to ca. 1000 m altitude (*Dimeria aristata*, etc.), and rarely localized up to 1600m in Peninsular India (*D. trimeni*).

The favourable zone for most species seems to be the lateritic or red-soil grasslands and margins along evergreen forest, or secondary habitats adjacent to these; a few taxa prefer more marginal habitats such as very steep cliffs, and alluvial soil plains.

Substrata is one of the most important ecological factors, which determines the distribution of ecological groups of plants such as Psamophytes (on sand), Lithophytes (on rock surfaces), and Chasmophytes (on rock crevices) (Raunkaiaer, 1934). Most annuals of *Dimeria* are seen on dry lateritic rocky plains (Lithophyte), some species on wet rocks (Lithophytes) (*D. kurumthotticalana* var. *kurumthotticalana*), and rarely grow naturally on coastal alluvial plains (*D. copei*) (Psamophytes); perennials like *D. namboodiriana*, usually prefer rock crevices (Chasmophytes) and some prefer wet sandy places along forest margins (Psamophytes) (*D. fuscescens*).

Some of the habitats of Dimerias are shown in Plate 4.

The sprouting, flowering and fruit-setting of annual species occur within a period of 4 months. In lateritic plains of Peninsular India, the Dimerias usually sprouts during October and completely dry out by the end of February. The seeds that fall and deposited in the crevices of laterite remains there for almost 10 months and on getting the post monsoons rain the seeds germinate.

Morphological adaptations

The annual Dimerias are usually adapted to the lateritic habitats exhibiting following vegetative morphological features:

a. Solitary (or few) and slender annuals: These inhabit dry grassy plains usually growing gregariously. Rarely, some species are adapted to the clay soil condition (e.g., *Dimeria copei*)

b. Tufted annuals: Usually growing in rocky crevices in dry or wet conditions and are sub-gregarious (e.g., *Dimeria agasthyamalayana*)

c. Branched and mat forming annuals: Inhabits wet grassy plains of Peninsular India (e. g., *D. hohenackeri* var. *kodagensis*).

Perennials are adapted to wet rocky meadows and coarse sandy areas along water bodies, and exhibit the following:

a. Tufted perennials: Inhabits rocky meadows of high altitude as well as in river sand. They possess strong rootstock and thick elongated fibrous roots for effective anchorage in the river-bed. (e. g., *D. fuscescens*).

b. Stoloniferous and creeping perennials: Growing along forest margins along wet rocky places. They usually show rooting at lower nodes which helps in creeping (e.g., *D. namboodiriana*).

Climate and Vegetation

Climate plays an important role in the occurrence and diversity of Dimeriinae in Peninsular India. Dimerias enjoy monsoon climate in general, and are localized along the Tropical wet region of Western Peninsular India.

All species except *D. ornithopoda* var. *ornithopoda* are restrictedly distributed along the tropical wet and dry region. Among these, 36 taxa are occurring in wet region of Western Ghats. The distribution of Dimeriinae represented by various sections of *Dimeria* and the genus *Ravia* in different climatic zones of Peninsular India is shown in the map 6.

The life cycle of annual Dimerias is confined to a rather short period especially for post-monsoonal species. The growth begins after the monsoon (early winter) and completes its life cycle at the end of winter, after which the seeds fall and lie dormant in the lateritic substrata. In contrast, the perennials prefer rocky meadows of forest margins with a yearly vegetative cycle and the flowering and fruiting occur during the late winter period.

During post monsoon period (November–December), the species of *Dimeria* display a remarkable vegetative domination over the surrounding winter grasses in the ghat regions of Peninsular India, especially along lateritic hilly slopes. In some grassy lateritic plains, Dimerias grow gregariously and occupy a large area after the North-West monsoon (monsoon-retreat). Interestingly, Dimerias show remarkable colour changes as they grow from the juvenile to mature stage. In some areas the colour of the vegetation shows a gradual change from green to golden yellow, and from green to reddish brown in some other places. This is attributed to the formation of pigments called anthocyanins (Bor, 1953). The regions and their respective taxa of Dimeriinae, which form the characteristic '*Dimeria* field' in Peninsular India, are the following:

1. Northern Western Ghats (Maharashtra, Goa): *Dimeria hohenackeri/D. stapfiana/D. woodrowii.*

2. Central Western Ghats (Karnataka): *D. hohenackeri/D. ornithopoda* var*. ornithopoda.*

3. Southern Western Ghats (Northern Kerala): *D. hohenackeri/D. raizadae /D. thwaitesii /D. bialata.*

4. Southern Western Ghats (Central Kerala): *D. lawsonii/D. kurumthotticalana*

5. Southern Deccan region (Tamil Nadu): *D. deccanensis/D. ornithopoda*.

The characteristic colour changes in the vegetation during the lifecycle of some Dimerias are shown in plate 5.

Dimerias usually grow in regions of high rainfall in Peninsular India, where the minimum temperature during winter season falls to 20^{0}C.

Substrata and exposure

Dimeria biotopes are mainly with well exposed lateritic soil or rocky places, typically with cracks and crevices of sloping rocks, the cliffs, and the coarse sand near the waterways. They can be also found in dry, more or less stony meadows where they flourish locally. Some species (e. g., *D. trimeni*) are even more frequent in wet highland meadows than in low altitude dry grasslands.

The preferential chemical nature of the substrata that accommodate *Dimeria in situ* is almost the same as that for rocky as well as laterite-species and doesn’t seem really specific, either for the pH (i.e., the level of alkinity or acidity) or for the mineral composition. However, laterite-substrata are rich in aluminium and iron content for which the annual species are having more affinity.

The lateritic rocky substrata of Southern Western Ghats are poor in iron content whereas the Northern Western Ghats are usually rich in iron content and the species distribution and abundance vary accordingly. Most of the species are endemic to their respective regions with few exceptions (e. g., *D. hohenackeri*).

The heliophilous character of Dimerias is rather well marked, although the perennial species usually prefer to grow in the shade. It is noted that Dimerias generally grow in good winter brightness and prefers the direct sun, which is quite exceptional. However, occasional rains or a sudden seasonal change will jeopardise the plant growth and cause marked morphological variations in vegetative features as in species like *Dimeria copei, D. bialata, D. deccanensis* and *D. kurumthotticalana*, in which slender or tufted culm habits.

Physiological adaptations

The Dimerias are primarily C_4 grasses, which exclusively prefer the natural tropical climate. The adaptation to the hot climate is partially aided by the presence of narrow linear leaves which reduces excess transpiration. The formation of anthocyanin pigments during growth period by the end of monsoon, cause the gradual change in colour from green which retards photosynthesis thereby limiting vegetative growth and promoting rapid flowering and fruit setting.

Associate Plants

Dimerias frequently grow as pure and isolated populations especially in laterite rocky crevices where they succeed the other monsoon plants and appear as last dominant elements of the post monsoon vegetation along with other grasses. The ability of

Dimerias to quickly establish in laterite hilly slopes during the post monsoon period facilitates their gregarious growth.

More generally, the annual Dimerias grow in their sites in association with numerous other post-monsoon grasses and certain non-grasses. Associate plants vary from dry laterite substrata to wet rocky area. Most often, they are found in high altitude meadows, or among the loose sandy soil cover in open sunny places. Rarely, they are solitary and subgregarious and occur along forest margins, in shady zones.

Common associates of Dimerias in dry regions are several post monsoon grasses, viz. *Arundinella mesophylla* Nees ex Steud., *Aristida setacea* Retz., *Bhidea fischeri* Sreek. & Shetty, *Chrysopogon tadulingamii* Sreek. *et al*., *Glyphochloa acuminata* (Hack.) Clayton, *Heteropogon contortus* (L.) P. Beauv., *Ischaemum indicum* (Hoult.) Merrill, *Dichanthium annulatum* (Forssk.) Stapf, *etc*. Most of these companion grasses are found to be endemic to Peninsular India.

The companion plants of some species of *Dimeria*, very often include other species of *Dimeria* as well, forming specific associations between them as in the case between *Dimeria ornithopoda* and *D. kurumthotticalana, D. hohenackeri* and *D. bialata, D. hohenackeri* and *D. stapfiana, D. hohenackeri* and *D. woodrowii*. However, in these cases, any natural hybrids between these species haven’t been observed.

Generally, polyploidy and hybridization are common among grasses which pave the way for speciation (De Wet & Harlan, 1970; Stebbins, 1972). Likewise, this might be occurring in Dimerias as well. In fact, a detailed study on the associations with companion plants and their diversity including the above aspects requires further investigation, and literature regarding these aspects among grasses completely lacking, making it a matter for further research.

Fruit dispersal

Fruit dispersal in grasses occurs in different ways, *viz.* by wind, by water, by termites, ants, birds, fish, and by means of physical contacts with animals including human, by means of ballistic movements (Pijl, 1972; Davidse, 1987; Sendulsky, 1993). The dispersal units (diaspores) usually consist of caryopsis protected by lemma, glumes or even whole spikelet itself.

In Dimeriinae, the mature fruit-carrying spikelet or whole raceme are serves as diaspores. The diaspores are usually dispersed by the following three ways: Firstly, by wind (*anemochory*), which is common in grasses. Secondly, the awns of the diaspore readily get attached or adhere to clothes, skin or feathers of passing animals and birds promoting successful dispersal and establishment (*epizoochory*). This happens to the diaspores of most perennial species of *Dimeria*. The third type of dispersal of diaspores is through *anemogeochory* (Pijl, 1972). The spikelet and raceme modifications of the annual species facilitate this kind of dispersal. In these case, the diaspore usually consists of a single spikelet or whole raceme. There are two types of *anemogeochory* observed in Dimerias.

1. Spikelet as whole diaspore: Many annual species of Dimeriinae manifest this type of dispersal mechanism. The mature spikelet bearing caryopsis has a characteristic awn that propels the fruit along the ground by hygroscopic movements of awns. The flexing and coiling nature of the awn-column by means of atmospheric moisture helps to outburst the diaspore unit from the parent plant. The diaspore then reaches far away by wind with the help of retrosely barbed bristle.
2. Whole raceme as diaspore: In members of *Dimeria* sect. *Annulares,* the rachises at first circinately coil or roll, and finally form a ‘globule’ or a ‘ringlet’. At maturity rolled racemes fall off and function as diaspores. The diaspores roll over the lateritic plateau by wind and get deposited at crevices having soil where the seeds germinate during favourable climatic conditions. This kind of dispersal is effective in the spread of the species on dry lateritic grassy-plains.

    In the case of *D. woodrowii*, the shedding of the spikelets take place from the diaspores only later and delayed dispersal mechanism is termed as ‘bradychory’ (literally means slow or delayed dispersal) (Dixon, 1933). In the case of *D. veldkampii* the spikelet disarticulation is immediately after the shedding-off of the diaspores from the plant, and is termed as ‘tachychory’ (literally means fast or rapid dispersal) (Dixon, *l.c.*).

The bradychorous and tachychorous nature of diaspore dispersal in grasses was previously unknown; it is hoped that the present observations on these modes of dispersal in the andropogonoid grasses will serve as a guide for further research.

Discussions

Present ecological study resulted in the following elucidations and conclusions as well as the identification of significant areas for further research on Dimeriinae of the World in general, and Peninsular India in particular.

1. In Peninsular India, most of the Dimerias (80%) are annuals, majority of which are laterite-loving, though some rarely favor alluvial soil; where as perennials prefer rocky crevices along mixed forest margins, rarely in high altitude meadows, or wet sandy planes along water courses.
2. Monsoon plays a major role in the establishment and diversity of Dimeriinae in general. The humid tropical wet climate favours the successful growth, maximum diversity and endemism in Peninsular India.
3. Physiological adaptations like C_4 plant anatomy enables the successful establishment of Dimerias in tropical regions like Peninsular India. The remarkable 'colour change' owing to the formation of pigments is a matter of further study.
4. The detailed study on the common associate plants and their interventions requires further research, which would bring out information on naturalization, hybridization, polyploidy and speciation within Dimeriinae.
5. In contrast to other Poaceae members, Dimeria exhibits effective fruit dispersal by means of three main

types of mechanisms, viz. anemochory, epizoochory, anemogeochory (bradychory & tachychory). This aspects makes to put forward two critical questions - Dimeriinae belongs to an advanced subtribe in grass family, and do these dispersal mechanisms have any evolutionary significance in the grass family as a whole?

Further research on phytogeography, ecology, phylogeny, and genetic diversity based on molecular systematic are needed for a complete understanding of Dimerias and its taxonomically related taxa. During the present study, in collaboration with University of Missouri, USA, a molecular study on selected species has been initiated to find out the phylogenetic relationships of subtribe. Also, an attempt on the world revision of the genus is in progress as a continuation of the present work.

ECONOMIC USES

Though the species of *Dimeria* have only little economic value, some members are used as fodder which are readily eaten by cattle after the shedding of spikelets. The awned spikelet may be harmful to cattles.

In many places of northern Kerala, where they are called as “Neyypullu” are found abundantly during post monsoon season, and *D. thwaitesii,* and *D. deccanensis* are given to the cattles after a ‘salt treatment’. Salt solution is sprinkled over the cut and dried grass and kept overnight. The next day it is given to the cattles as fodder.

SYSTEMATIC POSITION

GENERIC DELIMITATION

Dimeriinae is considered as one of the little known group of tribe Andropogoneae and is hitherto represented by a single genus *Dimeria*. The sub tribe occupies rather anomalous position in the classification due to its unique morphological characteristics like presence of continuous tough rachis with persistent pedicel, laterally compressed spikelets, etc. The taxonomic concept of the subtribe is mainly based on the combination of above morphological characteristics (Bor, 1960; Clayton, 1994). With these features, the subtribe affords no hint of affinity with any other genera of the tribe and certainly a peculiar branch with uncertain relationships to other subtribes of Andropogoneae. So, the subtribe Dimeriinae is hitherto considered as enigmatic group under andropogonoids (Keng, 1939; Clayton & Renvoize, 1986). According to Clayton and Renvoize (*l.c.*) Dimeriinae might have evolved from Ischaeminae by suppression of the sessile spikelet. During the course of the present study, this view is corroborated (discussed later) and found that *Dimeria* shows a distant relation with the genus *Pogonachne* Bor of Ischaeminae through a newly described evolutionary intermediate genus *Ravia* Kiran Raj et Sivad. (*ined.*). The new genus has been segregated from *Dimeria* R. Br., and well placed under Dimeriinae.

The subtribe Dimeriinae has never been subjected to a critical analysis for elucidating its generic relationships. For the proper delimitation of the genera of subtribe, a proper understanding of the systematic position of the Dimeriinae in the tribe Andropogoneae is necessary. Hence, a critical evaluation of the representative subtribes of the tribe based on the gross morphology is attempted here.

Comparative floral morphology of Andropogoneae

Roux and Kellogg (1999) studied the floral development in the tribe andropogoneae. They found that almost all members of the tribe have paired spikelets (one sessile and the other pedicelled) with paired florets. The two spikelets, each with two florets (bifloral), may differ in their sex expression. Sometimes, unifloral condition can be also seen. A diagrammatic representation of the spikelet structure in the tribe is shown in the Figure 8.

Clayton and Renvoize (1986) also pointed out that sex of the spikelet especially of the pedicelled spikelet, has a great taxonomic value in the subtribal classification. In Saccharinae, both of the paired spikelets retain their fertility and the rachis internodes are unspecialized. In Germainiinae, sessile spikelet is male or barren, and pedicelled one fertile. In Sorghinae, raceme triad of 1 sessile and 2 pedicelled spikelets is formed, of which sessile spikelet retains fertility.

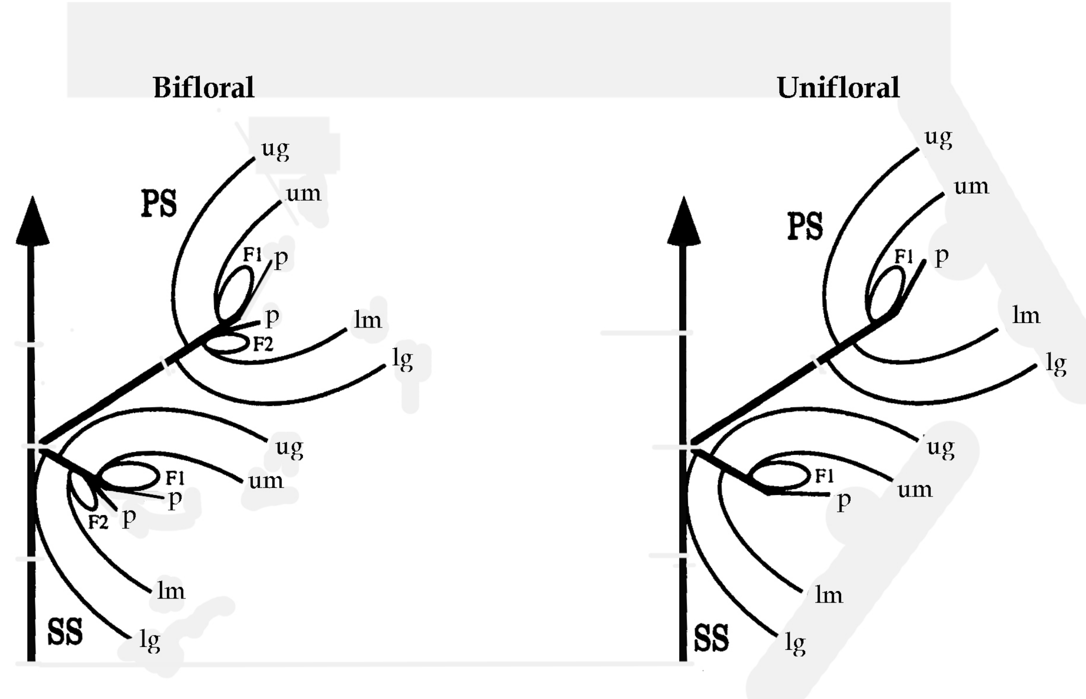

Fig. 8. Schematic presentation of spikelet structure in the tribe Andropogoneae showing the paired spikelet condition. (PS – Pedicelled spikelet; SS – sessile spikelet; lg – Lower glume; lm – Lower lemma; ug –Upper glume; ul – Upper lemma; p – palea; F1 – Upper floret; F2 – Lower floret. Dissected region represents the jointed portion or abscission point.) (*Source:* modified from Roux & Kellogg, 1999)

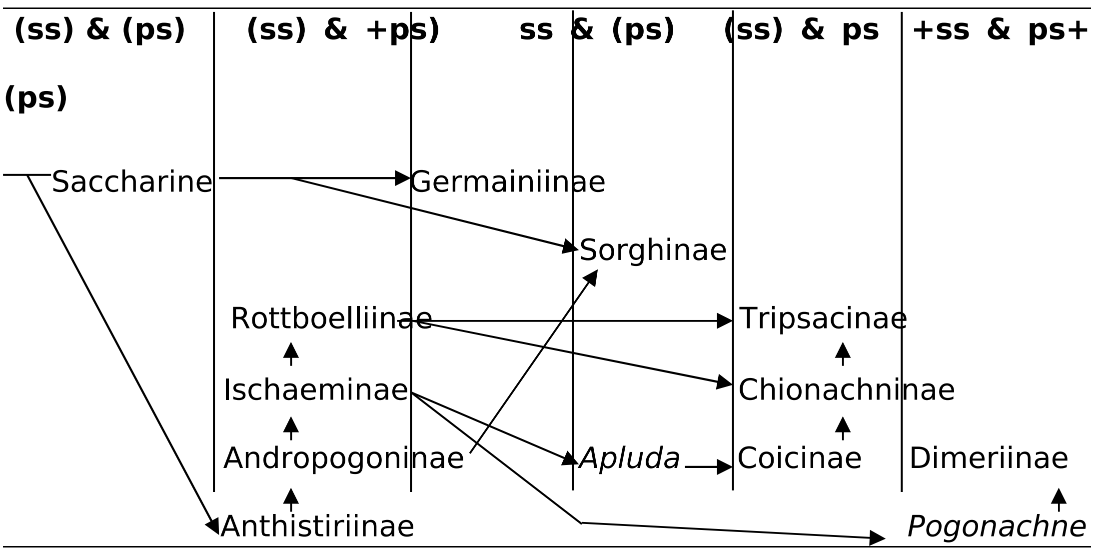

Fig. 9. Schematic representation of morphological affinities and trends

within the subtribes. **( )** = fertile, bisexual; + **)** = fertile, unisexual /bisexual; **+** = fertile, unisexual.

In Ischaeminae, Andropogoninae, Rottboelliinae, and Anthistiriinae the sessile spikelet bisexual and pedicelled spikelet either unisexual or bisexual. In Chionachninae, Coicinae and Tripsacinae, both spikelets are unisexual. In Dimeriinae, only the pedicelled spikelet retains fertility with bisexual upper floret and the rachis internodes are tough. Based on these observations, an attempt has been made to illustrate the morphological affinities within the subtribes proposed, which are shown in the figure 9.

The above hypothetical evolutionary ‘tree’ is primarily based on the sexuality of spikelets and discloses that Saccharinae can be considered as primitive and Dimeriinae as advanced. This visualization seems to be less significant in taxonomic interpretations but in a useful aid for discussion on interrelationships of Dimeriinae.

Gross morphological analysis of the subtribes of Andropogoneae

Clayton and Renvoize (1986) established 11 subtribes under the Tribe andropogoneae based on the gross morphological features. They also postulated certain evolutionary lines within the group, which are mainly based on the following morphological characters and its states:

1. Habitat establishment: occasional*→ gregarious*
2. Raceme texture: paniculate→ digitate*→ paired*→ solitary*

3. Pedicels and Rachis texture: filiform* → flat*
4. Pedicel type: Short* → long
5. Spikelets occurrence: Sessile + Pedicelled →Pedicelled*
6. Mode of compression of spikelet: Dorsally compressed→ rounded → laterally compressed*
7. Callus of the spikelet: obtuse, inserted*→ oblique, pungent *
8. Lower glume back: rounded→ 2-keeled→ 1-keeled*
9. Upper glume of the spikelet: awnless*→ awned*
10. Lower floret of the Pedicelled spikelet: Male flowered→ reduced with palea only → palea absent*
11. Number of stamens: Three → Two*

The asterisks denote the character, which is found in Dimeriinae. This indicates the possible evolutionary position of Dimeriinae in the tribe Andropogoneae and it can be considered as quite advanced when compared to other members of the tribe.

The classification of subtribes within the Andropogoneae has been regarded difficult, as more morphological data is needed (Clayton & Renvoize, 1986; Kellogg, 2000).

Generic relationships

Here is the first attempt to delimit the generic relationships of Dimeriinae. It is necessary to examine the closely related genera of the tribe Andropogoneae in detail, which helps to arrive at a satisfactory definition and delimitation of the subtribe. They may be defined as those members having solitary, paired or digitate racemes, laterally compressed pedicelled non-paired spikelets, the fertile lemma awned from the sinus of its 2-lobed tip and the lower floret of the spikelet reduced to a barren lemma. It is necessary to examine all andropogonoid genera with 'non-paired' spikelets.

Allied genera of Subtribe Dimeriinae

In the tribe Andropogoneae, the 'non-paired' spikelet condition has been encountered in 8 genera, *viz. Arthraxon* P. Beauv., *Cleistachne* Benth., *Dimeria* R. Br., *Mnesithea* Kunth, *Ophiuros* Gaertn., *Oxyrhachis* Pilger, *Pogonachne* Bor, and *Thaumastochloa* C. E. Hubb. (Clayton & Renvoize, 1986). The genera like *Mnesithea, Ophiuros, Oxyrhachis,* and *Thaumastochloa* (all under subtribe Rottboelliinae) have only well developed sessile spikelets. Here, pedicelled spikelet is completely suppressed. In raceme-segment, the rudimentary pedicel, lower glume of the spikelet and internode are together forming a 3-sided barrel-shaped box, which is enclosing the sessile spikelet. Morphologically, these genera are placed far from Dimeriinae.

Cleistachne Benth. and Dimeriinae

During the phylogenetic study of tribe Andropogoneae, Kellogg and Watson (1993) placed Dimeriinae close to *Cleistachne* (subtribe Sorghinae). But, their morphological observations were meager, because they compared the floral characters of

Dimeriinae and *Cleistachne* as "…the subtribe of having two fertile florets, rather than one fertile and other reduced, consistently appears as the sister genus of *Cleistachne*". Spikelets of Dimeriinae have an upper fertile floret only and the lower floret is reduced, and represented by a lemma only. Other distinctive morphological characters of Dimeriinae and *Cleistachne* are summarized in table 9. The affinity between the two is ambiguous (Fig. 10).

Table 9. Comparison of diagnostic features of *Cleistachne* and Dimeriinae

	Cleistachne	**Dimeriinae**
1.	Inflorescence a panicle, rachis jointed	Inflorescence a single or subdigitate or digitate raceme, rachis continuous
2.	Spikelets dorsally compressed	Spikelets usually laterally compressed
3.	Glumes 7–9-veined	Glumes 3-viened
4.	Lodicules ciliate	Lodicules glabrous
5.	Stamens 3	Stamens 2

Arthraxon P. Beauv. and Dimeriinae

In the genus A*rthraxon* (Andropogoninae), the inflorescence is sub-digitate or a single raceme, usually having well developed sessile spikelets. Rarely, in some species spikelets are in paired condition, and pedicelled spikelets are developed, but it becomes reduced. Occasionally, the species of *Arthraxon* are confused with the members of *Dimeria s. str.* in external morphology. A comparison of diagnostic features is shown in Table 10.

Table 10. Comparison of diagnostic features of *Pogonachne* Bor and Dimeriinae

	Arthraxon	**Dimeriinae**
1.	Raceme-rachis fragile	Raceme-rachis tough
2	Spikelets sometimes paired	Spikelets always solitary
3.	Callus glabrous	Callus usually bearded
4.	Glumes 5–20-nerved	Glumes 3-viened

The following features are common to both the groups: occurrence of paired or sub-digitate racemes, pedicelled spikelets, laterally compressed spikelets, glumes keeled or not, reduced lower floret, absence of lower palea, and number of stamens 2. Affinities and probable line of evolution morphological and phytogeographical affinity of *Arthraxon* and Dimeriinae are shown in Fig. 10.

In genera like *Pogonachne* (Ischaeminae) and *Dimeria s.l.*, the inflorescence is composed of single or digitate racemes and possess only well developed pedicelled spikelets. Observations on an attempt on the study of possible interrelationships of *Pogonachne* and Dimeriinae have been presented below:

Pogonachne Bor and Dimeriinae

It has been observed that members of the subtribe Dimeriinae (*Dimeria* and *Ravia* gen. nov.) show distant relation with *Pogonachne* Bor, an endemic genus of Northern Western Ghats of Maharashtra.

Spikelet morphology of *Dimeria, Pogonachne* and *Ravia* was more closely investigated and elucidates the fallowing observations.

The pedicelled spikelets of *Dimeria* are borne on tough raceme-rachises. The genus *Pogonachne* belongs to the subtribe Ischaeminae, and its fragile raceme-rachis bears only pedicelled spikelets. The spikelets of *Ravia* (Fig. 11, B) slightly resemble that of *Pogonachne* (Fig. 11, A) in having keel-less glumes and the upper lemma with a stout awn, but differs in having smaller spikelets with a long callus and in the absence of a median tuft of hairs along dorsal side of the upper glume but with the apical hairs. In *Dimeria,* the spikelets are laterally compressed and have dorsally keeled glumes. Within the genus *Dimeria*, the spikelets of the species of *Dimeria* sect. *Loriformes* (Fig. 11, D) differ from that of *Dimeria* sect. *Capillares* (Fig. 11, C) in having keel all along the dorsal side of the glumes. The probable spikelet evolution in *Pogonachne, Ravia* and *Dimeria* is schematically shown in the figure 11, A–D. All these genera have unifloral spikelets. A comparison of spikelet structure of *Pogonachne* and Dimeriinae is given in the Figure 12.

The close morphological resemblance of the inflorescences of *Dimeria* and *Ravia* and the occurrence of the two in the same geographical region, made to presume that *Dimeria* is closely related to *Ravia* and distantly related to *Pogonachne,* despite the differences in other floral characters. A comparison of other diagnostic features of *Pogonachne, Ravia* and *Dimeria* is shown in table 11.

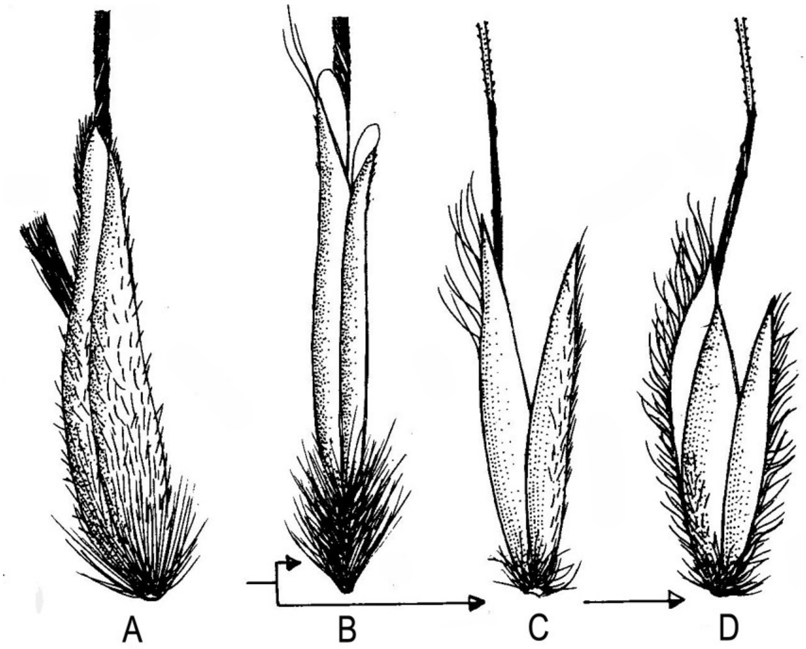

Fig.11. The probable line of evolution of spikelets of *Pogonachne, Ravia* and *Dimeria*: A. Spikelet of *Pogonachne racemosa* Bor; B. Spikelet of *Ravia santapaui* (N.C.Nair *et al*.) Kiran Raj et Sivad.; C. Spikelet of *Dimeria gracilis* (*Dimeria* sect. *Capillares*); D. Spikelet of *D. kurumthotticalana s.l.* (*Dimeria* sect. *Loriformes*).

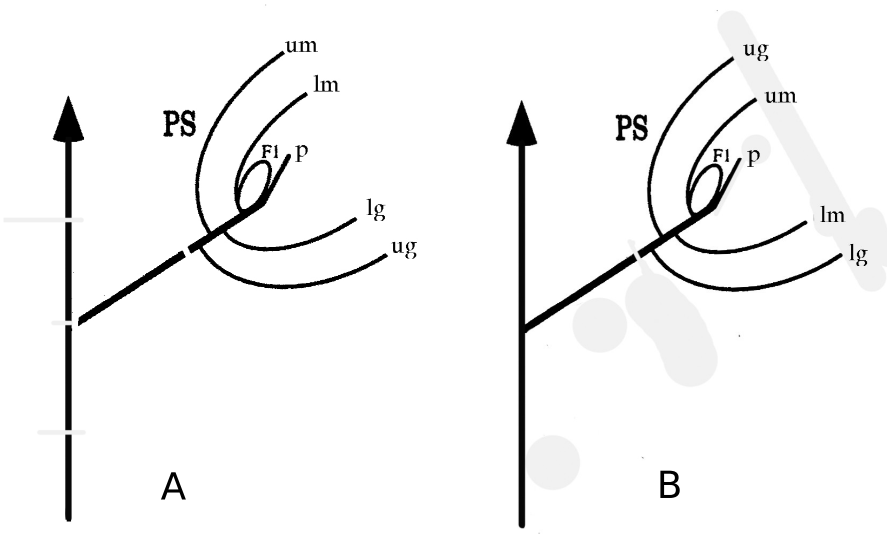

Fig. 12. Schematic presentation of spikelet structure *Pogonachne* and Dimeriinae: A. *Pogonachne;* B. Dimeriinae. (F1 – Upper floret; lg – lower glume; lm – lower lemma; p – palea; PS – Pedicelled spikelet; ug – upper glume; ul – upper lemma; Broken region represents the jointed portion or disarticulation point)

Table 11. Comparison of diagnostic features of *Pogonachne*, *Ravia,* and *Dimeria.*

	Pogonachne	**Ravia**	**Dimeria**
1	Inflorescence a raceme, terminal or auxillary.	Inflorescence single or paired raceme, terminal.	Inflorescence single, paired or digitate raceme, terminal.
2	Raceme-rachis jointed, fragile.	Raceme-rachis not joined, tough.	Raceme-rachis not joined, tough.
3.	Spikelets coriaceous.	Spikelets cartilaginous.	Spikelets coriaceous rarely chartaceus.
4.	Callus cuneate, bearded, base truncate.	Callus oblique, densely bearded, base pungent.	Callus cuneate or square, base truncate/ inserted.
5.	Glumes-margin hyaline, entire.	Glumes-margin hyaline, auricled at	Glumes-margin hyaline entire.

		apex.	
6.	Upper glume keeled at apex only, not winged.	Upper glume not keeled, not winged.	Upper glume keeled, winged or not.
7.	Upper glume with dorsal median tuft of hairs.	Upper glume glabrous throughout.	Upper glume with hairs all along the keel, or glabrous.
8.	Upper lemma with stout awn, 30-40 mm long.	Upper lemma with stout awn, 20-30 mm long.	Upper lemma with slender awn, 12-15 mm long
9.	Column of the awn present, 10-15 mm long, twisted, glabrous.	Column of the awn present, 8-10 mm long twisted, sparsely pubescent.	Column of the awn present or absent, 2-4 mm long, twisted, glabrous.
10.	Lower palea present.	Lower palea absent.	Lower palea absent.
11.	Stamens 3.	Stamens 2.	Stamens 2.

All genera (with non-paired spikelets) are having jointed (discontinuous) raceme-rachis except in *Dimeria* and *Ravia*. The interrelationships and probable line of evolution based on phytogeographical and morphological considerations are shown diagrammatically in the figure 10.

The figure 13 is showing the raceme-segments of relevant andropogonoid genera, and their possible interrelationships with Dimeriinae.

The interrelationships of genera with non-paired spikelets of the Tribe Andropogoneae can also be distinguished and separated by the following key, which is the modification of the key provided by Clayton and Renvoize (1986: 323 & 328).

Key to the genera with 'non-paired spikelets' of the tribe Andropogoneae

1a. Inflorescence with pedicelled spikelet only; pedicel well developed, rarely persistent with rachis (in Dimeriinae) 6

1b. Inflorescence with sessile spikelets only; pedicels rudimentary or suppressed (in *Arthraxon*). 2

2a. Inflorescence a panicle; spikelets awned. .... *Cleistachne*

2b. Inflorescence sub-digitate or single raceme; spikelets awnless....3

3a. Peduncle deciduous ....*Thaumastochloa*

3b. Peduncle not deciduous. 4

4a. Raceme dorsi-ventral; spikelets all on the same side in single row ....*Mnesithea*

4b. Raceme symmetrical, the spikelets on same side in two opposite rows ………………………………………………………… …………. 5

5a. Lower lemma epaleate …………………………………… *Oxyrhachis*

5b. Lower lemma paleate …………………………………………*Ophiuros*

6a. Raceme-rachis fragile…………………………………………………… 7

6b. Raceme-rachis tough ……………………………………………………8

7a. Raceme single, subtended by spatheoles; upper glume with median tuft of hairs ……………………………………… *Pogonachne*

7b. Raceme usually sub-digitate, never subtended by spatheoles; upper glume usually glabrous ……………… ……………..*Arthraxon*

8a. Spikelets cartilaginous; callus strongly oblique, base pungent, glabrous or bearded; glume-margins auricled at apex; awn-column stout, puberulent. ……………………………… ……….*Ravia*

8b. Spikelets usually coriaceous; callus cuneate or truncate, base blunt, densely hairy; glume-margins entire; awn-column slender, glabrous ……………………………… ………………….*Dimeria*

Tribe Paniceae and subtribe Dimeriinae

Clayton (1969) pointed out the possible affinity of subtribe Dimeriinae with tribe Paniceae of Panicoideae. Raceme with continuous rachis is one of the diagnostic features of Tribe Paniceae. Also, in external morphology, Dimeriinae are sometimes confused with some Paniceae members like *Digitaria* Haller. All members of the subtribes of andropogonoids having jointed rachis (with continuous raceme-rachis), except in members of Dimeriinae. But based on general morphological features, Dimeriinae can be easily separated from Paniceae. A comparison of diagnostic features is given in table 12. The affinity between these two groups is also doubtful.

Table 12. Comparison of diagnostic features of Tribe Paniceae and Dimeriinae.

	Paniceae	**Dimeriinae**
1.	Spikelets usually dorsally compressed or rounded.	Spikelets usually laterally compressed.
2	Glumes small, sometimes absent; smaller than lemmas.	Glumes large and prominent; larger than lemmas.
3.	Upper lemma usually awnless.	Upper lemma awned.
4.	Lower lemma large; chartaceus to cartilaginous.	Lower lemma small, hyaline.
5.	Stamens 3.	Stamens 2.

INFRAGENERIC DELIMITATION

Due to the presence of obviously related species, it is little difficult to make a very clear infra-generic delimitation. Since the Peninsular India holds majority of the World taxa, it is necessary to give a better system of classification for clear-cut delimitation of the infrageneric categories.

Dimeria *s.str.*

Bor (1953) had first attempted to accommodate the species of Dimerias under 3 sections. He found that the shape of raceme rachises, the orientation and time of disarticulation of spikelets, and the type of pedicels are of great diagnostic significance and his sections are based on these features. He grouped the species of India, Myanmar and Sri Lanka into the following sections. The sections of *Dimeria* and the included species as recognized and treated by Bor (1953) are provided below with the diagnostic features (as given by him) of the sections given in parenthesis.

Dimeria* sect. *Annulares (Rachis of the raceme on both sides a little convex, at first straight, afterwards at maturity ring-shaped, carrying the spikelets on the inside; spikelets slowly separating from the pedicels at maturity)

D. woodrowii Stapf

Dimeria* sect. *Capillares (Rachis of the raceme capillary, very thin or trigonous; in section nearly triangular, not winged; pedicel conical or compressed at all, spikelets at maturity free from the pedicels)

D. ballardi Bor

D. blatteri Bor

D. fuscescens Trin.

D. gracilis Nees *ex* Steud.

D. *hohenackeri* Hochst. *ex* Miq.

D. stapfiana C. E. Hubb. *ex* Pilger

D. velutina Bor

Dimeria* sect. *Loriformes (Rachis of the raceme flat and compressed, in section elliptical or plano-convex, dorsally flat or little convex, winged or not; pedicels distinctly compressed)

D. acutipes Bor

D. avenacea (Retz.) C. E. C. Fisch.

D. bialata C. E. C. Fisch.

D. ceylanica Bor

D. connivens Hack.

D. deccanensis Bor

D. fischeri Bor

D. lawsonii (Hook. f.) C. E. C. Fisch.

D. lehmannii (Nees & Steud.) Hack.

D. mooneyi Raiz.*ex* Mooney

D. orissae Bor

D. ornithopoda Trin.

D. pubescens Hack.

D. thwaitesii Hack.

During this work on the peninsular Indian species, it appeared that the infra generic subdivision rose by Bor (*l.c.*), based above limited characters, is unsatisfactory. It was found that species were accommodated in sections where they clearly did not agree with the sections, and that few sections couldn't be distinguished from each other satisfactorily due to the overlapping of characters. He neither appointed the types to the respective sections nor explained the sectional characters in detail.

Re-evaluation of the infrageneric classification of *Dimeria*

As far as the relative structure of raceme rachises, the morphology and orientation of the spikelets and the texture of the pedicels are concerned, it has been observed that these features are of great significance delimiting and distinguishing sections. With the help of more data obtained from overall morphological features of the taxa from Peninsular India, a revised and updated sectional treatment is provided.

Bor's Dimeria section Annulares is characterized by an unusual coiling of racemes and was represented by a single species. One more species (Kiran Raj & Sivadasan, 2008) has been added to the section during the present study.

The other two sections of *Dimeria* (sect. *Capillares* and sect. *Loriformes*) recognized by Bor have been critically evaluated and re-alignment of the constituent species have been made.

From these two sections, the species with strictly triqueterous raceme rachises, overlapping spikelets, and pedicels closely appressed to the rachis are excluded and are placed in the type section *Dimeria*. During the present work, the holotype of the *D. acinaciformis* R. Br., which is the type species of the genus, has been consulted at BM (Plate 3) which was collected from north-eastern Australia by Sir Joseph Banks and Daniel Carl Solander in 1770. The remaining taxa in *Dimeria* section Capillares (*s.l.*) recognized by Bor have racemes with strictly terete pedicels with filiform rachises, which agrees with the diagnostic characters of the proper sect. *Capillares.* The section has been lectotyped here.

The remaining taxa in Bor's section *Loriformes* (*s.l.*) have racemes with flattened rachises and compressed pedicels, which together defines the proper sect. *Loriformes.* This section has also been lectotyped here.

It is confirmed that the species of the four sections recognized here exhibit a definite overall similarity between the members of all the sections. A number of species with morphologically intermediate characters of other sections also are present and are considered as the intermediate taxa linking the sections. The revised sectional treatment of Peninsular Indian *Dimeria* with more static and reliable characteristic features is given below.

Dimeria Sect. **Annulares** Bor, Kew Bull. 7(4): 556.1953. – *Type: Dimeria woodrowii* Stapf

Annuals. Raceme 2(–3), rolled, as a whole shed off at maturity; raceme-rachis slightly compressed, a little convex on both sides, at straight when young, wingless, coiled or rolled at maturity, carrying the spikelets inside; rachis-internodes ca. 1.5

mm long; pedicel short, flat, diverging from rachis; spikelets distantly arranged along the rachis; Glumes never diverging at anthesis, upper glume winged at apex of the keel only, wing papery.

2 species in Peninsular India; Endemic to lateritic plains of Northern Western Ghats.

D. veldkampii Kiran Raj & Sivad.
D. woodrowii Stapf

Dimeria Sect. **Capillares** Bor, Kew bull. 7(4): 556.1953. – Lectotype: *Dimeria hohenackeri* Hochst. ex Miq. (designated here)

Annuals or Perennials. Racemes (3-)4–8(-11), straight; raceme-rachis capillary or wiry, nearly triangular or terete in cross section, flaccid, wingless; rachis-internode 2.5–3.5 mm long; pedicels up to 1.5 mm long, clavate, diverging form rachis; spikelets distantly arranged along rachis, not imbricate; glumes widely diverging at anthesis. Upper glume winged all along keel or wingless, wing corky or papery.

3 species in Peninsular India.

D. stapfiana C. E. Hubb. ex Pilger

D. *hohenackeri* Hochst. *ex* Miq.
D. gracilis Nees *ex* Steud.

Dimeria Sect. **Dimeria** – *Type: Dimeria acinaciformis* R. Br.

Annuals or perennials. Racemes (1–)2–3, stright; raceme-rachis triqueterous, trigonous in cross section, rigid, occasionally zig-zag in profile, usually wingless, if winged only at the rachis-internode only; rachis-internode ca. 0.5 mm long; pedicels up to 0.5 mm long, cuneate or truncate, flat, closely attached to rachis; spikelet coriaceous, often fuscous, compactly packed along rachis, imbricate; glumes never diverging at anthesis; upper glume winged usually towards the apex of the keel or wingless; wing papery.

12 spp. in Peninsular India.

D. acutipes Bor
D. agasthyamalayana Kiran Raj & Ravi
D. aristata Hack.
D. avenacea (Retz.) C. E. C. Fisch.
D. connivens Hack.
D. copeana Sreek. *et al.*
D. fuscescens Trin.
D. kanjirapallilana K. C. Jacob
D. lehmannii (Nees & Steud.) Hack.
D. orissae Bor
D. ornithopoda Trin.
D. trimeni Hook. f. (linking species, with sect. *Loriformes*)

Dimeria Sect. **Loriformes** Bor, Kew bull. 7(4): 556.1953. – Lectotype: *Dimeria pubescens* Hack. (designated here)

Mostly annuals. Racemes 1–2(–3), straight; raceme-rachis compressed; flattened in cross section, stiff but not rigid, distantly winged; rachis-internodes 0.5–1 mm long; pedicels 0.3–0.5 mm long, distinctly compressed, flat, somewhat attached to the wing of the rachis; spikelets coriaceous or chartaceus, compactly arranged along the rachis, early disarticulating with the pedicels; glumes diverging at anthesis; upper glume winged usually all along the keel or the apex, wing corky or papery.

16 spp. in Peninsular India.

D. balakrishnaniana Ravikumar *et al.*
D. bialata C. E. C. Fisch.
D. copei Ravi
D. deccanensis Bor (linking species, with sect. *Dimeria*)
D. fischeri Bor
D. jainii Sreek. *et al*.
D. josephii Ravi & Mohanan
D. kurumthotticalana K. C. Jacob
D. kurzii Bor
D. lawsonii (Hook. f.) C. E. C. Fisch.
D. mahendragiriensis Ravi *et al.*
D. mooneyi Raiz *ex* Mooney
D. namboodiriana Ravi & Mohanan
D. pubescens Hack.
D. raizadae V. J. Nair *et al.*
D. ravii Kiran Raj, Sivad. & Jomy (*ined.*)
D. thwaitesii Hack.

Phylogenetic considerations

The *Dimeria* sect. *Capillares* probably lies close to the ancestral line, for the species have primitive characters (the *Ravia*-like capillary raceme-rachis of *D. gracilis*). The supposed affinities and phylogentic considerations rest mainly on the raceme-rachis structure. Four points emerge from a consideration of morphological affinities:

(1) Sect. *Capillares* and sect. *Dimeria* : The triqueterous capillary raceme-rachis of *D. hohenackeri* var. *kodagensis* of sect. *Capillares* is close to the features of raceme-rachis of *Dimeria ornithopoda* var. *gracillima* (sect. *Dimeria*).

(2) Sect. *Dimeria* and sect. *Loriformes*: The sect. *Dimeria* are so closely related morphologically with linking species like *D. deccanensis* and *D. trimeni* of sect. *Loriformes*. These species with features like abaxially flattened triqueterous raceme-rachis must be considered as intermediate between the two sections.

(3) Sect. *Loriformes* and sect. *Annulares* : The sect. Annulares is widely separated from other sections in having the character of coiled rachises. But, sect. *Annulares* and sect. *Loriformes* have very little in common despite their flattened raceme-rachises. Rarely, abaxially convex raceme-rachis is found common in some species like *D. woodrowii* of sect. *Annulares* and *D. copei,* and *D. fischeri* of sect. *Loriformes*.

(4) Sect. *Annulares*: The inflorescence of the members of sect. *Annulares* shed off as a whole at maturity so as to perform the effective dispersal of seeds. The coiled raceme-rachis must be presumably regarded as an advanced character among members of the sections of *Dimeria*.

Therefore, *Dimeria* sect. *Annulares* should be regarded as phylogeneticaly advanced than other sections of the genus and other members of the subtribe.

The overall relationships among the sections and species, according to the morphological affinities is displayed in the figure 14.

TAXONOMIC & PHYTOGEOGRAPHIC ANALYSES

Diversity of the subtribe Dimeriinae in Peninsular India

Bor (1953) recognized only one genus, viz. *Dimeria* R. Br. with 25 species under the subtribe Dimeriinae *s.str.* from India, Sri

Lanka and Myanmar, of which 20 are represented in Peninsular India. Out of the 8 species described as new by Bor, 5 are from Peninsular India. In the present study, an additional genus, viz. *Ravia* has been recognized as new and a total of 35 species and 7 varieties have been recognised from Peninsular India alone.

Dimeria is the third largest grass genus in India and its high proportion of endemic taxa and species diversity in Peninsular India is unparallel to that of any other grass genera. Peninsular Indian region represents all the known Indian Dimerias.

Compared to other *Dimeria*-occurring regions like Sri Lanka, South China, North-east Russia, Taiwan, Japan, Vietnam, South Korea, Myanmar, Madagascar, Australia, Malesian region and Pacific Islands, Peninsular India holds high species diversity and have shown high degree of endemism.

The analysis on diversity and distribution provided some important findings on endemism and rarity of the taxa under subtribe Dimeriinae in Peninsular India (Table 13).

The recognition of the new genus *Ravia* Kiran Raj et Sivad. (*ined.*) with its characters having alliance with that of the *Pogonachne* Bor, an endemic genus of Western Ghtas, India, more or less clears the incongruity and anomalousness felt so far in the placement of genera of Dimeriinae under Andropogoneae. The occurrence and diversity of *Pogonachne* and Dimeriinae in the same geographical region, made to presume that *Dimeria* is closely related to *Ravia* and distantly related to *Pogonachne,* despite the differences in other floral characters.

Table 13. Diversity of the subtribe Dimeriinae in Peninsular India, percentage of endemism, and taxa known only from one locality.

	Number of taxa	% of taxa in P. India	% of P. Indian taxa among the World taxa
Peninsular Indian Total	42*	-	63
Peninsular Indian Endemics	30	70	45
Common endemics in P. India & Sri Lanka	9	22	15
Taxa known from one locality	14	34	22

P. India = Peninsular India; * including 7 varieties

Distribution and phytogeographical significance

A phytogeographic study of Dimeriinae in Peninsular India indicates that the region harbours maximum species of the subtribe and high percentage of endemism. Out of the 65 recognized taxa in the World, 42 (including 7 varieties) are reported from Peninsular India. The subtribe shows a high percentage of endemism within Peninsular India with 24 species and 6 varieties (under two genera), which are exclusively endemic to this region. There are 10 species considered near-endemic to Peninsular India, of which 9 species are distributed from Peninsular India to Sri Lanka, and one species (*D. kurzii*) is with extended distribution in Myanmar. The highest concentration of species is found in Southern Western Ghats. In fact 28 of the 42 Peninsular Indian taxa (including 7 varieties) can be found in this small region from the South of Goa, Karnataka, Kerala to Tamil Nadu states. A total of 17 taxa are exclusively endemic to this region. Eight species are found in Northern Western Ghats region along Maharashtra and Goa States, in which 3 species are found endemic to this region. Three species are restricted to Eastern Ghats region and 6 taxa are found scattered over Western Ghats, Eastern Ghats and Deccan region. Thirteen species are having extra peninsular Indian distribution.

Among the four sections of *Dimeria*, the sect*. Annulares*, which is represented by two species (*Dimeria veldkampii* Kiran Raj & Sivad. and *D. woodrowii* Stapf), is exclusively endemic to Peninsular India especially to Northern Western Ghats. *Dimeria* sect. *Capillares*, distributed from the Peninsular India to Sri Lanka, is considered as near-endemic to this region. The high degree of endemism in the Peninsular Indian region (especially in Western Ghats), both within Dimeriinae and among its allies, suggests that the subtribe originated in this area.

Ecology and habitat specificity

During the ecological study of Dimeriinae, it has been found that most of the Dimerias (80 %) are annuals, majority of which are laterite-loving, where as perennials prefer rocky crevices along mixed forest margins, rarely in high altitude meadows, or wet sandy plains along water courses. Monsoon plays a major role in the establishment and diversity of Dimeriinae in general. The humid tropical wet climate favours the successful growth, maximum diversity and endemism in Peninsular India.

Dispersal mechanisms

An interesting dispersal mechanism - anemogeochory - of some members of the subtribe, is found to be very unique among the members of the grass family and can be considered as an advanced feature of morphological adaptation for effective dispersal and establishment. Interestingly, in Dimerias the fruit dispersal takes place by three types of mechanisms, viz. anemochory (by wind) epizoochory (by animals), and anemogeochory (coiled racemes roll over the ground blown by wind and get dispersed). Aneomogeochory by means of two sub-types, bradychory (delayed dispersal) and tachychory (early dispersal). Due to the occurrence of these dispersal mechanisms, the present study believes that Dimerias belongs to an advanced group in the tribe Andropogoneae.

A world revision of the genus is needed to have a thorough knowledge on the exact diversity, phylogeny and interrelationships of the genus, and the work is in progress as a continuation of the present study.

Peninsular India, the center of diversity of

Andropogonoids ? – A hypothesis

The andropogonoids are considered as the advanced group among the grasses as they successfully occupy the warm tropical and subtropical regions especially in the Old World regions. The presence of C_4 photosynthetic pathway with NADP-ME (MS Type) metabolism (Chapman & Peat, 1992), vide array of reproductive systems especially andromonoecious habit (Connar, 1981), and breeding habit etc. are the important ecological adaptations of this group. Based on the preliminary critical study of the group, it is found that Peninsular India, especially Western Ghats region may be consider as the center of origin and diversity of Andropogonoids.

Phytogeographic as well as taxonomic considerations are the major criteria behind this assumption, which in turn lead to the following observations.

(1) *High Generic diversity*: Peninsular India is having the highest number of genera compared to other major Andropogonoid centers of the World (Tropical America, Tropical Africa, Sri Lanka, SE. Asia, and Australia) and is represented by 56 % of the World genera.

(2) *High degree of generic endemism*: Peninsular India having the highest number of endemic genera (8). Among these eight genera, only three genera - *Bhidea* (2 spp.) *Lophopogon* (2 spp.) and *Glyphochloa* (11 spp.) are widely distributed. The

remaining 5 genera viz., *Pogonachne, Trilobachne, Pseudodichanthium, Triplopogon* and *Manisuris* have only very narrow distribution, and are confined to the Western Ghats region and are monotypic ones.

(3) *Relatively high species diversity and endemism:* 25 % of the World species are found in Peninsular India. Only few genera have been well studied so far so that the species diversity the remaining genera are yet to be ascertained. Among the total estimated species, 45% are strictly endemic to Peninsular India (Hartley, 1958; Mehrothra & Jain, 1980). Genera like *Arthraxon* (60 %), *Chrysopogon* (52%), *Dichanthium* (55%), *Dimeria* (54%), *Heteropogon* (100%), & *Ischaemum* (60%) have maximum species diversity and endemism (Jain, 1986; Kiran Raj *et al.*, 2003). The details on andropogonoid genera having high species diversity and endemism in Peninsular India are shown in table 14.

(4) *The occurrence and diversity of the* Tribe Arundinelleae: Recent phylogenetic study on andropogonoids supports the monophyly of the subtribe and the relationship with Andropogoneae and *Arundinella* (Mathews *et al.*, 2002). Arundinelleae is one of the smallest tribes of the subfamily Panicoideae and is well represented in Peninsular India with 3 genera, *viz*. *Arundinella, Jansenella* and *Chandrasekharania*. *Arundinella* is represented by 25 species in India (51% of the world spp.) with more than 15 endemics. Out of the total species in India,

17 species are found in Peninsular India with 13 endemics. *Jansenella* and *Chandrasekharania* are monotypic genera; former is exclusively found in Indian subcontinent and the latter endemic to Southern Western Ghats. The occurrence and diversity of these closest relatives of andropogonoids have also supported the above hypothesis.

(5) *Occurrence and diversity of primitive as well as advanced subtribes*: Clayton and Renvoize (1986) found that subtribe Saccharinae is primitive under the tribe. This group is well represented in Peninsular India with 13 genera (out of 15) including one endemic genus, *viz. Lophopogon*. The subtribe Dimeriinae is represented in Peninsular India with 2 genera (one endemic) and 70% of the world species. The subtribe is considered as the advanced group in the tribe and is hypothysed that Peninsular India is the primary center of origin of *Dimeria* (present study).

(6) *Phytogeographic considerations*: Many workers observed the phytogeographical similarity between India and Africa (Fischer, 1934; Mehrotra & Jain, 1980; Nayar & Ahemedulla, 1984; Singh *et al*., 2002). It is observed that the tribe became most dominant in the grass flora of Peninsular India, Tropical Africa, Sri Lanka and Australia compared to that in the other regions of the World. These regions were the part of historic Gondwanaland before the Cretaceous breaking. The genera like *Vossia, Thelepogon, Cleistachne* (all monotypic), etc have shown common endemism

and *Arthraxon, Saccharum*, etc. have shown maximum species diversity in Tropical Africa and Peninsular India. On a preliminary study, it is reasonably observed that savannah of Africa shows a close affinity with that of Indian savannah as both are having the predominant members of the Tribe Andropogoneae.

A critical study based "on a phylogenetic framework, to see if the endemic genera and species of Peninsular India are basal or derived, where their sister taxa fall and so on ….." (Strömberg, pers. comm.) would bring out the actual conclusion on the center of diversity of andropogonoid grasses.

Table 14. Andropogonoid genera of Peninsular India (endemic and near-endemic) and their species diversity, endemism and distribution.

Genera	Distribution	No. of World species / No. of species in P. India (*) / Remarks
1	2	3
Apluda	Tropical Asia	3spp./3 spp. (2) / P. India-center of diversity (?); a close relative of *Ischaemum* L.
Arthraxon	Old world Tropics	20 spp. /12 spp.(8)/ P. India-center of diversity (?)
Bhidea	Endemic to P. India	(2 spp.)
Bothriochloa	Old World Tropics	35 spp./ 14 spp.(9)
Capillipedium	Tropical Asia, Africa	14 spp./ 7 spp. (3)/ P. India-Primary or secondary centre of diversity (?)
Chrysopogon	Old World Tropics	29 spp./ 15 spp.(10)/P. India-

		Primary or secondary centre of diversity (?)
Cleistachnae	T. Africa, India	1 sp.
1	2	3
Cymbopogon	Old World Tropics	± 40 spp./ ± 20 (5)/ Major savanna element; P. India-Primary or secondary centre of diversity (?)
Dichanthium	Old World Tropics	± 20 spp/ ± 10 spp.(7)/ P. India-Centre of diversity (?)
Dimeria	Tropical Asia, Australia	± 65 / ca. 40 spp. (26) /P. India - center of diversity **
Glyphochloa	Endemic to P. India	(11 spp.)
Heteropogon	Old World Tropics	6 spp./ 6 spp. (3)/P. India-Centre of diversity (?)
Ischaemum	Tropical Asia	ca.85/ 60 spp.(35)/ P. India-center of diversity (?)
Lophopogon	Endemic to India	3 spp. / extending to Andaman & Nicobar Islands
Manisuis	Endemic to P. India	(2 spp.)
Ophiorus	P. India, T. Africa, Australia	4 spp. /3 spp. (1)/ P. India-Primary or secondary centre of origin (?)
Pogonachne	Endemic to P. India	(1 sp.)
Pseudodichanthium	Endemic to P. India	(1 sp.)
Ravia	Endemic to P. India	(1 sp.)**
Sehima	Old World Tropics	5 spp./ 3 spp.
Thelepogon	P. India, T. Africa	(1 sp.)
Themeda	Tropical Asia, Africa	18 spp./15 spp. (5)/ P. India-Primary or secondary Centre of origin (?); Dominant savanna element.
Trilobachnae	Endemic to P. India	(1 sp.)
Triplopogon	Endemic to P. India	(1 sp.)
Vossia	P. India, T. Africa	1 sp.

Genera shown in bold letters requires thorough systematic studies in Peninsular India; * = Number of endemic species in Peninsular India. ** = Data based on the present study. P. India = Peninsular India. T. Africa = Tropical Africa.

S Y N O P S I S

OF THE THESIS ENTITLED

TAXONOMIC REVISION OF THE SUBTRIBE *DIMERIINAE* HACK. OF ANDROPOGONEAE (PANICOIDEAE – POACEAE) IN PENINSULAR INDIA

Submitted to the
UNIVERSITY OF CALICUT
in part-fulfilment of the requirements for the award of the Degree of

DOCTOR OF PHILOSOPHY
IN
BOTANY

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CERTIFICATE

This is to certify that the thesis entitled **Taxonomic revision of the subtribe Dimeriinae** Hack. **of Andropogoneae (Panicoideae - Poaceae) in Peninsular India** submitted to the University of Calicut by Mr. M. S. Kiranraj, in part-fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Botany is a *bona fide* record of the research work carried out by him under my supervision and guidance. No part of the present work has formed the basis for the award of any other degree or diploma previously.

Prof. (Dr.) M. Sivadasan
(Supervising teacher)

C. U. Campus
15. 07. 2008

DECLARATION

The thesis entitled **Taxonomic revision of the subtribe Dimeriinae** Hack. **of Andropogoneae (Panicoideae - Poaceae) in Peninsular India** submitted by me in part-fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Botany has not been submitted earlier either in part or in full for any degree or diploma of any University and it represents the original work done by me.

Kiranraj, M. S.

C. U. Campus
15. 07. 2008

dedicated to

My Parents & Ravi Sir

CONTENTS

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M. S. Kiranraj

	Inflorescence with sessile spikelets	Inflorescence with pedicelled spikelets
Spik[illegible]d	*Cleistachne* SORGHINAE 1 sp.; P. India, T. Africa ?? *Arthraxon* ANDROPOGONINAE ± 10 spp.; T. Asia (mainly P. India) T. Africa, Madagascar ??	*Pogonachne* ISCHAEMINAE 1 sp.; P. India **DIMERIINAE** *Ravia* (1 sp.; P. India) *Dimeria* [ca. 65 spp.; T. Asia (mainly P. India), Madagascar, Australasia]
Spikelet awnless	ROTTBOELLIINAE *Mnesithea* (1 sp.; T. Asia) *Ophiuros* (4 spp.; P. India, T. Africa, S. China, Australia) *Oxyrhachis* (1sp.; Africa, Madagascar) *Thaumastochloa* (7 spp.; Australia, New Guinea)	

Fig. 10. Diagram showing the distribution (based on spikelet morphology) of andropogonoid genera having unpaired spikelets. Affinities between members of subtribe Dimeriinae and allied genera are also shown, based on phytogeographical and morphological considerations. (*Arrow marks* : Probable evolutionary trends between taxa; *Shaded region* : Raceme-rachis tough; P. India = Peninsular India; T. Asia = Tropical Asia; T. Africa = Tropical Africa; S. China = Southern China; ?? = doubtful affinity)

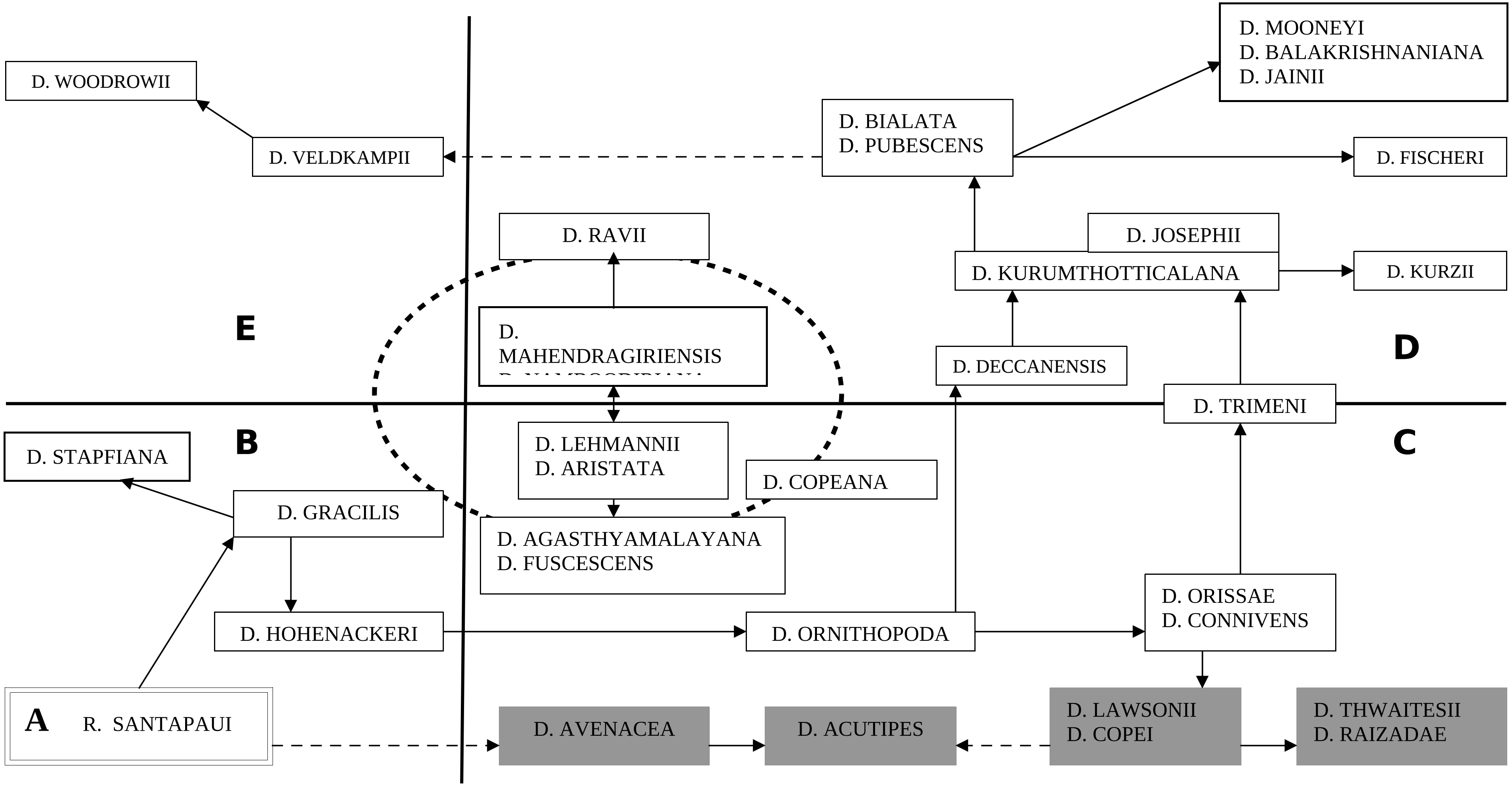


Fig. 14. Morphological affinities and probable origin and interrelationships in Dimeriinae: A. *Ravia*; B. *Dimeria* sect*. Capillares*; C. *Dimeria* sect. *Dimeria*; D. *Dimeria* sect. *Loriformes*; E. *Dimeria* sect. *Annulares*. (Each box represents the individual species or species complexes. Arrow represents affinity and probable relation between the taxa. Distance between boxes represents the percentage of affinity. Broken arrow = doubtful affinity. Broken circle = True perennials, with stolon. Box in gray colour = Taxa with upper glume-awn. Broken lined box = Perennial, without stolon. Dark-outlined box = Taxa with corky glume-wing)

FChapter 6. TAXONOMIC TREATMENT

THE SPECIES CONCEPT AND DELIMITATION OF SPECIES

In Dimeriinae, the formation of a concept of species is difficult, as variation is apparently continuous among much of the species. Therefore, critical examination of each taxon was made to develop a clear species concept. As this study is mainly based on herbarium materials, the taxonomic concepts applied are founded on morphology. They are essentially similar to those used in taxonomic revisions by Clayton (1969) and Veldkamp (1973). The species recognized in the present work are represented by morphologically identifiable populations, which indicate the constancy of morphological character states both within and between the populations. If two species were found to differ in only a single character other than the stable diagnostic character states, the two have been considered as conspecific. A single difference is more likely to denote variability within one species than representing two distinct taxa. A variety of diagnostic characters as given in table 15 has been used in the delimitation and description of the species.

Subordinate categories

The recognition of infraspecific categories which are differentiated by minor, and often distinct, and stable morphological characters are partially associated with geographical or ecological phenomena. They have been recognized after studying the degree of differences and the distribution and stability of characters.

Table 15. Diagnostic characters and their states used in the delimitation of species of the subtribe Dimeriinae.

Sl. No.	Character	Character states
1.	Habit	Annual; Perennial
2.	Habit establishment	Gregaroius; Matforming; Occassional
3.	Culm	Stoloniferous; non stoloniferous
4.	Culm type	Slender; Robust
5.	Culm establishment	Single or few from the base; Tufted
6.	Leaf arrangement	Scattered all along the culm; Crowded at culm-base
7.	Number of raceme	1; 2; 3–11
8.	Raceme	Solitary; Paired; Digitate
9.	Raceme direction	Erect; Coiled
10.	Raceme-rachis	Terete ; Trigonous; Flat
11.	Raceme-rachis texture	Flaccid; Rigid
12.	Pedicel	Truncate; Cuneate; Clavate
13.	Pedicel morphology	Terete; Flat
14.	Spikelet	Compact; Lax
15.	Spikelet arrangement	Imbricate; non imbricate
16.	Spikelet texture	Chartaceous; Coriaceous; Crustaceous
17.	Callus	Cuneate; Square or Truncate; Oblique
18.	Callus base	Transverse; Pungent
19.	Glume dorsal surface	Keeled; not keeled
20.	Glume-margin apex	Auricled; not auricled
21.	Lower glume	Winged throughout along the keel; Winged at apex; Wingless
22.	Upper glume	Winged throughout along the keel; Winged at apex or middle third; Wingless
23.	Upper glume wing	Corky; Thin or Papery

24.	Upper glume apex	Aristate or awned; Awnless
25.	Upper lemma	With perfect awn; With imperfect Awn
26.	Column	Present; Absent

SUB TRIBE D I M E R I I N A E Hack.

Dimeriinae Hack. in Engl. & Prantl, Nat. Pflanzenfam. 2, 2: 22. 1887 (‘Dimerieae’), in A. DC., Monogr. Phan. 6: 76. 1889 (‘Dimerieae’); C. E. Hubb. in Hutchinson, Fam. Fl. Pl. 227.1934; Keng, Sinensia 10: 277.1939 (‘Dimerieae’); Pilger in Engl. & Prantl, Nat. Pflanzenfam. 2, 14e: 109. 1940; Clayton, Kew Bull. 27(3): 462. 1972; Clayton & Renvoize, Genera Graminum 348. 1986; Chen *et al.,* Fl. Repub. Popul. Sinicae 10(2): 169. 1997.

Type: Dimeria R. Br.

Annuals or perennials. Culms slender or tufted, nodes glabrous or bearded; leaves scattterd or confined at culm-base; leaf-sheath keeled or not; ligule usullay a ciliate membrane; blades linear-acuminate, rather thick, with prominent midrib, tapering to a stout tip. Inflorescence terminal; racemes single or digitate; raceme-rachis tough, with persistent pedicel. Spikelets solitary, packing compactly or distantly in 2 rows, usually laterally compressed; callus usually cuneate or square, glabrous or pilose; glumes subcoriaceous to crustaceous, often fuscous, keeled or not, keel often winged, surface smooth or hairy, rarely echinate towards apex, margin hyaline; apical margin auricled or not. Lower floret reduced to a barren lemma, epaleate. Upper floret complete, bisexual; upper lemma bilobed, sub-hyaline, with slender or stout awn from bifid apical sinus; awn-column twisted, glabrous or pubescent, rarely absent; palea usually present; lodicules 2, incospicous; stamens 2; style 2, plumose; fruit a caryopsis.

Distribution: Tropical Asia extending to Australia and Madagascar; mainly in Peninsular India.

2 genera (*Dimeria* R. Br. and *Ravia* Kiran Raj et Sivad., gen. nov. - *ined*.); ca. 65 species.

Notes: The recognition of the new genus *Ravia* Kiran Raj et Sivad., (*ined.*) - during the present work with its characters having alliance with that of the *Pogonachne* Bor, more or less clears the incongruity and anomalousness felt so far in the placement of Dimeriinae under Andropogoneae. *Ravia* is placed in the subtribe Dimeriinae, together with its close relative *Dimeria* R. Br. The establishment of a new genus and its inclusion under the subtribe Dimeriinae necessiated an amendment of diagnostic characters of the subtribe provided by Clayton and Renvoize (1986).

KEY TO THE GENERA OF DIMERIINAE Hack.

1a. Spikelets chartaceous or coriaceaes; callus cuneate or truncate with transverse base; glumes dorsally keeled, usually throughout or towards the apex, apical margins not auricled;

upperlemma-awn slender, 5–15 mm long, column 1–4 mm x 1 mm (rarely absent), glabrous. .... **Dimeria**

1b. Spikelet crustaceous; callus strongly oblique with pungent base; glumes not keeled, apical margins with hyaline auricle; upper lemma-awn stout, 20–30 mm long, column 10–12 mm x 2 mm, pubescent. .... **Ravia**

DIMERIA R. Br.

Dimeria R. Br., Prodr. Fl. Nov. Holl. 204. 1810; Trin., Fund. Agrosto. 166. 1820, Mem. Acad. Imp. Sci. St. Petersbourg, VI, Sci. Math. 2: 334. 1832; Steud., Syn. Plant. Glum. I: 412. 1854; Benth., Fl. Australiensis 7: 522. 1878; Hook. in Benth. & Hook.f., Gen. Pl. 3: 1128. 1883; Hack. in Engler & Prantl, Pflanzenfam. 2 (2): 22. 1887, Hack. in A. DC., Monogr. Phan. 6: 76. 1889; Hook.f., Fl. Brit. India 7: 103. 1896, Trimen, Handb. Fl. Ceylon 5: 194. 1900; A. Camus in Lecomte, Fl. Indo-China 7: 226. 1922; Ridley, Fl. Malaya Peninsula 5: 191. 1925; Bews, World grasses 243. 1929; Honda, Jour. Fasc. Sc. Univ. Tokyo Bot. 3(1): 322. 1930; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1711. 1934; Bor, Kew Bull. 7(4): 553. 1953; T. Cooke, Fl. Pres. Bombay 3: 462. 1958; J. N. Mitra, Fl. Pl. Eastern India 203. 1958; Bor, Grass. Burma, Ceylon, India and Pakistan 136. 1960; Roberty, Boissiera 9: 397. 1960; Backer, Fl. Java 3: 583. 1968;

Clayton, Kew Bull. 27(3): 462. 1972; L.Watson & Dallwitz, Australian Grass Genera 54. 1980; Clayton & Renvoize, Genera Graminum 348. 1986; Sreek. & V. J. Nair, Fl. Kerala Grass. 80. 1991; L.Watson & Dallwitz, Grass Gen. World 333. 1992; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 7:171. 1994; Moulik, Grass. Bamboos India 278. 1997; Chen & S. M. Phillips in Chen *et al.,* Fl. China 22: 207. 2006.

Type: D. acinaciformis R. Br.

Haplachne C. Presl, Reliq. Haenk. 1(4-5): 234, t. 38. 1830. – *Type: Haplachne pilosissima* C. Presl (= *Dimeria chloridiformis* (Gaudich.) K.Schum. & Lauterb.)

Didactylon Zoll. & Moritzi in Moritzi, Syst. Verz. Zoll. Pfl. 99.1854. *nom. rej*. – *Type: Didactylon simplex* Zoll. & Moritzi (= *Dimeria ornithopoda* Trin.)

Psilostachys Steud., Syn. Pl. Glumac. 1: 413. 1855. non Turcz., 1843. – *Type: Psilostachys hohenackeri* Steud. based on *Arthraxon hohenackeri* Hochst. *nom. illegit*. (= *Dimeria hohenackerii* Hochst. *ex* Miq.).

Pterygostachyum Nees *ex* Steud., Syn. Pl. Glumac. 1: 413. 1855. *nom. rej*. – *Type: Pterygostachyum lehmanii* Nees *ex* Steud. based on *Leptochloa pectinata* Kunth *nom. illegit.* [= *Dimeria lehmannii* (Nees *ex* Steud.) Hack.]

Woodrowia Stapf in Hook., Ic. Pl. 25: t. 2447. 1896, Fl. Brit. India 7: 241. 1896. – *Type: Woodrowia diandra* Stapf (= *D. stapfiana* C. E. Hubb. *ex* Pilger)

Herbaceous annuals or perennials. Culms usually caespitose, extremely slender to robust, erect to geniculate at base, sometimes rooting at lower nodes, usually gregarious to sub-gregarious in habit, rarely matforming; nodes glabrous or bearded. Leaves lineaer-acuminate hardly contracted at the base, almost always ascending, usually scattered all along the culm or rarely crowded at base, a midrib well marked on the lower surface usually carried down on the sheath as a keel, glabrous or more often densely covered with long colourless tubercle-based hairs, often pigmented when mature; sheaths strongly keeled from apex to base, uasully shorter than internodes, villous in the upper half with or without tubercle-based hairs, the lower half with similar hairs or entirely glabrous, shining, striate, hyaline on the margins; ligule very short (ca. 1 mm long), membranceous, usually fombraite at apex, glabrous; leaf blades linear-acuminate, rather thick, with a broad mid-rib, usually with scattered bulbous-based white hairs on the upper surface or toward the collar (junction of the leaf-sheath and lamina) region or glabrous, scabrid or glabrous adaxially, margins smooth or very minutely scabrid, tapering to acuminate or aristate tip.

Inflorescence terminal, peduncle usually exserted from spatheole, but rarely enclosed; racemes, 1–5 (2), rarely 7or 11, usually paired, straight or curved, pressed together or divergent, raceme-rachises tough, persistent, terete or angled or flat on abaxially and either convex or keeled adaxially, the rachis may be flexuous, zig-zag or straight, and rarely coiled (*Dimeria* sect. *Annulares*), winged or wingless; glabrous to scaberulous or densely ciliate on the margins, 'pedicellate' (leaving the pedicles on the rachis), Spikelets linear-oblong, reddish, greenish-olive or dark reddish-purple, often fuscous, firmly compressed, solitary; secund, biseriate, compactly or distantly arranged along the rachis, imbricate or not imbrcate; 2-flowered, callus usullay cuneate or acute, bearded or glabrous. Glumes two, more or less equal, chartaceous to coriaceous, hyaline on the margins, dorsally keeled, 1–3 nerved; lower glume usually linear-elliptic when spread, shorter than uppreglume; upper glume as long as the spikelet, usually oblong-ellptic when spread, keeled dorsally, keel winged or wingless, wing papery or corky or when confined to the very tip with marked nervation. Florets two in each spikelet. Lower floret reduced and empty; lemma a hyaline scale half to three-quarters the length of the spikelet, 1-nerved; palea absent. Upper floret complete and bisexual; lemma sub-hyaline, oblong or elliptic-acute, split at the apex into two obtuse or acute lobes, between which the median nerve produced into a perfect or imperfect awn;

awn geniculate, glabrous, much longer than body of the lemma, usually dark, chestnut-coloured, column twisted, glabrous, bristle (limb) slender, scabrid; palea present or absent; lodicules 2, ca. 0.2 mm long, usually truncate at apex and cuneate at base, apically toothed, very hyaline and incospicous; stamens 2; anthers linear, yellow or pale; ovary small, ca. 0.3 mm long; styles 2, ca. 0.5 mm long, jointed; stigmas 0.6–1 mm long, plumose, usually issuing laterally from the sides of the spikelet. Grain oblong-elliptic, slightly compresed, hilum basal, linear-punctiiform; embyo about one-third the length of the grain, without an epiblast, with a scutellate tail, and an elongated mesocotyl internode; embryonic leaf margins overlapping.

Etymology: The generic epithet derived form Greek; ‘dis’ means double and ‘meros’ means part, alluding to most species of the genus with two racemes.

Occurrence & Distribution: ca. 65 species; tropical and subtropical regions of Asia (India, Sri Lanka, Myanmar, Southern China, North Eastern Russia, Taiwan, Japan, Malaya, Malaysia, Philippines, Palau, Java, Polynesia, Mascarene Islands., New Caledonia Island., Papua New Guinea) extending to North-East Australia and Madagascar.

The Indian subcontinent (Indo-Burma and Sri Lanka) holds maximum species diversity; Peninsular India alone is represented by about 65% of the known taxa; out of which 70 % are exclusively endemic to this region.

Ecology & Habitat: Occassional, gregarious or subgregariuos; mainly on humid grassy places along low altitude regions, usually on lateritic or red soil, sometimes wet rocky slopes along forest margins, rarely in alluvial soil. Common in Peninsular India during the post-monsoon period (October–December) along lateritic plateaus, dominant element in post-monsoon vegetation in Western Ghats regions; 0 – 1600 m above sea level in peninsular India.

Phenology: In Peninsular India, sprouting of the annual species starts immediately after the retreat of monsoon (October). Flowering usually commences during October–November, and fruiting during December–March.

Chromosome numbers: 2n = 14, 32, 46, 50 (x = 7)

Notes: *Dimeria* as circumscribed here contains all four sections, viz. sect. *Annulares* (2 spp.), sect. *Capillares* (3 spp. and one variety), sect. *Dimeria* (12 spp. and 2 varieties), and sect. *Loriformes* (17 spp. and 4 varieties).

Key to the Sections of *Dimeria* R. Br. in Peninsular India

1b. Racemes 1–3, not divergent; raceme-rachis rolled to form ‘globule’ or ‘ringlet’; spikelets not exposed; inflorescence as a whole shedd off at maturity. …………………. **i. D.** sect. **Annulares**

1a. Racemes 1–11, divergent; raceme-rachis never rolled; spikelets well exposed; spikelets alone shedd off at maturity …………. …….2

2a. Raceme-rachis triangular or flat, rigid, winged or not; spikelets compactly arranged, easily disarticulating with the pedicels; pedicels 0.5–1mm long, truncate or cuneate, flattened, outer margin often ciliate. ……………………………………………………….3

2b. Raceme-rachis capillary or wiry, flaccid, wingless; spikelets distantly arranged, not readily disarticulating with the pedicels; pedicles 1–1.5 mm long, clavate, terete, glabrous. ………………………………………………………….**ii. D.** sect. **Capillares**

3a. Raceme-rachis triquetrous or angular, 0.5–0.75 mm wide, wingless or minutely winged along internode, scaberulous to sparsely ciliate along margins; spikelets usually, reddish-purple or fuscous, imbricate; glumes usually subcoriaceous. …………………………………………………………..**iii. D.** sect. **Dimeria**

3b. Raceme-rachis flat or compressed, 0.75–1.5 mm wide, distinctly winged, glabrous to ciliate along margins; spikelets usually greenish-olive or pale, not imbricate; glumes coriaceaeous. ....**iv. D.** sect. **Loriformes**

i. DIMERIA SECT. ANNULARES Bor

Key to the species of *Dimeria* sect. *Annulares*

1a. Peduncle bending downward at maturity; raceme-rachis tightly rolled; raceme-globule shed off with the peduncle and spatheole; glumes distinctly winged at apex; awn-column absent. ....**2. D. woodrowii**

1b. Peduncle straight; raceme-rachis loosely rolled; raceme-ringlet shed without the peduncle or spatheole; glumes wingless or minutely winged at apex awn-column present..**1. D. veldkampii**

1. Dimeria veldkampii Kiran Raj & Sivad.

- Fig. 15; Plate 6, D–F; Map 7.

D. veldkampii Kiran Raj & Sivad., Novon 18(2): 183. 2008.

Type: India, **Goa**, North Goa Dist.: Taleigoa $\pm$ 50 m, 27th October 2002, *Kiran Raj CU 81073* (Holo - CALI; Iso - MO, MH).

Annuals; culms few to many from the base, up to 18 cm tall, erect or decumbent at the base, smooth, glabrous; nodes sometimes hairy; internodes shorter than the sheaths. Leaves usually all along the culm; sheaths very loose, longer than the internodes, smooth and glabrous, striate, margins hyaline, the uppermost spathe-like, subtending the inflorescence; ligule membranous, ciliate, 1–1.5 mm; leaf blades linear-acuminate, 3–6 cm x 1-2.5 mm, rather thick, with a broad mid-rib, 0.4 mm, with scattered bulbous-based white hairs on the upper surface toward the base or glabrous, minutely scabrid adaxially, margins smooth or very minutely scabrid, tapering to aristate tip.

Inflorescence straight, peduncle enclosed in spatheole, racemes 2, ca. 4 cm long when rachis spread, racemes with flat, tough rachis, straight at first, circinately recurved at maturity and drying, each forming a ‘ringlet’ with the spikelets on the inner surface; rachis smooth and glabrous, angled adaxially and convex dorsally; pedicel stout, ca. 0.5 mm long, glabrous; lip flat. Spikelets distanly arranged, oblong-lanceolate, 4.5–5 mm long (incl. callus);

callus cuneate, ca. 0.5 mm long, densely hairy, hairs 0.1-0.2 mm, white; lower glume oblong-obtuse when spread, ca. 4 mm long, coriaceous, yellowish brown when dry, glabrous or with a few hairs on hyaline margins, scabrid along keel; upper glume oblong-obtuse when spread, coriaceous, 4.5–5 mm long, margins hyalinaceous, sparsely hairy and wingless or minutely winged along the keel toward apex. Lower floret empty; lemma oblanceolate, 2–2.5 mm long, hyaline. Upper floret complete, bisexual; lemma oblong-acute, 2.5 mm, cleft at apex, with a strong midrib produced into a definite awn; awn 8–12 mm long, column well differentiated, 3–4.5 mm long; palea absent; lodicules 2, small, ca. 0.3 mm, truncate, apically toothed; stamens 2, anther ca. 1 mm; styles 2, distinct; stigmas plumose. Grain ca. 1.5 mm long, slightly compressed; embryo half as long as the grain; hilum basal, small.

Etymology: Named in honour of Dr. J. F. Veldkamp (National Herbarium of the Netherlands, University of Leiden, The Netherlands), a World-renowned agrostologist.

Distribution: Endemic to North Western India (Goa); known only from the type locality.

Habitat & Ecology: Grassy plains of dry lateritic plateau; alt. $\pm$ 50 m above MSL; seasonal, post-monsoon specific.

Flowering & Fruiting: October – January.

Interrelationships: In raceme morphology, *Dimeria veldkampii* closely resembles *D. woodrowii*, an endemic species of peninsular India, but differs from it by its exerted, non-articulated peduncle, and the loosely incurved raceme-rachis. The comparative diagnostic characters of *D. veldkampii* and *D. woodrowii* are given in Table 15.

Table 15. Comparison of diagnostic features of *Dimeria woodrowii* Stapf and *D. veldkampii* Kiran Raj & Sivad.

	D. woodrowii	**D. veldkampii**
I	II	III
1.	Culm straight; bent at upper most node.	Culm sometimes geniculate at the base; not bent at upper node.
2.	Racemes 2 or 3; tightly rolled together forming a raceme globule.	Racemes 2, loosely rolled separately forming single or double ringlet.s
3.	Raceme-group articulated with the peduncle, enclosed in spatheole at maturity.	Raceme-group not articulated with the peduncle, not enclosed in spateole
4.	Spikelets sub-crustaceous, acute at apex, reddish brown when dry	Spikelets coriaceous, acuminate to aristate at apex, yellowish brown when dry.
5.	Glumes dorsally rounded at the base and keeled at apex, hairy along the sides below.	Glumes dorsally keeled throughout, hairy towards keeled apex.
6.	Upper glume with a broad wing at the apex.	Upper glume with or without a minute wing at apex.
I	II	III
7.	Awn of lemma without a basal column.	Awn of lemma with a well-differentiated basal column.
8.	Tardy disarticulation of	Early disarticulation of the

spikelets from the diaspore and dispersal, hence bradychorous.	spikelets from the diaspore and dispersal, hence tachychorous.

Notes: In *D. veldkampii*, the rachises at first circinately coil, and finally form a 'ringlet'. At maturity coiled racemes fall off and function as diaspores. The diaspores roll over the lateritic plateau by wind and get deposited at crevices having soil where the seeds germinate during favourable climatic conditions. This kind of dispersal mechanism -anemogeochory - is very unique and effective in the spread of the species on dry lateritic grassy-plains (Kiran Raj & Sivadasan, 2008). In *D. veldkamopii*, the spikelet disarticulation is immediately after the shedding of the diaspores from the plant and hence effect early dispersal which is termed as tachychory (Dixon, 1933).

Dimeria sect. *Annulares* was hitherto represented by single species, viz. *D. woodrowii* Stapf and was characterised by the rolling of rachises, a phenomenon not found in any of the andropogonoid grasses. By the inclusion of *D. veldkampii* under the section *Annulares,* the number of species of the section has been enhanced to two.

2. Dimeria woodrowii Stapf - Fig. 16; Plate 6, B–C; Map 7.

D. woodrowii Stapf, Hook. Icon. Pl. XXIV: 2312. 1894; Hook. f., Fl. Brit. India 104. 1897; Bor, Kew Bull. 7(4): 590. 1953; T. Cooke, Fl. Pres. Bombay 3: 463. 1958; Bor, Grass. India, Burma, Ceylon & Pakistan 144. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; B. G. P. Kulk., Fl. Sindhudurg 513. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; S. M. Almeida, Fl. Sawantwadi 2: 125. 1990; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 470. 1996; Moulik, Grass. Bamboo. India 285. 1997.

Type: India, "**Bombay State**", Ratnagiri Dist.: Karanji, October 1892, *Bhiva Babajee s.n.* (Holo - BLAT, Iso - K !)

Dimeria avenacea (Retz.) C. E. C. Fisch. subvar. *woodrowii* Roberty, Boissiera 9: 398. 1960, *nom. inval.*

Annuals. Culms few to many from the base, with stilt roots from the lowest node, up to 15 cm tall, erect or very shortly decumbent at the base, sometimes bent downwards at the immediate node below the peduncle when mature, simple or much branched, smooth and glabrous, hairy at the nodes, with the internodes shorter than the sheaths. Leaves all along the culm; sheaths very loose, longer than the internodes, smooth and glabrous, striate, hyaline on the margins, spathe-like at the uppermost node, subtending the inflorescence; ligule a ciliate membrane, 1–1.5 mm long;

blades linear-acuminate, 5–7 cm x 2–3 mm, rather thick, with a very broad mid-rib, with a few bulbous-based white hairs on the upper surface towards base, or glabrous, very minutely scabrid on the upper surface, smooth or very minutely scabrid on the margins, tapering to a rather stout point.

Inflorescence bent downwards, peduncle enclosed in spatheole, articulated with it at maturity, racemes 2–3, ca. 4 mm long when rachis stretch, each racemes with flat, tough rachis, straight when young, afterwards circinately involute when mature, together forming a 'globule' with the spikelets on the inner surface; rachis smooth and glabrous, angled adaxialy and convex dorsally; pedicels stout, 0.5 mm long, glabrous, lip flat. Spikelets oblong-lanceolate, distanly arranged, 4.5–5 mm long (incl. callus); callus truncate, ca. 0.2 mm long, sparsely hairy; lower glume ca. 4 mm long, subcrustaceous, chestnut brown when dry, oblong-obtuse when spread, glabrous, or with a few hairs on the sides, scrabid along keel; upper glume 4.5–5 mm long, subcrustaceous, oblong-obtuse when spread, glabrous, or with a few whitish hairs at hyaline margins, scarbid along keel, broadly winged 1/3 of the keel from the middle upwards. Lower floret empty; lemma oblanceolate, 2–2.5 mm long, hyaline. Upper floret complete, bisexual; lemma oblong-acute, 2.5 mm long, cleft at apex, with a strong mid-rib produced into a short awn, awn 3–5 mm long, column not differentiated or absent; palea absent; lodicules 2, small, truncate, apically toothed; stamens 2, anthers 1 mm long; styles 2, distinct; stigmas plumose. Grain 2.5 mm long, slightly compressed; embryo half as long as the grain; hilum basal and small.

Etymology: Named after Dr. G. M. Woodrow (1846–1911), a lecturer in the College of Agriculture, Pune, whose useful notes about this peculiar species on the type herbarium sheet (*Bhiva Babajee s.n.*), leads the identity of the taxon.

Distribution: Endemic to North Western India (Maharashtra, Goa); occurrence in Kanataka is doubtfull (Sharma *et al*., 1984).

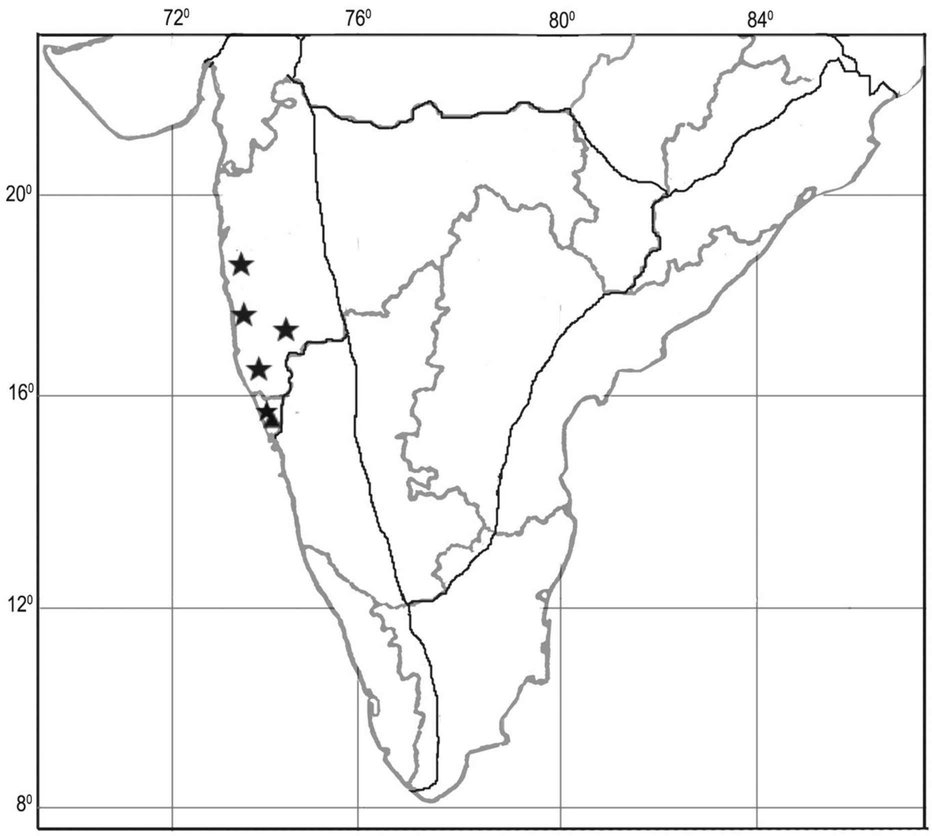
Habitat & Ecology: Dry lateritic plateau; growing in grassy plains; alt. $\pm$100m above MSL; seasonal, post-monsoon specific.

Flowering & Fruiting: October - January.

Interrelationships: D. woodrowii is similar to *D. veldkampii* and is perhaps related to that species; see the general key and under *D. veldkampii* for differences.

Notes: Bor (1953) pointed out that *D. woodrowii* is the strangest and most highly evolved of all the Dimerias. The peduncle, which supports the two racemes, is enclosed in spatheole is articulated to a short branch which itself arises in the axil of a sheath. This articulation point is hairy and appears to be glandular. When the two racemes emerge from the spathe-like sheath they are straight and are pressed together. On emergence of the racemes from the sheath it is not possible to differentiate an upper and lower surface. The alternately arranged pedicels which carry the spikelets are lateral to the axis. As anthesis approaches the two rachises diverge from one another and at the same time curve inwards, as do the pedicels which carry the spikelets. The peduncle meanwhile begins to move on its joint outwards and finally downwards so that by the time the inflorescence is mature it and hanging vertically. The spikelets do not fall readily from their pedicels. Eventually, the peduncle disarticulates at its base, and the inflorescence, consisting of the peduncle and tightly coiled racemes still carrying the spikelets (functioned as diaspore), fall to the ground. There is a delay before the spikelets disarticulate from the diaspore (bradychorus), and the diaspore is carried miles away by wind (Kiran Raj & Sivadasan, 2008). This dispersal-type is much effective than the diaspore dispersal in *Dimeria veldkampii* Kiran Raj & Sivad. (Also see under *D. veldkampii* and 'Fruit dispersal' under Chapter 4).

Specimens examined: **Goa,** South Goa Dist.: Loliem, 10th September 1997, *V. C. Joshi & S. Rajkumar 944* (GOA); *Ibid.,* Marmagoa, 14th October 1919, *W. A. Talbot 2557* (BSI); North Goa Dist.: Taleigoa, 23rd October 1997, *V. C. Joshi & S. Rajkumar 357* (GOA). **Maharashtra**, Ratnagiri Dist.: 15th October 1961, *C. Saldanha 7132A* (BLAT); *Ibid.,*19th December 1962, *V. D. Vartak,* *s.n.* (AHMA); *Ibid.,* Malwan, Adari-Nandruk, 29th October 1970, *B. G. Kulkarni 121287* (BSI); *Ibid.,* Near Deogad Rest house, 28th February 1970, *B.G. Kulkarni 120364* (BSI); *Ibid.,* Sangameshwar ± 100m, 21st January 2002, *Kiran Raj CU 81020* (CALI); Sindhudurg Dist.: Kaziwadot sada, Achra, 23rd February 1970, *B. G. Kulkarni 120259* (BSI); "Bombay", Vasco da gama, September 1909 *R. K. Bhide s.n.* (BLAT).



Map 7. Distribution of *Dimeria veldkampii* Kiran Raj & Sivad. (▲) and *D. woodrowii* Stapf (★)

ii. DIMERIA SECT. CAPILLARES Bor ex Kiran Raj et Sivad.

Key to the species of *Dimeria* sect. *Capillares*

1a. Spikelets 5–8 mm long; internodes of raceme rachis ca. 4 mm long; upper glume winged from base to apex, wing corky .... **5. D. stapfiana**

1b. Spikelets 3.5–6 mm long; internodes of raceme rachis 2.5–2.75 mm long; upper glume not winged. 2

2a. Racemes few (3–5); culms slender; rachis some what triangular in cross section; spikelets 3.5–5.5 mm long; pedicels ca. 0.5 mm long; callus less than 0.2 mm long, rounded....**4. D. hohenackeri**

2b. Racemes many (5–11); culms robust or slender; rachis terete in cross section; spikelets 5–6 mm long; pedicels ca. 3 mm long; callus ca. 0.5 mm long, cuneate. .... **3. D. gracilis**

3. Dimeria gracilis Nees *ex* Steud. - Fig. 17; Plate 29, D; Map 8.

D. gracilis Nees *ex* Steud., Syn. Pl. Glum. 1: 413. 1855; Hook. f., Fl. Brit. India 7: 105. 1897; C. E. C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; S. M. Almeida, Fl. Sawantwadi 2: 124. 1950; Santapau, Fl. Khandala 310. 1953; Bor, Kew Bull. 7(4): 588. 1952; Seneratna, Grass. Ceylon 164. 1956; T. Cooke, Fl. Press. Bombay 3: 462. 1958;

Bor, Grass. Burma, Ceylon, India and Pakistan 140. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 327. 1984; B. G. P. Kulk., Fl. Sindhudurg 520. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 109. 1989; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 179. 1994; Moulik, Grass. Bamboo. India 282. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 269. 2001.

Type: “**Ceylon**”, (no date), *Macrae 229* (CGE)

D. laxiuscula Thw. & Trimen, J. Bot. 23: 272. 1885. –*Type*: “Ceylon”, (no date), *Thwaites C.P. 3863* (K !)

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *gracilis* Roberty, Boissiera 9: 398. 1960, *nom. inval.*

Perennials. Culms up to 80 cm tall, somewhat stout, smooth and glabrous even on the nodes, striate, covered at the base with the bases of old sheaths which are hirsute with whitish hairs; hairy at nodes. Leaves ascending, scattered; sheath tight, close, overlapping, smooth and glabrous except those at the junction of sheath and lamina wth stiff whitish hairs; ligule very short, membranous, lacerate; blades linear, 15–25 cm x 7–8 mm, narrowed at the base to the sheath, absolutely smooth and glabrous or covered sparsely with whitish hairs, usually flat, sometimes plicate, tapering gradually to a very acuminate, stout point.

Racemes 5, 6 or 7 rarely up to11, ca. 12 cm long, peduncle long-exserted from spatheole, glabrous; raceme-rachis tough, glabrous, filiform, bearing pedicelled spikelets, one to a node, rachis internode ca. 4 mm long; pedicels clavate, 2.5 mm long, glabrous, sometimes ciliate along the outermargin with hairs up to 2 mm long. Spikelets 5.5–6 mm long (incl. callus); callus cuneate, 0.5 mm long, bearded, gaping at the mouth; lower glume linear-oblong, 5–5.5 mm x 1–2 mm (when spread), shortly aristate at apex, often bent backwards, chartaceous, margins hyalinaceous, covered all over the dorsal suface with white hairs or almost glabrous; upper glume oblong-acute, 5–6 mm long, coriaceous in texture becoming thin on the margins, with the aristste tip, keel somewhat scabrid towards the apex and covered all over with fairly long white hairs, or almost glabrous. Lower floret empty; lemma oblanceolate, 1.5–3 mm long, hyaline, short hyaline hairs along margins. Upper floret bisexual; lemma linear-oblong, 4 mm long, cleft at the tip into two acute or obtuse lobes, hyaline, with a few hairs at the top, awned in the cleft; awn 9–10 mm long, column brownish, 4 mm long, twisted; palea absent; lodicules 2, small, truncate; stamens 2, anthers 3 mm long; styles 2, stigmas plumose, purple. Grain oblong-elliptic, ca. 2 mm long.

Distribution: Sri Lanka and Western Ghat region of Peninsular India (Maharashtra, Goa, Karnataka)

Habitat & Ecology: Lateritic hillocks; alt. $\pm$ 100 m; seasonal, post-monsoon specific.

Flowering & Fruiting: October-December.

Interrelationships: This species is very close to *D. leptorhachis* Hack., a Sri Lankan species but differs from it in having 7 to 11 racemes and rachis-internode with 2.5 – 3 mm long. In *D.*

leptorhachis Hack., racemes 4 to 5 and rachis-internode width 4 – 5 mm long.

Notes: Two morphological variants are encountered (slender & tufted) even in the same population of different seasons as seen in *D. copei* Ravi.

Etymology: The specific epithet *‘gracilis’* is derived from Latin, which means ‘slender’, and referes to the nature of recemes of the species.

Specimens examined: **Karnataka**, “North Kanara”, 25th November 1895, *W.A.Talbot 3547* (CAL); Belapur, November 1890, *S.N.1527* (CAL); **Goa**, South Goa Dist.: Marmagoa, 15th October 1891, *W.A.Talbot 2642* (CAL); *Ibid.,* 22nd December 2002, *Kiran Raj CU 92985* (CALI); North Goa Dist.: Porvorim, 7th November 1963, *U. R.Deshpande 92843* (CAL); **Maharashtra**, Pune Dist.: R’war 3000ft. *V. D.Vartak 14030* (AHMA); *Ibid.,* Ambavne-Mukshi, 25th October 1964, *B.V.Reddi 99461* (CAL); *Ibid.,* Paud, 18th October 1956, *S.K.Jain 8234* (CAL); *Ibid.,* Lonavala, 11th November 1956, *J.K.J 8921, 99461* (CAL); Ratnagiri Dist.: Amboli Reservoir, 7th November 1975, *B.G.Kulkarni 106362* (CAL); *Ibid.,* Ramgharh from Chandgad, 28th October 1969, *B.G.Kulkarni 119153* (CAL); Sawantwadi Dist.: *s. loc.*, 6th October 1970, *B.G.Kulkarni 121723* (CAL).

4. Dimeria hohenackeri Hochst. *ex* Miq.

D. hohenackeri Hochst. *ex* Miq., Verth. Ned. Inst. 3, 4: 35. 1851; Hook. f., Fl. Brit. India 7: 103. 1897; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Bor, Kew Bull. 7(4): 570. 1953; Bor, Grass. Burma, Ceylon, India and Pakistan 142. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 327. 1984; B. G. P. Kulk., Fl. Sindhudurg 522. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; S. M. Almeida, Fl. Sawantwadi 2: 124. 1990; Sreek. & V. J. Nair, Fl. Kerala Grass. 90. 1991; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra – Monocot. 468. 1996; Moulik, Grass. Bamboo. India 282. 1997; K. G. Bhat, Fl. Uduppi 795. 2003; Sasidh., Bio. Doc. Kerala - Fl. Pl. 566. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006.

Type: "**Madras**", Manglore, September 1847, *Hohenacker 231* (K !)

Psilostachys hohenackeri (Hochst.) Steud., Syn. Pl. Glum. 413. 1855; *nom. illegit*. based on *Arthraxon hohenackerii* Hochst.

Dimeria avenacea (Retz.) C. E. C. Fisch. subvar. *hohenackerii* Roberty, Boissiera 9: 398, 1960, *nom. inval.*

Annuals. Culms slender; 30–60 cm long; erect or procumbet. Leaf-blades 3–6 cm x 2–4 mm, flaccid. Racemes 3–5, digitate, 4–12 cm long; rachis filiform or angular, glabrous on margins; pedicels cuneate, 0.2–0.9 mm long, flattened. Spikelet lineare-elliptic, 4–5 mm long, lax, falling entire; callus 0.25 mm long, base obtuse;

glumes coriaceous, dissimilar; lower glume 4–5 mm long, keel-less; surface scabrous, acute at apex; upper glume keeled from the middle upwrds, wingless, surface pubescent, acuminate at apex. Lower floret barren; lemma lanceolate, hyaline, ciliate on margin. Upper floret fertile; lemma elliptic, 2-fid, hyaline, 1-veined, awned; awn from a sinus, geniculate, 10 mm long overall, column 4 mm long, glabrous; palea minute. Lodicules present.

Two varieties are found in Peninsular India.

Key to the varieties of *Dimeria hohenackeri*

a. Culm up to 60 cm long, slender, erect; leaves scattered; racemes 3–5; spikelets 30 – 40 in each raceme ………………………………… ………………………………………**4a**. **D. hohenackeri** var. **hohenackeri**

a. Culm up to 25 cm long, tufted, procumbent; leaves crowded at the base of the culm; racemes 2–3; spikelets 15–20 in each raceme ……………………………………**4b**. **D. hohenackeri** var. **kodagensis**

4a. Dimeria hohenackeri Hochst. *ex* Miq. **var**. **hohenackeri**

- Fig.18; Plate 7, E–H; Map 8.

Type: "**Madras**", Manglore, September 1847, *Hohenacker 231* (K !)

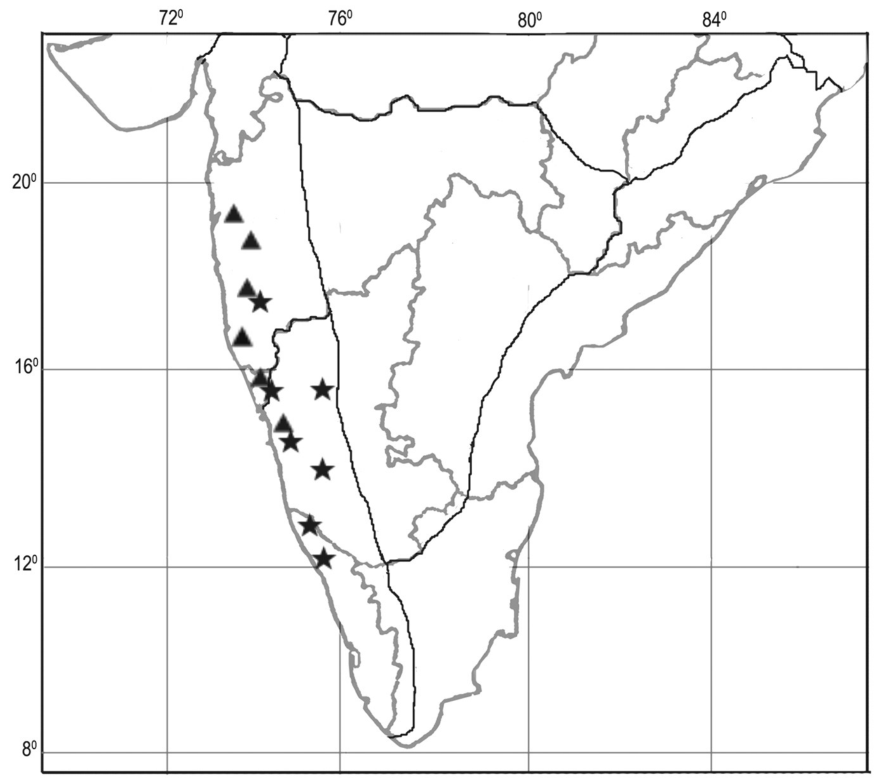
Annuals. Culms slender, erect, up to 60 cm long, sometimes forming a kind of rosette, shortly bearded at nodes; leaves short, usually scattered; sheath much longer than internodes, very loose, keeled in the upper half, rounded below, striate, smooth, shining and glabrous in the lower two thirds, pilose in the upper third with bulbous based hairs; ligule membranous, up to 1mm long, truncate and fimbriate at apex; leaf blade linear-acuminate, 3–7 cm x 2–4 mm, keeled on the midrib below with the keel continuous with that of the sheath, acuminate at apex, rounded at the base, coarsely scabrid on the nerves of both surfaces and margins, bulbous-based hairs on the upper surface and margins.

Inflorescence with peduncle hardely exserted from spatheole; racemes 3, 4 or 5, 5–10 cm long, subdigitate, rachis terete or angled, ca. 0.2 mm wide, glabrous, tough; pedicels clavate, 1–1.5 mm long, terete below, glabrous. Spikelets linear oblong, 4–5.5 mm; callus very short, 0.25 mm long, usually parallel to the rachis, densely bearded; lower glume oblong-acuminate, 4–5 mm long, coriaceous, rounded on back and keeled towards apex, not winged, sparsely hairly along the keel towards apex, hyaline on the margins; upper glume linear-acuminate, 5–5.5 mm long, coriaceous, straight on back, not winged, with few long hairs on each side of the scabrid wing at the apex. Lower floret empty; lower lemma very hyaline, oblanceolate, 1.5–2 mm long; 1-nerved, ciliate on the margins towards the apex. Upper floret complete, bisexual; upper lemma elliptic-acute, 3–3.5 mm long, sub-hyaline, bifid at the apex with acute lobes, awned from the sinus; awn up to 12 mm long with a dark twisted 4 mm long column; palea absent; lodicules 2, small, truncate, apically toothed; stamens 2; anthers 1.5–2 mm long; styles 2, short; stigmas plumose.

Distribution: Endemic to lowland regions of Western Ghats (Karnataka, Maharashtra, Goa, Kerala).

Habitat & Ecology: Laterite hillocks; alt. 50 – 200 m above MSL; seasonal, post-monsoon specific, dominant species in the monsoon vegetation of the lateritic area.

Flowering & Fruiting: October–December.



Map 8. Distribution of *Dimeria gracilis Nees ex Steud.* (▲) and *D. hohenackeri* Hochst. ex Miq. var. *hohenackeri* (★)

Notes: The species resembles *D. gracilis* Nees ex Steud., but differs mainly by it having following features (1) the pedicels are short (1-1.5 mm) and, (2) the spikelets appressed to the rachis. In *D. gracilis*, pedicels are ca. 2.75 mm long, and spikelets widely spread from raceme-rachis.

Etymology: The species epithet is named after H. F. Hohenacker (1798 – 1874), a German botanist and collector.

Specimens examined: **Goa**, Cotigoa, 11th November 1998, *Vaisali C. Joshi & S. Rajkumar 1687* (GOA). **Karnataka**, Mysore Dist.: 4th December 2002, Anmod Castle rock, (no date), *B. M. Wadhwa 119546* (BSI); Uttar Kannada Dist.: Kumberwada, January 1890, *s.coll., 9713* (BLAT); *Ibid.,* Mastani-Basantbail forest, 24th November 1950, *J.Fernandez 1844* (BLAT); *Ibid.,* Sirsi, 28th December 2003, *Kiran Raj CU 92881* (CALI); *Ibid.,* Top of Jog Falls, 27th December 2003, *Kiran Raj CU 92878* (CALI); Yellapur, November 1880, *Talbot 9712* (BLAT); "Uduppi", 26th November 1932 *C.E.C.Fischer 2420* (MH). **Maharashtra**, Ratnagiri Dist.: Tirali, 6 km from Bhedsh, 19th February 1966, *B. G. Kulkarni 106491* (BSI); *Ibid.,* Ratnagiri, Bhairypathar-phonda, 25thOctober 1969, *B.G.Kulkarni 119065* (BSI); Savantwadi, Chartha, 9th October 1968, *Pavaskar & M.R. Almeida 1056* (BLAT); **Kerala**, Malappuram Dist.: Chelari, 16th December 1997, *Ravi TBG&RI 36983* (TBGT); Kannur Dist.: Madaipara, 8th October 2002 *Kiran Raj CU 92852, 92863* (CALI); Kasaragode Dist.: Hosedurg $\pm$ 50m, *Kiran Raj CU 92965* (CALI); Kozhikode Dist.: Quilandy, 11th December 1996, *Ravi TBG&RI 31894* (TBGT).

4b. Dimeria hohenackeri Hochst. *ex* Miq. var. **kodagensis** Kiran Raj *et* Sivad., var. nov. (*in ed*.) - Fig.19; Plate 7, I; Map 9.

A var. typica culmi tagetes formantes basi ramosi, foliis congestis, racemi 1–3 distinguenda.

Type: India, **Karnataka**, Kodagu Dist.: on the way to Mercara, 3rd December 2002, *Kiran Raj CU 92982* (Holo - CALI); *Paratype:* **Karnataka**, Shimoga dist.: Jersopa ± 250, 28th December 2003, *Kiran Raj CU 92880* (CALI).

Annuals. Culms tufted, procumbent, up to 30 cm long, mat forming, nodes bearded at upper halves; leaves confined to the base of the culm; sheath much shorter than internodes, keeled in the upper half, rounded below, striate, smooth, shining and glabrous in the lower two thirds, pilose in the upper third with bulbous based hairs; ligule membranous, up to 1mm long, truncate and fimbriate at apex; laef blade linear-acuminate, up to 3–5cm x 2–4 mm, keeled on the midrib below with the keel continuous with that of the sheath, acuminate at apex, rounded at the base, coarsely scabrid on the nerves of both surfaces and margins, bulbous-based hairs on the upper surface and margins.

Racemes 2 or 3, subdigitate, 4–6 cm long, peduncle long exserted from spatheole; rachis terete or angled, ca. 0.2 mm wide, glabrous, tough, upon which pedicelled spikelet alternately arranged; pedicels 1 mm long, lip cupuliform, terete below, glabrous. Spikelets linear-oblong, 3–4 mm long; callus very short, 0.25 mm long, densely bearded, often spreading at right angles to the rachis; lower glume coriaceous, oblong-acuminate, 3–3.5 mm long, rounded on back and keeled towards apex, not winged, sparsely hairly along the keel towards apex, hyaline on the margins; upper glume coriaceous, linear-acuminate, 3.5–4 mm long, strongly compressed, straight on back, not winged, garnished with few long hairs along the keel at the apex. Lower floret empty; lower lemma very hyaline, oblanceolate, 1.5 mm long; 1-nerved, ciliate on the margins towards the apex. Upper floret complete, bisexual; upper lemma elliptic-acute, 2–2.5 mm long, bifid at the apex with acute lobes, sub-hyaline, awned from the sinus; awn up to 12 mm long with a dark twisted 3.5 mm long column; palea absent; lodicules 2, small, truncate, apically toothed; stamens 2; anthers 1.5–2 mm long; styles 2, short; stigmas plumose.

Distribution: Southern Western Ghats (Karnataka).

Habitat & Ecology: Grassy slopes along forest margins; mat-forming; alt. $\pm$ 300 m.

Flowering & Fruiting: October–December.

Notes: New variety differs from the typical variety in having matforming culms and branched at the extreme lower internodes, leaves crowded at culm-base; raceme 1–3 in number; spikelets 3–4 mm long; glumes widely gaping at anthesis.

Etymology: The infraspecific epithet indicates the name of the district –Kodagu, the type locality in Karnataka State.

5. Dimeria stapfiana C. E. Hubb. *ex* Pilger – Fig. 20; Map 9.

D. stapfiana C. E. Hubb. *ex* Pilger in Engl. *et* Prantl, Die Natur. Pflanzenfam. 14e: 109. 1894; Bor, Kew Bull. 7(4): 583. 1953; Santapau, Fl. Khandala 310. 1953; Bor, Grass. Burma, Ceylon, India and Pakistan 144. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; Rao, Fl. Goa, Diu, Daman, Dadra and Nager Haveli 498. 1986; B. G. P. Kulk., Fl. Sindhudurg 523. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; S. M. Almeida, Fl. Sawantwadi 2: 125. 1990; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 469. 1996; Moulik, Grass. Bamboo. India 284. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 269. 2001; K. G. Bhat, Fl. Uduppi 796. 2003.

Type: India, "**Bombay state**", Poona Dist.: Mawal, (no date), *Woodrow 24* (K !) (Plate 8).

Dimeria blatteri Bor, Kew Bull. 1949: 70. 1949 & Kew Bull. 7(4): 583. 1953; Santapau, Fl. Khandala 310. 1953; Bor, Grass. Burma, Ceylon, India and Pakistan 144. 1960; Raghavan *et al*; Add. Cooke 's Fl. Bombay Pres. 199.1981; B. G. P. Kulk., Fl. Sindhudurg 520.1988; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 470. 1996; Moulik, Grass. Bamboo. India. 281. 1997. – *Type :* "Bombay state", Khandala, Echopoint, October 1918, *Blatter & McCann s.n.* (BLAT !).

D. diandra (Stapf) Bhide, J. Proc. Asiat. Soc. Bengal, n. s. 7: 517. 1911; *nom. illegit.*, non Griffith, 1851. -- *Woodrowia diandra* Stapf, Hooker's Icones Plantarum 25: t. 2447. 1896. – *Type:* “Poonah District” *Woodrow s. n.* (K)

Annuals. Culms slender, erect, many to few at the base, up to 30–50 cm long, sometimes branching at nodes; nodes bearded. Leaves all along the culm; sheath much longer than internodes, very loose, keeled on the upper half, rounded below, striate, smooth, shining and glabrous in the lower two thirds, pilose in the upper third with bulbous-based hairs; ligule membranous, up to 1mm long, lacerate and fimbriate at apex; leaf blade linear-acute, up to 3–7 cm x 2 mm, keeled on the midrib below with the keel continuous with that of the sheath, acuminate at apex, rounded at base, coarsely scabrid along nerves of both surfaces and margins, bulbous-based hairs on the upper surface and margins.

Racemes 4, 5, 6 or 7, digitate, up to 10 cm long, peduncle well exserted; rachis terete or angled, ca. 0.2 mm across, glabrous, tough; pedicels 1–2 mm long, terete below, lip cupuliform, glabrous. Spikelets linear oblong, 5–7 mm; callus very well marked, ca. 1.5 mm long, often widely spreading to the rachis, densely bearded; lower glume coriaceous, oblong-obtuse, 4-6 mm long, rounded on back and keeled towards apex, thin to hyaline at the sides, smooth and glabrous on the sides, scabrid towards apex; ulpper glume coriaceous, linear-acute, 5–7 mm long, strongly compressed, straight on back, keeled, with a corky wing in the upper-third, with few long hairs on each side of the scabrid wing at the apex. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 1.5–2 mm long; ciliate on the margins towards the apex. Upper floret complete, bisexual; upper lemma elliptic-obtuse, 3–3.5 mm long, bifid at the apex with acute lobes, sub-hyaline, awned from the sinus; awn 15 mm long with a dark twisted 5 mm long column; palea absent; lodicules 2, small; stamens 2; anthers 2.5–3 mm long; styles 2; stigmas plumose.

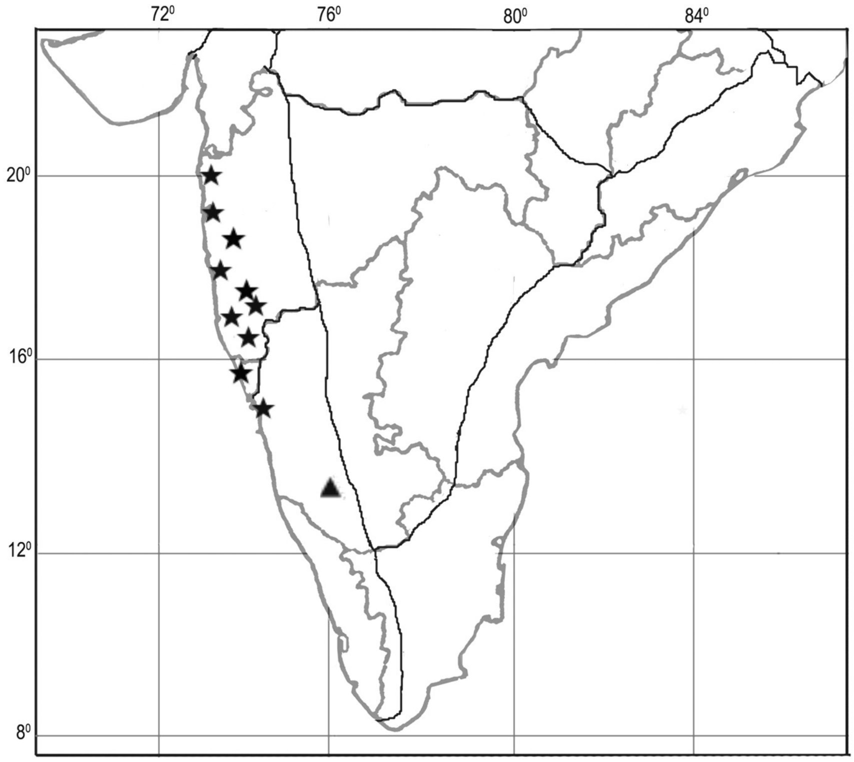
Distribution: Endemic to Western Ghats (Karnataka, Maharashtra, Goa).

Habitat & Ecology: Lateritic rocky hillocks; gregaroius; seasonal, monsoon specific; the dominant species in the humid region of Northern Western Ghats. The yellowish culms-base after the fruit dispersal forms a conspicuous feature of the ground layer during the dry season.

Flowering & Fruiting: September – January.

Interrelationships: D. stapfiana is somewhat similar to *D. gracilis* and to *D. hohenackerii.* The raceme rachises of these species are more or less identical. The species easily distinguished from above species by the presence of definit wing (corky) in the spikelet glumes.

Notes: D. stapfiana is a polymorphic species distributed mainly in the Western Ghat region of Maharashtra, Karnataka and Goa. The multitude of the culm habit in the species has been cause of difficulties in the correct determination of species in the herbaria. Studies of large number of specimens now available indicated that there is a large amount of variations overlapping ofvegetative as well as spikelet characters of the related specimens.



Map 9 . Distribution of *Dimeria hohenackeri* Hochst. ex Miq. var. *kodagensis* Kiran Raj et Sivad., var. nov. *(ined.)* (▲) and *D. stapfiana* C. E. Hubb. ex Pilger (★)

The materials can be subdivided into two groups on the basis of culm-habit and spikelet morphology, but these extremes are linked with nearly all-possible intermediates and no satisfactory subdivision is possible. The two ‘morpho-variant’ groups are as follows:

1. Specimens with giant culms and larger spikelets: The wing of the upper glume extremely attenuate and forms a broad wing (as described in Bor’s ‘*blatterii’*). This character is variable and not static.

2. Specimens with slender culms and smaller spikelets: Based on nutrient availabity, some other species of Dimeriinae exhibit these characters within population, which is also variable.

As the discontinuities in morphological features found in the materials are considered insufficient for specific and infraspecific recognitions, *D. stapfiana* is here treated as a single polymorphic species. The species like *D. raizadae* V.J. Nair *et al., D. deccanensis* Bor, and *D. kurumthotticalana* K.C.Jacob. (all under sect. *Loriformes*) also exhibit similar degree of polymorphism.

Nomenclature problem of the taxon has been discussed in Chapter 2.

Etymology: Named after O. Stapf (1857–1933), an Australian botanist who was Curator of Royal Botanic Gardens, Kew.

Specimens examined: **Karnataka,** “Karwar”, December 1918, *L.J. Sedgwick & T.R.D.Bell 5075* (CAL); **Goa**, South Goa Dist.: Chimbel reservoir, 9th November 1963, *M.Y.Ansari 92928, 92929* (BLAT); *Ibid.,* Marmagoa, way to Madgoa 8th November 1962, *Rolla S. Rao 84469* (BLAT); Marmagoa, 28th September 2002, *Kiran Raj CU 81083, CU 81084* (CALI); **Maharashtra**, Kohlapur Dist.: Radhanagari, 1st October 1970, *B.M.Wadhwa 127935* (BSI); Sadyaghat top, Takevada range, 15th November 1968, *K.V.Billore 115479* (BSI); *Ibid.,* Taranga Hills, Waranghburhi, 11th October 1970, *B.M.Wadhwa 128383* (BSI); Vaghya, Bhimasankar, 10th October 1962, *K.P.Janardhanam 81830* (BSI); Ratnagiri Dist.: Ramghat, 28th October 1969, *B.G.Kulkarni 119152* (BSI); *Ibid.,* way to Savantwadi, 6th November 1969, *B.G.Kulkarni 119490* (BLAT); Pune Dist.: Lonavale, 14th October 1909, *R.K.Bhide s.n.* (BSI); *Ibid.,* October 1897, *G.M.Woodrow s.n.* (CAL); *Ibid.,* Lonavale, Sakarpathar plateau, 27th September 1964, *U.R.Deshpandae 98770* (BSI); *Ibid.,* Bushilake, Mawal Taluk, 28-9-1964, *B.V.Reddi 98791* (BSI); Junnar, Dhurgak hilly plateau, 1st October 1965, *K.Hemadri 107530* (CAL); Satara Dist.: Khandala, 0ctober 1918, *C. McCann 6024* (BLAT); Malad, Qary hills, 2nd October 1955, *G.L.Shah 6023* (BLAT); *Ibid.,* Khanvel, 5th October 1963, *M.Y.Ansari 94214* (BLAT); Sindhudurg Dist.: Savantwadi, 23rd December 1968, *M.R.Almeida 859* (BLAT); *Ibid.,* Amboli, 27th November 1961, *M.Y.Ansari 78543* (BLAT); *Ibid.,* Amboli, on the way to Savantwadi, 22nd December 2002 *Kiran Raj CU 92984* (CALI); *Ibid.,* Phonda, 25th October 1969, *B.G.Kulkarni 118978* (BLAT); Thane Dist.: Sawa forest, 23rd October

1967, *K.V. Billore 113177* (BLAT); *Ibid.,* Takmak hill, Dahisar range, 20th January 1969, *K.V. Billore 6738* (BLAT); "Bombay", Castle road, October 1909, *R.K.Bhide s.n.* (BLAT); **Dadra & Nager Haveli,** Dadra, 29th September 1963, *M.Y.Ansari 93805* (CAL); **"Deccan"**, May 1880, *G.M.Woodrow 172* (CAL).

iii. DIMERIA SECT. DIMERIA

Key to the species of *Dimeria* sect. *Dimeria*

1a. Perennials; raceme-rachis narrowly winged along the two abaxial angles 2

1b. Annuals; raceme-rachis usually wingless, if winged broadly or minutely at the internode only.. 7

2a. Upper lemma with a perfect awn, column present. 4

2b. Upper lemma with imperfect awn or awnless, coulmn absent.....3

3a. Culms usually stoloniferous; leaves scattered; racemes widely divergent; raceme-rachis ciliate on wings along the two abaxial angles ....**14. D. lehmannii**

3b. Culms not stoloniferous, but with thick rootstock; leaves crowded at base, racemes slightly divergent; raceme-rachis scabrid along three angles ……………………………… **7. D. agasthyamalayana**

4a. Upper glume winged all along the keel. ………………… ………….6

4b. Upper glume wingless, if winged confined at the apex only………5

5a. Racemes 2–4; raceme-rachis zig-zag, sharply angled, angles scabrid; spikelets 2.5–3.5 mm long ………………**11. D. copeana**

5b. Raceme 2; racme-rachis straight, slightly compressed, sides glabrous to ciliate; spikelets 4.5–5 mm long. …… **17. D. trimeni**

6a. Culms with thick rootstock, not stoloniferous; raceme-rachis scabrous along three angles; spikelets 3.5–4 mm long ……………………………………………………………**12. D. fuscescens**

6b. Culms stoloniferous; raceme-rachis ciliate along two abaxial angles only; spikelets 4–5.5 mm long ………………. **8. D. aristata**

7a. Pedicels oblique, lip transverse; callus ca. 1.5 mm, upper glume with long arista or awn (ca. 3 mm long) at apex………………. ….11

7b. Pedicels straight, lip concave or transverse; callus ca. 0.5 mm, upperglume acute to acuminate at apex without an arista. ……8

8a. Upper glume winged from base to apex ……….. **10. D. connivens**

8b. Upper glume wingless, if winged confined at apex only ……. …….9

9a. Spikelets 3.5–4.5 m long; upper glume winged at apex …. …….10

9b. Spikelets 1–3.5 mm long; upper glume wingless. ………………….

…………………………………………………………….**16. D. ornithopoda**

10a.Racemes 5–8 cm long, long exserted, widely divergent, apical end bent upwards at maturity; rachis-internode minutely winged; upper glume wingless or minutely winged at apex. …………………………………………………**13. D. kanjirapallilana**

10b.Raceme 3–5 cm long, hardly exserted, not divergent, apical end not bent upwards at maturity, rachis-internode distinctly winged; upper glume broadly winged at apex ....**15. D. orissae**

11a. Spikeletss 6–7 mm long; upper glume broadly winged from base to apex .... **9. D. avenacea**

11b. Spikelets 4–5 mm long; upper glume wingless ... **6. D. acutipes**

6. Dimeria acutipes Bor – Map10.

D. acutipes Bor, Kew Bull. 7(4): 560. 1952; Bor, Grass. Burma, Ceylon, India and Pakistan 138. 1960; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3:109. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Moulik, Grass. Bamboo. India. 281. 1997.

(excl., Manilal & Sivar., Fl. Calicut 339. 1982; H. O. Saxena & Brahmam, Fl. Orissa 4: 2333. 1996; Britto, J. Bombay Nat. Hist. Soc. 86: 274. 1989; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006).

Type: "**Madras**", September 1898, *Bourne 35* (K !) (Plate 9).

D. thwaitesii auct., non. Hack., 1889: C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934.

Annuals. Culms slender, erect, tufted; up to 15 cm long; nodes bearded. Leaves crowded at base; sheath much longer than internodes, very loose, slipping from the culms, keeled in the upper half, rounded below and almost smooth without hairs; ligule membranous, up to 1mm long, fimbriate at apex; leaf blade linear-lanceolate, up to 3–4 cm x 2 mm, keeled on the midrib, keel continuous with the sheath, revolute on the margins, acuminate at apex, coarsely scabrid on upper nerves, bulbous-based hairs on upper surface and margins towards the base.

Racemes solitary, ca. 3 cm long, peduncle long exserted; raceme-rachis triquetrous, slightly flattened on back, ca. 0.3 mm wide, triangular in section; pedicels 0.5 mm long, flattened, beadered on the outer edge, and oblique lip. Spikelets linear oblong, 4–5 mm long (excl. upper glume-awn and callus); callus very well marked, 1–1.5 mm long, densely bearded; lower glume coriaceous, linear-acute, 4 mm long, ending in a very short arista, rounded on back and keeled towards apex, glabrous; upper glume coriaceous, linear-acute, 5 mm long, strongly compressed, straight on back, keeled but not winged, pilose on the keel and sides, produced at the tip into a straight slender, scabrid awn, 3–4 mm long. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 1.5–2 mm long, sparsely ciliate on the margins towards the apex.

Upper floret complete, bisexual; upper lemma elliptic-obtuse, 3–3.5 mm long, bifid at the apex with acute lobes, sub-hyaline, awned from the sinus; awn 15 mm long with a column 4 mm long; palea absent; lodicules 2, small; stamens 2; anthers ca. 0.5 mm long; stigmas plumose.

Distribution: Southern Eastern Ghats: "Madras" (Tamil Nadu); known only from the type locality.

Habitat & Ecology: Paddy fields along sandy tracts (Bor, 1953).

Flowering & Fruiting: Not known.

Interrelationships: The species is similar to *D. thwaitesii* Hack., but distinct in having very much longer awn of the upper glume, the much longer callus and the oblique articulation between pedicel and callus. The taxon is also similiar to *D. avenacea* (Retz.) C.E.C.Fisch., but distinguished from it by much tufted habit and the absence of upper glume-wing on the keel (Bor, *l.c.*).

Notes: Bor (*l.c.*) described this species based on a single collection made by Bourne (K!). No specimens of the taxon are known to have been collected by others and available in any herbaria. During this study, I could neither collect nor see any living specimens of *D. acutipes.*

According to Clayton (1997), *D. acutipes* is conspecific with *D. avenacea* (Retz.) C.E.C.Fisch. The critical examination of the type specimens of two species revealed otherwise. *D. autipes* clearly differs from latter in having more tufted habit, wingless upper glume and smaller spikelets (4–5 mm long excluding 3–4 mm long awn), hence the Bor's view is maintained here.

Britto (1989) had reported the rediscoverey of '*D. acutipes*' based on the specimen (*RHT 30576*) collected from Narthamalai of Tamil Nadu dist. On critical examination, the specimen was found to be not *D. acutipes* Bor because of the presence of a distict upper glume wing, which is one of the main diagnostic features used in the species delimitation of *Dimeria.*

Again, subsequent workers (Mishra *et al*., 1983; Manilal 1982; Saxena & Brahmam, 1996) mistakenly pointed out the occurrence of *D. acutipes* in Kerala and Orissa. Mishra *et al.* (*l.c*.), and Saxena & Brahmam (*l.c.*) wrongly pointed out the occurrence of this species in Orissa Dist., based on a single specimen (*P. C. Nanda 2360*) which is housed at CAL. On critical examination of the specimen, which has a distict wing along the keel of the upper glume from base to apex it has been revealed that it is *D. avenacea* (Retz.) C. E. C. Fisch.

Manilal (l982) has pointed out the occurrence of *D. acutipes* in Kerala. I have not been able to examine the specimens but from the description it is apprarently a member of *Dimeria* sect. *Loriformes* and belongs to *D. thwaitesii* Hack.

Many workers (Karthikeyan *et al*., 1989; M. P. Nayar & Ramamoorthy, 1973; Nair *et al.,* 1989; Moulik, 1997; T. S. Nayar *et al.,* 2006) have mentioned this species in their enumerations. But, these observations are merely based on the distributional data obtained from the protologue or publications !

Etymology: The specific epithet '*acutipes'* derived form Latin refers to the 'acute base' of the spikelet.

7. Dimeria agasthyamalayana Kiran Raj & Ravi - Fig. 21; Map 10.

D. agasthyamalayana Kiran Raj & Ravi, Rheedea 11(2): 93. 2001; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 565. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.

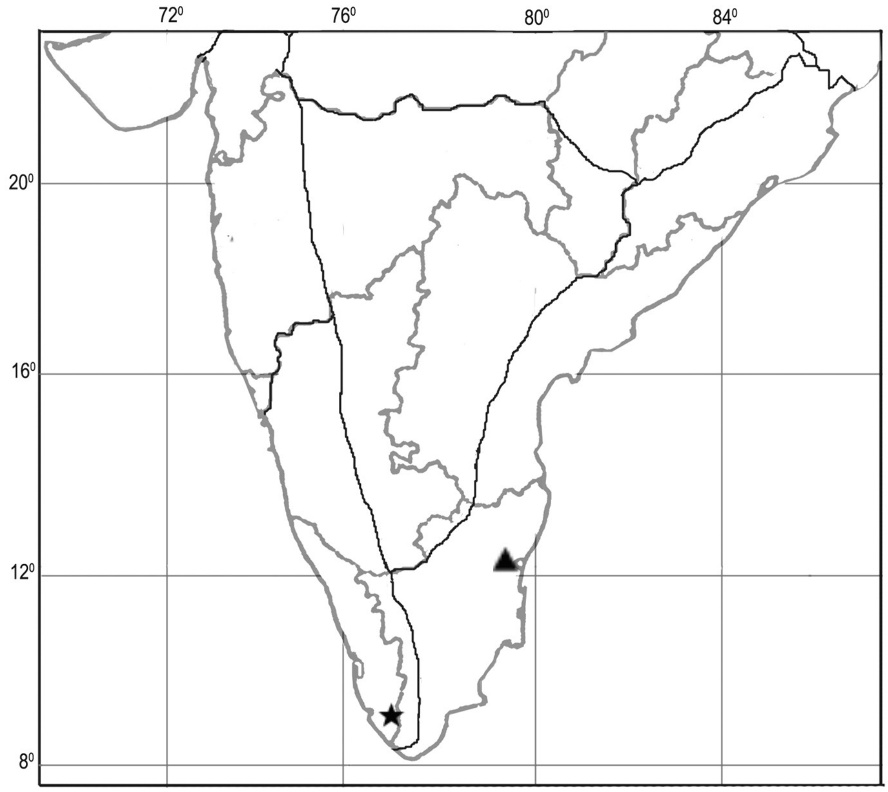
Type: India, **Kerala**, Thiruvananthapuram Dist: Agasthyamala Hills, Bonaccord, ± 800 m, 1st February 2000, *Kiran Raj TBG&RI 41939* (Holo - TBGT; Iso - CALI, K, MH) (Plate 10).

Annuals. Culms stout with thick rootstock, tufted, up to 40 cm long; nodes glabrous. Leaves mostly confined to the base; sheath up to 11 cm in the upper ones, keeled all along the back with the keel less prominent in the upper ones, and almost smooth without hairs; ligule membranous, up to 1.25 mm long, obtuse-truncate and fimbriate at apex; leaf blade linear-lanceolate, ca. 8 cm x 5 mm, keeled on the midrib below with the keel continuous with that of the sheath, acuminate at apex, glabrous or beset with a few bulbous-based hairs towards the base.

Racemes 2 or 3, up to 9 cm long; raceme-rachis triquetrous, ca. 0.75 mm wide, flattened on the back, convexly ridged on the face and longitudinally keeled along the middle and narrowly winged on the sides with the keel and the wings scabrid to scaberulous on the margins; pedicels 0.5–1 mm long, oblong, concave at the apex and glabrous. Spikelets oblong to oblanceolate, 4–5 mm long including a short 0.3–0.4 mm long, moderately bearded callus; lower glume coriaceous, linear-oblong, 3.5–4 mm long, acute at the apex, keeled on the back and keel narrowly winged towards the apex and scabrid on the margins, glabrous; upper glume coriaceous, oblong-elliptic, 4–4.5 mm long, keeled on the back and the keel broadly winged all along, acute at the apex, scabrid on margins, glabrous or sometimes with a few long hairs on the wing. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 2.5–3 mm long, sparsely ciliate on the margins except towards the apex and at 1/3 portion at the base. Upper floret complete, bisexual; upper lemma oblong-oblanceolate, 3–3.5 mm long, bifid at the apex with acute lobes, sub-hyaline, awned from the sinus; awn simple, 2.5–8 mm long, filiform and scaberulous, without a column; palea hyaline, lanceolate, extremely small and sparsely papillate hairy; palea absent; lodicules 2, small; stamens 2; anthers 1–1.5 mm long; styles 2, ca. 0.5 mm long; stigmas 2, 0.6–1 mm long, plumose. Grain linear-oblong, 2–2.5 x 0.25 mm, subcompressed, acute-apiculate at the apex, brown.

Distribution: Endemic to Agasthyamala hills of Southern Western Ghats in Kerala. Known only from the type locality.

Habitat & Ecology: Wet rocky hill slopes; growing in rock crevices; seasonal, post-monsoon specific; alt. ± 800 m.



Map 10. Distribution of *Dimeria acutipes* Bor (▲) and *D. agasthyamalayana* Kiran Raj & Ravi (★)

Flowering & Fruiting: January – March.

Variation & Interrelationships: The wing texture of the upper glume may vary from 'narrowly winged' to 'broadly winged' all along the keel. The species is close to *D. lehmannii* by having an imperfect awn in the upper lemma but differs from it having leaves confined to culm-base and raceme-rachis scabid angles along the three angles.

Only three species of *Dimeria viz.*, *D. agasthyamalayana* Kiran Raj & Ravi, *D. lehmannii* (Nees & Steud.) Hack. and *D. woodrowii* Stapf, in Peninsular India have imperfect awn of upper lemma without a column.

Etymology: The specific epithet is indicative of the name of the type locality - Agasthyamala hills, an endemic hotspots of Western Ghats.

Specimen examined: **Kerala**, Thiruvananthapuram Dist: Agasthyamala Hills, Bonaccord, ±800 m, 2nd January 2002, *Kiran Raj CU 92968* (CALI).

8. Dimeria aristata (Hack.) Senaratna - Fig. 22; Map11.

D. aristata (Hack.) Senaratna, Grasses of Ceylon 163. 1956; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 172. 1994.

Type: "**Ceylon**", *Thwaites CP 952* (K !) (Plate 11).

D. lehmannii (Steud.) Hack. var. *aristata* Hack. in A. DC., Monogr. Phan. 6: 83. 1889. based on *Pterygostachyum lehmanii* Nees *ex* Steud., Syn. Pl. Glumac. 1: 413. 1855 (1854) -- Type: “Ceylon”, *Thwaites CP 952* (K !)

D. lehmannii auct., non Hack., 1889: Hook.f. in Trimen, Handb. Fl. Ceylon 5: 196. 1900; Bor, Kew Bull. 7(4): 587. 1953; Bor, Grass. Burma, Ceylon, India and Pakistan 142. 1960; H. O. Saxena & Brahmam, Fl. Orissa 3: 2336. 1996.

Perennials. Culms up to 40–60 cm tall, terete, smooth and glabrous, erect from the base or ascending, rarely branching, glabrous to bearded at nodes. Leaves ascending; sheaths of the culm tight and wrapped around the culm, markedly keeled on the upper half or third, round on the back in the lower half, smooth and glabrous, striate; ligule membranaceus, lacerate, ciliate on the upper truncate margin, 1 mm long; leaf-blades acuminate, hardly rounded, or only slightly, at the base to the sheath, 6–15 cm x 2–4 mm, minutely scabrid on both surfaces and on the revolute margins particularly towards the tip, upper surface towards the collar region with sparse tubercle-based hairs, a well-marked prominent mid-rib on the lower surface.

Racemes 2 or 3, divergent, 4–8 cm long; raceme-rachis triquetrous, 0.6–0.7 mm wide, straight or zig-zag, ciliate on the margins, convex and keeled adaxially, very narrowly winged between the internodes; pedicel flat, half as broad as the rachis, lip concave, ciliate on the outer margin. Spikelets narrowly oblong, 3.5–4(4.5) mm long, firmly compressed, with a short callus 0.4 mm long, lying closely appressed to the rachis; lower glume 3–3.8 mm. long, linear-acute, straight on the back but curved just at the tip, strongly compressed, keeled at the tip, rounded on the lower dorsal surface, scabrid on the keel, hairy or ciliate on the dorsal surface; upper glume very firmly compressed, 3.5–4 mm long, winged with a broad papery crest towards the tip, sparsely ciliate on the wing and scabrid towards the tip, oblanceolate-acute when spread, more or less straight on the back, then curved towards the tip, margins hyaline. Lower floret empty; lemma a hyaline oblong scale, 2 mm long, ciliate on the margins towards the tip. Upper floret complete and bisexual; upper lemma elliptic-acute, cleft at the tip into two acute lobes, 3 mm long sub-hyaline, awned from the sinus; awn 8–12 mm long with a column 3–4 mm long; palea absent; lodicules 2, small, cuneate; stamens 2, anthers 1–1.5 mm long; styles 2; stigmas plumose. Grain compressed, nearly 3 mm long.

Distribution: Sri Lanka, Peninsular India (Kerala, Orissa)

Habitat & Ecology: Along the rocky forest margins; not common; alt. $\pm$ 700m.

Flowering & Fruiting: November – February.

Variation & Interrelationships: The spikelet size of the *D. aristata* varies from 3.5–4.5 mm. The species differs from *D. fuscescens* in the narrowly winged and ciliate rachis, smaller spikelets, but the distinction is not sharp. Clayton (1997) pointed out that it is also closely allied to *D. chloridiformis* (Gaudichaud) K. Schum. & Lauterb., a species from South East Asia and *D. dipteros* Reeder, a species from New Guinea (I have not seen any type specimens of both).

Etymology: The specific epithet '*aritstata*' derived from Latin; means 'awned', and refers to awn of the upper glume.

Specimens examined: **Kerala**, Idukki Dist.: Periyar Tiger Reserve, Thekkady, 19th November 2000, *Kiran Raj CU 92914* (CALI). **Orissa,** Sambalpur Dist.: Khariar, Sonabera, 2150 ft, 29th September 1949, *H.F. Mooney 3658* (DD).

9. Dimeria avenacea (Retz.) C.E.C. Fisch. - Fig. 23; Plate 12; Map11.

D. avenacea (Retz.) C. E. C. Fisch., Kew Bull. 1932: 72.1932; Bor, Kew Bull. 7(4): 561. 1952; Senaratna, Grasses of Ceylon 161. 1956; Bor, Grasses of Burma, Ceylon, India and Pakistan 139. 1960; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 109. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 172. 1994; Moulik, Grass. Bamboo. India 281.1997; T. T. Pullaiah, Fl. Andhra Pradesh 3: 1181. 1997.

(excl., M. Mohanan & A. N. Henry, Fl. Thiruvavanthapuram 537. 1994; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.)

Type: India, "**Tranquebar**", *Koenig s.n*. (LE)

Anthoxanthum avenacea Retz., Obs. Bot. 3:8. 1783 ('*avenaceum* ').

Dimeria pusilla Thw., Enum. Pl. Zeyl. 369. 1864; Hook. f., Fl. Brit. India 7:103. 1896. Hook f. in Trimen, Handb. Fl. Ceylon 5: 195.1900. –*Type*: Ceylon, Kokkutuduvai, *Gardner CP 957* (K !)

D. avenacea (Retz.) C.E.C. Fisch. var. *elatior* (Hook. f.) Bor. Kew Bull. 7: 562.1953; Bor, Grass. Burma, Ceylon and Pakistan 139. 1960. – *Type*: not seen.

D. elatior (Hook. f.) Senaratna, Grasses of Ceylon 162. 1956. -- *D. pusilla* Thw. var. *elatior* Hook. f., Fl. Brit. India 7: 103. 1896. – *Type*: Ceylon, Trincomalee, *Glennie CP 957* (K)

D. acutipes auct. non Bor, 1953: Mishra *et al*., Ind. J. Forestry 6(4): 289. 1983; H. O. Saxena & Brahmam, Fl. Orissa 4: 2333. 1996; Britto, J. Bombay Nat. Hist. Soc. 86: 274. 1989.

Annuals. Culms erect, slender, solitary; up to 25 cm long; nodes sparsely bearded. Leaves usually confined to the base; sheath much longer than internodes, rather loose, keeled, smooth without hairs, broadly hyaline on the margins; ligule membranous, 0.6 mm long, and fimbriate at apex; leaf blade linear-acuminate, up to 5 cm x 2–2.5 mm, keeled on the midrib below with the keel continuous with that of the sheath, smooth and glabrous or minutely scabrid on both surfaces, a few bulbous-based hairs on the upper surface and margins towards the base.

Raceme solitary, 4–4.5 cm long, peduncle long exserted; raceme-rachis triquetrous, ca. 0.4 mm wide, flattened abaxially, triangular in section; pedicels 0.5 mm long, obconic-truncate, beadered, and flat lip. Spikelets linear oblong, 7–9 mm long, including awn of upper glume; callus slightly flattened, 1 mm long, bearded on two edges and at the base; lower glume coriaceous, linear-acute, 5 mm long, ending in short awn up to 1mm long, rounded on back and keeled towards apex, coarsely scabrid near tip; upper glume coriaceous, oblong-acute, 4.5–5 mm long (excl. upper glume-awn), strongly compressed, straight on back, keeled, winged from base to apex, sometimes wing never reach at the base, scabrid on the free edge, produced at the tip into a straight slender, scabrid awn up to 3–4 mm long. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 2.5 mm long, sparsely ciliate on the margins towards the apex. Upper floret complete, bisexual; upper lemma oblong-acute, 3–3.5 mm long, bifid at the apex with acute lobes, sub-hyaline, awned from the sinus, awn 13 mm long with a twisted chestnut-coloured column, 5 mm long; palea absent; lodicules 2, small; stamens 2, anthers 0.8 mm long; stigmas plumose.

Distribution: Eastern Ghats (Orissa, Andhra Pradesh, Tamil Nadu) and Sri Lanka.

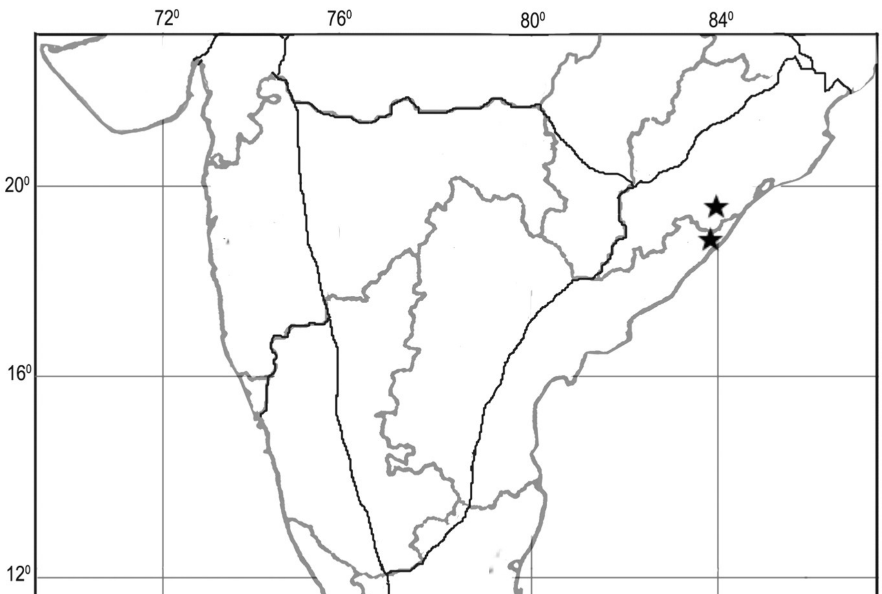
Habitat & Ecology: Occassional; along sandy grassy open places; seasonal, post-monsoon specific.

Flowering & Fruiting: November – February.

Variation & Interrelationships: Culms may sometimes be robust, and with large racemes and spikelets. Usually, upper glume is winged from base to apex along the keel. Sometimes, the wing failed to reach at the base of the glume. The species is similar to *Dimeria lawsonii* (Hook. f.) C.E.C.Fisch., but distinguished from it by the presence of narrow raceme-rachis (0.3 mm wide), long callus (1.5 mm), and long spikelets (6–7 mm).

D. avenacea also resembles with *D. acutipes* Bor, but the presence of upper glume-wing distinguishes the species from latter (Bor, 1953).

Notes: The occurrence of *D. avenacea* in Kerala as reported by Mohanan and Henry (1994) is doubtful. The critical study of their description of "*D. avenacea*" revealed that it actually is *D. lawsonii* (Hook. f.) C.E.C.Fisch. During the present study, I could neither see the cited specimens nor collect the species from Kerala.



Map 11. Distribution of *Dimeria aristata* Hack. (▲) and *D. avenacea* (Retz.) C. E. C. Fisch. (★)

Etymology: The specific epithet '*avenacea'* derived from Latin means 'similar to *Avena* or Wheat', and refers to the spikelet of the species which somewhat resembles *Avena* or Wheat.

Specimens examined: **Orissa**, Koraput Dist.: Naani shorta pottangi, 14th December 1960, *P.C. Nanda 2360* (CAL); *Ibid*., Lakshmipur, 8th January 2003, *Kiran Raj CU 92988* (CAL). "**Madras State**", Kambakam Hills, Chingelput Dist. (Andhra Pradesh), 15th March 1901, *Bourne 2466* (K).

10. Dimeria connivens Hack. - Fig. 24; Map 12.

D. connivens Hack. in A. DC., Monogr. Phan. 6: 689.1889; Hook. f., Fl. Brit. India 7: 104. 1896; Haines, Bot. Bihar & Orissa 1063.1924; Mooney, Suppl. Bot. Bihar & Orissa 263. 1950; Bor, Kew Bull. 7(4): 577. 1953 & Grass. Burma, India & Pakistan 140.1960; J. N. Mitra, Fl. Pl. East. India 1: 204. 1958; A. K. Mukh., Fl. Pachmarhi & Bori Res. 355. 1984; D. M. Verma *et al.,* Fl. Raipur, Durg & Rajnandgaon 454.1985; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Sreek. & V. J. Nair, Fl. Kerala Grass. 86. 1991; Shetty & Singh, Fl. Rajasthan 1030.1993; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 467. 1996; Moulik, Grass. Bamboo. India 281. 1997; Naik *et al.*, Fl. Marathwada 2:1023.1998;

Murti & Panigrahi, Fl. Bilaspur 758. 1999; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006.

Type: India, "**Bihar, Ranchi Dist**.", 600m, 25th October 1873, *C. B. Clarke 20607 A* (Holo - K !, Iso - CAL !) (Plate 13).

Annuals. Culms up to 25 cm tall, erect, sometimes shortly decumbent at the base, terete, smooth and glabrous, shortly bearded at nodes. Leaves usually confined at culm-base; sheaths longer than the lower internodes, shorter than the upper, the latter tight, clasping, the former rather loose and slipping from the culms, keeled in the upper half, rounded below, broadly hyaline on the margins, smooth and glabrous; ligule a short ciliate membrane less than 1 mm long; leaf blades lanceolate or linear-acute, 2–5 cm x 2 mm, upper culm-sheath usually rudimentary, with tubercle-based hairs minutely scabrid on both surfaces, coarsely scabrid towards margins.

Racemes 2, slightly diverging, 2–4 cm long; raceme-rachis tough, continuous, flat or slightly convex on the upper surface, narrowly winged, ciliate on the margins of the wings, lower surface of the axis keeled, pedicels very short, 0.3 mm long, flat, obconic, concave on the upper margin. Spikelets 3(4)–5 mm long, oblong, with a very short, bearded callus; lower glume 3 mm long, excluding the callus, much compressed, very narrow, ending above in a very sharp point, keeled above, rounded below, covered all along the back with forwardly directed cilia, thin on the margins; upper glume 3–5 mm long, elliptic-acute when spread, compressed, winged all along the keel, sometime narrowly winged towards base, wing opaque, 0.25 mm wide, ciliate, cilia much longer at the tip, and margins hyaline; Lower floret empty; lower lemma oblong, hyaline, scaly, 1.5–2 mm long, hyaline-cilia along upper half margins. Upper floret bisexual; upper lemma elliptic-acute, 2.5 mm long, sub-hyaline, 2-fid, acute lobes, awn ca. 9 mm long, column dark-coloured, twisted, 3 mm long; palea absent; lodicules 2, very minute, toothed; stamens 2; anthers 0.6 mm long; styles 2; stigmas plumose. Grain linear, sub-compressed, terete, 2 mm long.

Distribution: Peninsular India (Kerala, Karnataka and Madhya Pradesh, Orissa) extending to Bihar. Mainly to Eastern and Western Ghat regions, and North Eastern plains of Deccan plateau.

Habitat & Ecology: Lateritic soil along grassy hill-slopes; locally abundant; seasonal, post-monsoon specific; alt. 200-500 m.

Flowering & Fruiting: September – December.

Notes: Haines (1924) pointed out that this species might be a 'form' of *D. ornithopoda*. But, larger spikelts with a distinct lower glume-wing, distinguishes the taxon.

Etymology: The specific epithet *'connivens'* derived from Latin means 'converging', and refers to the recemes of the species which are close and not divergent.

Specimens examined: **Kerala**, Kannur Dist.: Kulathur, 30th October 1999, *Kiran Raj TBG&RI 41569* (CALI); Palakkad Dist.: Nelliampathy 1025 m, 10th January 2001, *Kiran Raj CU 92925* (CALI); Kasaragode Dist.: Poinachi 60 m, 8th December 2001, *Kiran Raj CU 92960* (CALI); *Ibid.,* Hosedurg, 17th December 2001, *Kiran Raj CU 92964* (CALI); Kozhikode Dist.: Kakkayam, 18th January 2002 *Kiran Raj CU 92974* (CALI); **Andhra Pradesh**, East Godavari Dist.: Way to Y.Ramavaram, 25th November 1993, *T.Pullaiah & M.S.Gayathri 12286* (SKU); **Maharashtra**, Pagara, Central province, September 1918, *J.Fernandez s.n.* (BLAT); **Madhya Pradesh,** Chindwara Dist.: Pachmarhi, Panarpani area, 15th November 1960, *P.C. Nanda 2600* (BSI); *Ibid.,* Ketad, Abjahmarh, 30th September 1985, *G.P.Roy & S.K.Dixit 42490* (BSA); *Ibid.,* Jatashankers caves 25th October 1957, *R.C.Bharadwaja 33325* (LWG); Bhopal Dist.: Midghat to Barkara, 21st September 1956, *R.C.Bhardwaja 32695* (LWG); **Orrissa**, Satyamba, 7th November 1959, *G. Panigrahi 20952* (CAL).

11. Dimeria copeana Sreek. - Fig. 25; Map 12.

D. copeana Sreek., V.J. Nair & N.C. Nair, J. Bombay Nat. Hist. Soc. 78(3): 577. 1981; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 565. 2004: T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.

Type: India, **Kerala**, Alleppey Dist.: Thrikkunnapuzha, 13th March 1980, *P. V. Sreekumar 66736* (Holo- CAL !; Iso -MH !) (Plate 15).

Dimeria chelariensis Ravi Rheedea 5(1): 37. 1995; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 565. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006. – *Type*: India, Kerala, Malappuram Dist.: Chelari, 28th November 1992, *Ravi 3606* (*Holo*- TBGT !; *Iso*- MH !, KFRI)

Perennials. Culms slender, tufted, stoloniferous or with thick root stock, rooting at nodes, nodes usually bearded. Leaves scattered; sheath up to 4.5 cm long, sharply keeled on the back, lower sheaths long-ciliate, especially towards apex with bulbous-based hairs, upper ones sparsely ciliate to almost glabrous; ligule membranaceous, more or less rounded and prominently fimbriate at apex, up to 1 mm long; leaf blade linear-lanceolate, ca. 20 cm x 3.5 mm, acuminate, long-cilliate with bulbous-based hairs mostly on the margins and mid-rib below, more profuse towards the base in lower leaves and mostly on the margins in the upper ones.

Racemes 2, 3 or 4, 5–7 cm long; raceme-rachis slender, 0.25–0.5 mm wide, zig-zag, triquetrous, sharply angled and scabrid at angles. Spikelets elliptic, 2.5–3 mm; pedicel ca. 0.25 mm long, with lip concave, scabrid on the margins with one or more bristly hairs towards apex; callus short, ca. 0.25 mm long, callus hairs ca. 0.5 mm long; lower glume 2.5 x 0.25 mm, linear-oblong, acuminate-aristate and incurved at apex, keeled on the back; keel scabrid, narrowly winged towards apex, sides subcoriaceous, sparsely scabrid, especially towards apex; upper glume 2.5–2.75 x

0.6–0.7 mm, elliptic to oblong-oblanceolate, acute-aristate at apex, keeled on the back; keel scabrid and narrowly winged towards apex, with a few long cilica, sparsely hairly on dorsal surface, sides subcoriaceous, margins hyaline, long-ciliate from the middle upwards except the tip. Lower floret empty; lower lemma 1.5–1.75 mm long, hyaline, oblanceolate-acute, 2-veined along the middle, ciliate on 2/3 margins towards apex. Upper floret complete, bisexual; upper lemma ca. 2 mm long, sub-hyaline, 2-fid at apex, lobes acute, sparsely short-ciliate on the margins, awned from the sinus; awn ca. 8 mm long with a 2.5 mm long column, scaberulous; palea small, ca. 0.4 mm long, lanceolate, papillate; lodicules 2, small; stamens 2, anthers 1.5 mm long; styles ca. 0.2 mm long; stigmas ca. 0.5 mm long. Grain oblong, sub-compressed, obliquely acute at apex, ca. 1.5 mm long.

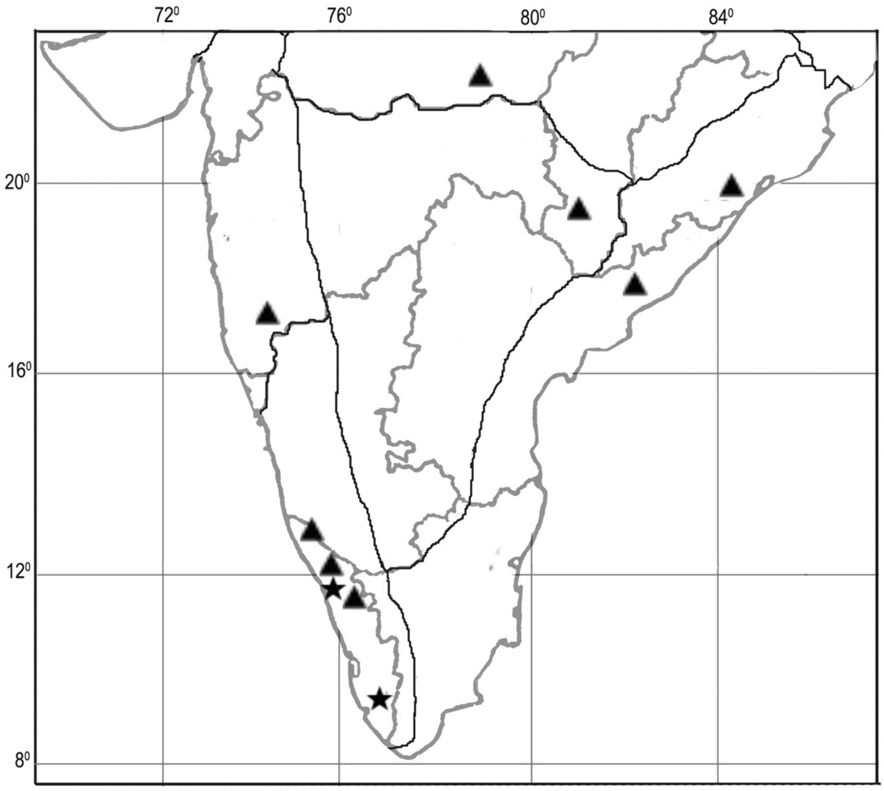
Distribution: Southern Western Ghats in Kerala.

Habitat & Ecology: Lateritic and alluvial soil along planes, open grassy slopes; from the lowlands to $\pm$ 100m alt. above MSL.

Flowering & Fruiting: November – February.

Notes: '*Dimeria chelariensis* Ravi' is considered here as a morpho-variant (ecotype) of *D. copeana*. A critical examination of the type specimens of both the species elucidated that morphologically there is no marked difference between the two except in their spikelet-size. Also, the species exhibit seasonal variations in plant size and habit, and hence considered as conspecific.

During the present study, the species was relocated from its type locality.



Map 12. Distribution of *Dimeria connivens* Hack. (▲) and *D. copeana* Sreek. *et al* (★)

Etymology: Named after Dr. T. A. Cope of the Royal Botanic Gardens, Kew, who is a world-renowned agrostologist.

Specimens examined: **Kerala**, Malappuram Dist.: Chelari, *Kiran Raj CU 92991* (CALI); Alappuzha Dist.: K. V. Jetty, near Thrikkunnapuzha, 12th January 2008, *Shaju 96119* (CALI).

12. Dimeria fuscescens Trin. - Fig. 26; Plate 7, A-D; Map 13.

D. fuscescens Trin., Mem. Acad. Sci. Petersb. 6 (2): 335. 1832; Hook. f., Fl. Brit. India 7: 105. 1897; Bor, Kew Bull. 7(4): 560. 1952, & Grass. Burma, Ceylon, India and Pakistan 140. 1960; J. N. Mitra, Fl. Pl. East India 1: 204. 1958; Raghavan *et al.,* Add. Cooke, Fl. Bombay Pres. 199. 1981; Britto & K. M. Matthew in K. M. Matthew, Fl. Tamil Nadu Carnatic 1841. 1983; K. M. Matthew, Illust. Fl. Tamil Nadu Carnatic 4: 760. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 109. 1989; K. M. Matthew, Excursion Fl. Central Tamil Nadu 602. 1991; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 174. 1994; Moulik, Grass. Bamboo. India. 282. 1997; Sasidh., Bio. Doc. Kerala - Fl. Pl. 567. 2004: T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.

Type: Nepal, (1821), *Wallich 8841* (K !, Microfiche -CALI !) (Plate 15).

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *fuscescens* Roberty, Boissiera 9: 398. 1960, *nom. inval*.

Perennials. Culms robust, erect or geniculate from the base, up to 70 cm long, sometimes rooting at nodes; nodes shortly bearded. Leaves all along the culm; sheath much longer than internodes, very loose, keeled, smooth, shining and glabrous in the lower two thirds, pilose in the upper third with bulbous-based hairs; ligule membranous, up to 1mm long, ciliate on the truncate apex;

leaf blade linear-acute, up to 4–15 cm x 2–4 mm, keeled on the midrib below with the keel continuous with that of the sheath, acuminate at apex, rounded at base, coarsely scabrid on nerves of both surfaces and margins, bulbous-based hairs on the upper surface and margins.

Racemes 2, rarely 3 or 4, digitate, 5–12 cm long, peduncle long exserted; raceme-rachis triquetrous, ca. 0.2 mm wide, very narrowly winged, straight or slightly zig-zag, scabrid on margins, carrying alternately arranged pedicelled spikelets; pedicels 1 mm long, compressed but not flattened, concave above, glabrous. Spikelets linear-oblong, 4.5–5 mm long, closely appressed to rachis, with glumes widely spreading at anthesis; callus 0.5 mm long, bearded on the lower edge; lower glume coriaceous, 4.5 mm long, linear-oblong, acuminate at apex, straight on back and keeled towards apex, thin to hyaline at the sides, scabrid all along the back and often ciliate; upper glume coriaceous, 5mm long, oblong-elliptic, acute at apex, strongly compressed, straight on back, keeled, narrowly winged all along the keel, often garnished with few long hairs on each side of the scabrid wing at the apex. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 1.5–2 mm long, acute at apex, ciliate on the margins towards the apex. Upper floret complete, bisexual; upper lemma elliptic-obtuse, 3 mm long, bifid at the apex with acute lobes sub-hyaline,, awned from the sinus; awn 12–14 mm long with a dark twisted 3 mm long column; palea absent; lodicules 2, small; stamens 2; anthers 2.5-3 mm long; styles 2, short; stigmas plumose.

Chromosome Number: 2n = 50 (Mehra & Kalia, 1975)

Distribution: Peninsular India, Nepal, Sri Lanka, Thailand. In Peninsular India, rarely found in Eastern Ghats and Southern Western Ghats.

Habitat & Ecology: Usually in damp grassy slopes along forest margins, sometimes in moist sandy planes along rivers; alt. 300–1600m.

Flowering & Fruiting: September–December.

Variations: The spikelet characters are extremely variable in the species, as encountered in some forms of *D. copei* Ravi and *D. deccanensis* Bor. In habit, it is usually a larger plant with two racemes. The great variability expressed by the upper glume-wing of the spikelet in the specimens (*Kiran Raj 92884, 92885*) is notworthy. In the spikelets of lower part of the raceme, the broad apical wing sometimes reaches at the base of the upper glume. Very rarely the rachis of raceme is provided with cilia.

Some Malayan forms are much hairy than typical Indian species in which racemes and awns are much longer and the tips are quite straight and not flexuous (Ridely, 1925)

Etymology: The specific epithet *'fuscescens'* derived from Latin means 'turnig brown or dark', and refers to the colour of spikelets of the species which turn to brown at maturity.

Specimens examined: **Andhra Pradesh**, Chittoor Dist.: Kambakam hills, 14th December 2004, *Kiran Raj CU 92884, CU 92885, CU 92886* (CALI). **Tamil Nadu**, Thirunelveli Dist.: Sengottai, (no date), *N. .Mohanan TBG&RI 45129* (TBGT); Salem Dist.: Yercad, 26th November 2001 *Kiran Raj CU 92940* (CALI). **Kerala,** Thiruvananthapuram Dist.: Chemungi hills, 12th December 2003, *Kiran Raj CU 92994* (CALI).

13. Dimeria kanjirapallilana K. C. Jacob - Fig. 27; Map 13.

D. kanjirapallilana K. C. Jacob, J. Bombay Nat. Hist. Soc. 47 (1): 48.1947; Manilal & Sivarajan, Fl. Calicut 338. 1982; Sreek. & V.J.Nair, Fl. Kerala Grass. 91. 1991; Ravi & N. Mohanan, Comm. Trop. Sub-trop. Sedge. Grass. 137. 2002; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 586. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.

Type: India, "**Travancore**", Peermedu, 3200 ft., December 1941, *K. C. Jacob 86320* (MH !)

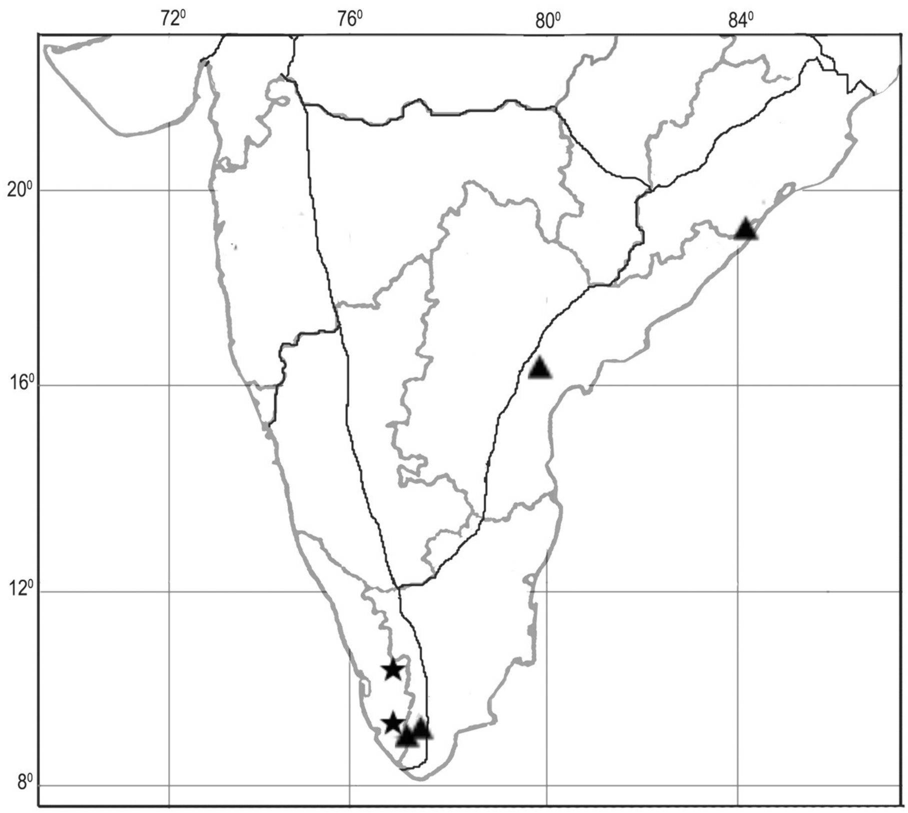
Annuals. Culms erect, often tufted, up to 45 cm long and glabrous; nodes bearded. Leaves all along culm; sheath up to 10 cm long, keeled on back, glabrous or sparsely hairy with bulbous-based

hairs; blade linear-elliptic, up to 10 cm x 3 mm, acuminate at apex, base shortly narrowed to rounded, sparsely hairy with up to 6 mm long, bulbous-based hairs especially on upper side towards margins, and scaberulous on margins towards apex.

Racemes 2, ca. 8 cm long, widely divergent when old and apically bent upwards; raceme-rachis trigonous, up to 0.6 mm wide, flattened on back, convex adaxiazlly, narrowly winged and scabrid on margins; pedicels ca. 0.3 mm long, concave at apex, scabrid on sides and sparsely hairy towards apex. Spikelets oblong-elliptic, 3.5-4 mm long; callus ca. 0.25 mm long, bearded; lower glume coriaceous, oblong, 3-3.25 mm long, acute-aristate at apex, keeled on back, keel scabrid and narrowly winged towards apex, scabrid on sides towards apex, minutely scaberulous; upper glume coriaceous, oblong-elliptic, ca. 3.75 long, acute-aristate at apex, keeled on back, keel scabrid and narrowly winged towards apex, scabrid on sides towards keel and scaberulous, sparsely ciliate on margins in middle. Lower floret empty; lower lemma oblanceolate, 1.5-2 mm long, hyaline, acute at apex and sparsely ciliate on margins in upper half. Upper floret complete, bisexual; upper lemma elliptic, ca. 2.5 mm long, 2-cleft at apex, awned from sinus, sub-hyaline; awn up to 10 mm long with column ca. 4 mm long; palea small, ca. 0.5 mm long and papillate; lodicules 2, ca. 0.3 mm long; stamens 2, anthers ca. 0.75 mm long pale brown; styles ca. 0.6 mm long; stigmas ca. 1 mm long. Grain oblong-elliptic, ca. 2 x

0.3 mm, sub-compressed, obtuse-apiculate at apex, pale brown.

Distribution: Endemic to Southern Western Ghats (Central to Southern Kerala).



Map 13. Distribution of *Dimeria fuscescens* Trin. (▲) and *D. kanjirapallilana* K. C. Jacob (★)

Habitat & Ecology: Common at high elevation in hilly tracts on rock cuttings, hillocks and open grasslands; locally abundant; alt. 300-600 m.

Notes: The species is sometimes easily recognized by its peculiar raceme structure. At maturity, both ends of the widely divergening racemes bend from the middle upwards and attains an ‘ u ’ shap.

Flowering & Fruiting: September – December.

Etymology: The specific epithet is based on the name of the type locality 'Kanjirapalli', a highland place in Kottayam Dist., Kerala.

Specimens examined: **Kerala**, Idukki Dist.: Kakki dam site, 4th January 1996, *Ravi 24042, 24043* (TBGT, CALI); Patthanamthitta Dist.: Kokkathode, 21st December 2000, *Kiran Raj CU 92915* (CALI); *Ibid*., Kuttikanam, ± 1100m, 15th November 2001, *Kiran Raj CU 92933* (CALI); Thiruvananthapuram Dist.: Ponmudi, Seethathode, 22nd November 2001, *Kiran Raj CU 92938, CU 92939* (CALI).

14. **Dimeria lehmannii** (Steud.) Hack. - Fig. 28; Map 14.

D. lehmannii (Steud.) Hack. in A. DC., Monogr. Phan. 6: 82. 1889 ('lehmanni'); Hook. f., Fl. Brit. India 7: 104. 1897 ('lehmanni'); C. E. C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Senaratna, Grass. Ceylon 164. 1956 ('lehmanni'); Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 175. 1994; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 109. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Moulik, Grass. Bamboo. India 283. 1997.

(excl.: Bor, Grass. Burma, Ceylon, India and Pakistan 142. 1960; H. O. Saxena & Brahmam, Fl. Orissa 3: 2336. 1996).

Type: "**Ceylon**", (no date), *Thwaites CP 955* (K !) (Plate 16).

D. alata Hook.f., Fl. Br. India 7: 105. 1896; Bor, Kew Bull. 7(4): 571. 1952; Bor, Grass. Burma, Ceylon, India, and Pakistan 139. 1960. -- *Dimeria ornithopoda* Trin. var. *mutica* Thw., Enum. Pl. Zeyl. 369. 1854. -- *D. lehmannii* (Steud.) Hack. var. *mutica* Hack. in A. DC., Monogr. Phan. 6:83.1889 (‘*lehmanni*’); Hook.f., in Trimen, Handb. Fl. Ceylon 5: 197. 1900; *nom. Illegit*., based on *Pterygostachyum lehmani* Nees *ex* Steud., Syn. Pl. Glumac. 1: 413. 1855 (1854) -- *Type:* “Ceylon”, (no date) *Thwaites CP 955* (K !)

D. avenacea (Retz.) C.E. C. Fisch. subvar. *lehmannii* Roberty, Boissiera 9: 398. 1960, *nom. inval*.

Perennials. Culms up to 50 cm tall, terete, smooth and glabrous, erect from the base, simple, rarely branching, bearded at the nodes; sheaths of the upper part of the culm tight and wrapped around the culm, those of the lower part loose and slipping from the culm, the latter markedly keeled on the upper half or third, round on the back in the lower half, smooth and glabrous, striate; ligule membranaceous, lacerate and ciliate on the upper truncate margin, 1 mm long; leaf-blade linear-lanceolate, 5–12 cm x 2–4 mm, acuminate at apex, usually glabrous, minutely scabrid on both surfaces and margins particularly towards the tip.

Racemes 2 or 3, divergent, 4–8 cm long; raceme-rachis triqutrous, flat on the back, 0.6–0.7 mm wide, straight or zig-zag, ciliate on the margins, convex to keeled adaxially, very narrowly winged; pedicels flat, half as broad as the rachis, ciliate on the outer margin, lip concave. Spikelets 4–4.5 mm long, firmly compressed, with a short callus 0.4 mm long, lying closely appressed to the rachis; lower glume 3–3.8 mm long, linear-acute, straight on the back but curved just at the tip, strongly compressed, keeled at the tip, rounded on the dorsal surface lower down, scabrid on the keel, hairy or ciliate on the dorsal surface; upper glume very firmly compressed, 4–4.5 mm long, winged all along the dorsal surface, ciliate on the wing and scabrid towards the tip, oblanceolate-acute when spread, more or less straight on the back, then curved towards the tip, almost hyaline on the margins. Lower floret empty; lemma a hyaline oblong scale 2 mm long, ciliate on the margins towards the tip. Upper floret complete and bisexual; lemma elliptic-acute, hyaline, cleft at the tip into two acute lobes, 3 mm long; awnless or an imperfect awn with a bristle at most 3 mm long; palea absent; styles 2; stigmas plumose; stamens 2; anthers 1–1.5 mm long. Grain subcompressed, nearly 3 mm long.

Chromosome Number: 2n = 32, 46 (Gould & Soderstorm, 1974)

Distribution: Sri Lanka and Southern Western Ghats (Southern Kerala). Collected during the present study after a period of 75 years.

Habitat & Ecology: Along the wet rocky, grassy hill-slopes; not common; alt. 500 m – 1000m.

Flowering & Fruiting: November – February.

Variations & Interrelationships: The broad papery wing of the upper glumes sometimes narrowed towards base of the glume. The lower glumes are minutely winged or rarely wingless at apex.

The species resembles *D. agasthyamalayana* Kiran Raj & Ravi, but quite distinct in having stoloniferous culms with scattered leaves, widely divergent racemes and ciliate raceme-rachis margins.

Notes: D. lehmannii can be easily recognised by having an awnless upper lemma (sometimes with a tiny bristle up to 2–4 mm long) without a column. Bor (1953, 1960) had erroneously given the name as "*D. lehamanii*" for the description of the species *D. aristata* in his treatment. Subsequent workers (Raizada, 1948; H. O. Saxena & Brahmam, 1996) followed this mistake.

Etymology: Named after F. C. Lehmann (1850 – 1903).

Specimens examined: **Kerala**, Pathanamthitta Dist.: Kochupampa hills, 1100 m, 16th December 2003, *Kiran Raj CU 92995, CU 92996* (CALI); Thiruvananthapuram Dist.: Seethathode, 13th November 1996, *Ravi 31738* (TGBT).

15. Dimera orissae Bor - Fig. 29; Map 14.

D. orissae Bor, Kew Bull. 7(4): 579. 1953 & Grass. Burma, Ceylon, India and Pakistan 142. 1960; V. J. Nair in Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 110. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; K.M.Matthew, Illustr. Fl. Tamil Nadu Carnatic 4: 761. 1988 & Excur. Fl. Centr. Tamil Nadu 602. 1991; H. O. Saxena & Brahmam, Fl. Orissa 4: 2340. 1996; Moulik, Grass. Bamboo. India 281.1997.

Type: India, **Orissa**, Koenjihar, Pipokhuri, 1000m, 1st October 1946, *H. F. Mooney 2758* (K !) (Plate 17).

Annuals. Culms slender, unbranched, up to 20 cm tall, terete, smooth and glabrous, closely invested with the sheaths, glabrous at the nodes; sheaths rather tight and clasping the culms, keeled in the upper half, rounded below, glabrous and smooth, striate, the upper portion spathe-like with reduced blades; ligule membranaceous, lacerate, 0.5 mm long; leaf bade linear-acuminate, 3–7 cm x 2–3 mm, erect, with a very mid-rib above, prominent below and carried down the sheath as a keel, glaucous lower surface, margins with tubercle-based hairs, sometimes found on the upper surface towards base, scabrid on both surfaces, minutely on the lower, more coarsely on the upper, tapering to rather stout tip.

Racemes 2, 3–5 cm long, pressed together when young, slightly divergentat maturity peduncle hardly exserted; raceme-rachis ca. 0.75 mm wide, straight or slightly zig-zag, clearly winged, flat on the upper surface, scabrid on the margins; pedicels marginal, ca 0.5 mm long, truncate-cuneate. Spikelets 4–4.25 mm long, oblong, awned;

callus truncate, 0.3 mm long; bearded; lower glume subcoriaceoues, 3–3.25mm long, linear-acute when spread, straight on the back, margins hyaline, scabrid on the keel from tip to base and with a few hairs near the tip; upper glume 4 mm long, strongly compressed, hyaline on the margins, firmer about the mid-nerve, strongly keeled almost all along the back, scabrid on the keel, the keel curves forward to an acute point, not winged on the keel but narrowly winged on the curved portion at the tip, scabrid on the back, and with a few long hairs on the sides at the tip. Lower floret empty; lemma a very small hyaline scale, 2 mm long, oblanceolate-acute, ciliate on the margins above. Upper floret bisexual; lemma 2 mm long, elliptic-acute, hyaline, cleft at the tip into two short lobes, awned in the sinus, awn 10 mm long; column chestnut-brown, twisted, 4 mm long; palea absent; lodicles 2, inconspicuous, stamens 2; anthers 0.5 mm long.styles 1; stigmas plumose.

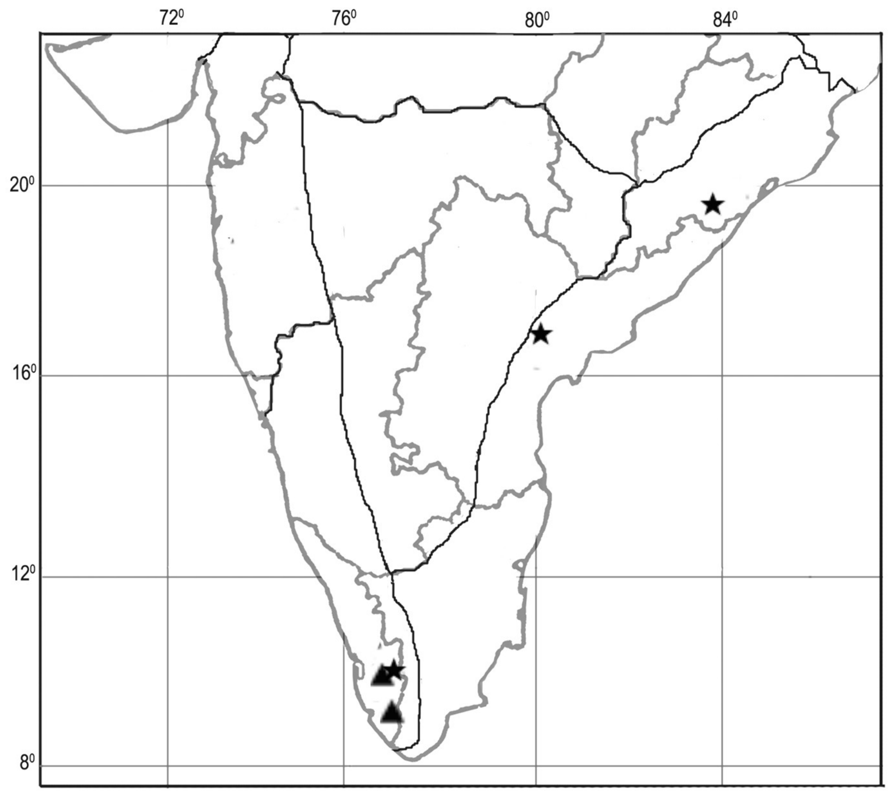
Distribution: Endemic to Peninsular India (Kerala, Tamil Nadu & Orissa).

Habitat & Ecology: Sub-gregarious along grassy plains; on rocky crevices along moist places seasonal, post-monsoon specific; alt. 1000–1400m.

Flowering & Fruiting: October – January.

Interrelationships: This species is close to *D. connivens* Hack, but distinct in having the upper glume minutely winged at apex only (vs. wing all along the keel). It also similar to *D. deccanensis* Bor, but differs from it in having small culm size and non-tufted habit, smaller anthers, larger keel-wing below the tip of the upper glume.

Etymology: The specific epithet is indicative of the name of the type locality – Orissa.



Map 14. Distribution of *Dimeria lehmannii* (Steud.) Hack. (▲) and *D. orissae* Bor (★)

Specimens examined: **Kerala,** Pathanamthitta Dist.: Kokkathode, ± 960 m, 18th December 2003, *Kiran Raj CU 92998* (CALI). **Tamil Nadu,** Namakkal Dist.: Yercad, Kolli hills 1300 m, 28898 (RHT).

16. Dimeria ornithopoda Trin.

D. ornithopoda Trin., Fund. Agrost. t. 14. 167. 1820; Steud., Syn. Glum. 1: 413. 1855; Hack. in A. DC., Monog. Phan. 6: 81. 1889; Hook. f., Fl. Brit. India 7: 104. 1897; E. G. Camus & A. Camus in Lecomte, Fl. Gen. de L'Ind.-Chin. 7: 227. 1923; Merril, Enum. Philip. Fl. Pl. 1: 30. 1922; Haines, Bot. Bihar & Orissa 1062. 1924; Ridely, Fl. Malay Peninsula 5:192. 1925; Honda, J. Fac. Sci. Univ. Tokyo III(3): 324. 1930; Blat. & McCann, Bombay Grass t.4. 8. 1935; Bor, Fl. Assam 5: 420. 1940; Mooney, Suppl. Bot. Bihar and Orissa 263. 1950; Bor, Kew Bull. 7(4): 572. 1953 (incl. *D. ornithopoda* var. *genuina*, *nom. inval.*); Santapau, Fl. Khandala 307. 1953; T. Cooke, Fl. Pres. Bombay 462. 1958; Bor, Grass. Burma, Ceylon, India & Pakistan 144. 1960; Saldanha & Nicolson, Fl. Hassan Dist. 715. 1976; Shah, Fl. Gujarat 2: 815. 1978; Raghavan *et al.*, Add. Cooke's Fl. Bombay Pres. 199. 1981; B. D. Sharma *et al.*, Fl. Karnataka 328. 1984; D. M. Verma *et al.*, Fl. Raipur, Durg & Rajnandgaon 454. 1985; Rao, Fl. Goa, Diu, Daman Dadra & Nagerhaveli 2: 498. 1986; Bole & Pathak., Fl. Saurashtra 3: 421 1988; Manilal, Fl. Silentvalley 352. 1988; B. G. P. Kulk., Fl. Sindhudurg 522. 1988; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 110. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Kesh.Moorthy & Yogan., Fl. Coorg 537. 1990; Vajravelu, Fl. Palghat 571. 1990; S. M. S. M. Almeida, Fl. Savantwadi 2: 125. 1990; Sreek. & V.J.Nair, Fl.

Kerala Grass. 98. 1991; K.M.Matthew., Ex. Fl. Centr. Tamil Nadu 603. 1991; Shetty & Singh, Fl. Rajasthan 3: 1030. 1993; Subramanian, Fl. Thenmala 448. 1995; Hajra & D. M. Verma, Fl. Sikkim 1: 253. 1996; Lakshmin. in B. D. Sharma *et al*., Monocotyledones 468. 1996; Sandhya Despande *et al*., Fl. Mahabaleswar & Adj. 2: 679. 1997; T. Pullaiah, Fl. Andhrapradesh 3: 1182.1997; Moulik, Grass. Bamboo. India 283.1997; Murti & Panigrahi, Fl. Bilaspur 2: 759. 1999; K. G. Bhat & Nagendran, Sedges & Grasses 272. 2001; Ravi & N. Mohanan, Comm. Trop. Sub-trop. Sedge. Grass. 140. 2002; N. Mohanan & Sivad., Fl. Agasthyamala 816. 2002; K. G. Bhat, Fl. Uduppi 796. 2003; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 587. 2004; Anilkumar *et al*., Fl. Pathanamthitta 574. 2005; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 792. 2006.

Type: India, "**Madras**", *C.B. Trinius 567* (LE).

Andropogon filiformis Roxb., Fl. Ind. 1: 256. 1820, non Pers. 1805. -- *Andropogon roxburghianus* Roem. & Schult., Mant. 2: 451. 1824. -- *Dimeria filiformis* (Roxb.) Hochst. in Metz (Hohenack. distr.), Exsicc. Pl. Ind. Or. no. 231. 1847, nom. superfl., *ex* Miq., Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. III, 4: 35. 1851; J. N. Mitra, Fl. Pl. East India 1: 203. 1958. -- *Psilostachys filiformis* Dalzell & A. Gibson, Bombay Fl. 305. 1861, nom. superfl. – *Type:* Herb. *Roxburgh s.n.* (BM, CAL !, K)

Dimeria tenera Trin., Mem. Acad. Petersb Ser. VI. 2: 335.1833; Benth. Fl. Austral. 7: 523. 1878; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Pilger in Engler & Prantl, Natur. Pflanzf. 14e, 109. 1940; H. O. Saxena & Brahmam, Fl. Orissa 4: 2342. 1996; Mooney, Suppl. Bot. Bihar & Orissa 263. 1950. non Benth., 1883. -- *D. ornithopoda* Trin. var. *tenera* (Trin.) Hack. in A. DC., Monogr. Phan. 6: 81. 1889. – *Type* : not seen

D. diandra Griff., Notul. 3: 71. 1851. non Stapf, 1911.

Didactylon simplex Zoll. & Moritzi in Moritzi, Syst. Verz. Zoll. Pfl. 99.1854. – *Type*: *Zollinger 1595* (U)

Dimeria stipiformis Miq., Prolus. Fl. Japan 176. 1866. (“*stipaeformis”)* non Franch. & Sav., 1864. -- *Andropogon stipaeformis* Stued., Syn. Glumac. 1: 377. 1855 – *Type*: not seen.

D. avenacea (Retz.) C. E. C. Fisch. subvar. *ornithopoda* Roberty, Boissiera 9: 401. 1960 (incl. subvar. *tenera*), *nom. inval.*

This taxon is very variable in form as expected from the long synonymy in Peninsular India and the varieties recognized based on their culm structure and spikelet size. Three varieties can be found in Peninsular India.

Key to the varieties of *Dimeria ornithopoda* Trin.

1a. Racemes 2 or 3; culms long (25–35 cm), branched................. ....**16a**. **D. ornithopoda** var. **ornithopoda**

1b. Racemes 2; culms short (ca. 5 – 15 cm), not branched. 2

2a. Leaves scattered; culms capillary, up to 10 cm long; spikelets 1–1.5 mm long. ....**16b**. **D. ornithopoda** var. **gracillima**

2b. Leaves crowded at base of the culm; culms not capillary but slender, up to 15 cm long; spikelets 3–3.5 mm long.................. ....**16c**. **D. ornithopoda** var. **khasiana**

16a. Dimeria ornithopoda Trin. var. **ornithopoda** Bor

- Fig. 30; Plate 29, B; Map 15.

D. ornithopoda Trin. var. *ornithopoda* Bor, Kew Bull. 7(4): 572. 1953; Grass. Burma, Ceylon, India & Pakistan 144. 1960; Karth., S. K. Jain, M. P. Nayar and Sanjappa, Fl. Ind. Enum. Monocot. 210.1989; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 470. 1996.

Type: India, "**Madras**", *C.B. Trinius 567* (LE).

D. ornithopoda Trin. var. *megalantha* Bor, Kew Bull. 7(4): 572. 1953, & Grass. Burma, Ceylon, India & Pakistan 144. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210.1989; Lakshmin. in B. D. Sharma *et al*., Fl. Maharashtra - Monocot. 470. 1996. – *Type*: "Bombay", 25th May 1914, *s. coll. 10414* (K !)

Annuals. Culms 25–50 cm long, terete, slender, capillary to fairly robust, smooth and glabrous, usually bearded at the nodes, very leafy, erect from the base, branched. Leaves scattered; sheaths strongly keeled from apex to base, often longer than the internodes, villous in the upper half with tubercle-based hairs, the lower half with similar hairs or entirely glabrous, shining, striate, hyaline on the margins, the lower loose and slipping from the culms, the upper tight and clasping, the spatheole with rudimentary blades; ligule about 0.5 mm long, membranous, lacerate, truncate or convex on the upper margin; leaf-blades linear-acuminate, 4–6 cm x 1–2 mm, a mid-rib prominent on lower surface, runs down on the sheath as a keel, covered on both surfaces with long (2–3 mm) tubercle-based hairs, glabrous or sparsely hairy, both surfaces minutely scabrid or somewhat coarsely scabrid on the upper surface, particularly towards the stout tip.

Racemes 2 or 3, appressed together when young, divergent at maturity, peduncle usually well exserted; raceme-rachis trigonous, flat back, 0.25–0.3(–0.5) mm wide, wingless or minutely winged, glabrous, minutely scabrid on the angles; pedicels flat, glabrous, lip concave. Spikelets strongly compressed, narrowly linear-oblong or slightly elliptic-oblong, 1.5–2.5 mm long; lower glume 0.8–2 mm long, linear-acute, much compressed, chartaceous, margins hyaline, shortly hairy, scabrid along dorsal surface; upper glume 1–2.5 mm long, slightly keeled at the apex, chartaceous to coriaceous, margins hyaline and shortly hairy, coarsely scabrid along the dorsal surface. Lower floret empty; lemma hyaline, scaly, 0.5–1mm long. Upper floret bisexual; lemma 0.5–1mm long, narrowly elliptic-acute, 2-fid, awned in the sinus, awn 4-5 mm long, column chestnut-coloured, ca. 1.5 mm long, twisted; palea absent; lodicules 2, very small, truncate, toothed; stamens 2; anthers 0.25–0.5 mm long; styles 2; stigmas plumose. Grain terete, subcompressed, 1.5 mm long.

Chromosome Number: 2n = 32 (Christopher, 1978)

Distribution: Tropical Asia, extending to Australia; Throughout India; Common in Peninsular India.

Flowering & Fruiting : September –April.

Habitat & Ecology: Common in hilly tracts on cuttings, rock crevices, hill slopes and grasslands; alt. 250 – 600 m.

Interrelationships: Resembling *D. deccanensis* Bor, but differs from it in having slender culms, wingless glumes and filiform raceme-rachis.

Notes: This is the most common representative of the genus in *Dimeria* - occurring regions (Map 15) and exhibits a great range of morphological variations. The var. *ornithopoda* is not difficult to recognize, being well characterised by smaller spikelets (1.5–2.5

mm long) with wingless glumes; slender culms and filiform raceme-rachises. However, within the typical variety, several variants have been noted intermediates. Critical analysis of the 'morpho-variants', confined that *D.ornithopoda* var. *megalantha* Bor also falls within the range of variability of the Peninsular Indian forms and hence treat synonymoused here.

Vernacular Name: Bird's foot grass (English); "khap-kardi" (Marathi).

Etymology: The epithet *'ornithopoda'* derived from two Greek words 'ornitho'(s) means birds, and 'podo' means foot indicates the general appearance of the orientation of the racemes which resembles bird's foot.

Specimens examined: **Kerala**, Thiruvananthapuram Dist.: Kurisumala, 1000m, 8th November 1984, *V.J.Antony* (CAL); *Ibid.*, Bonaccord, 21st December 1989, *N..Mohanan 9006* (CALI); Kannur Dist.: 'Telichery', November 1910, *A.Meemold 12068* (CAL); *Ibid.,* Parassinikadavu 200m, 21st September 1982, *R.Ansari 73938* (CAL); Kollam Dist.: Kulathupuzha, Aryankavu, 10th November 1901, *s. coll. 88289* (MH); *Ibid.,* Aryankavu, 11th November 1996, *Ravi TBG&RI 24714, 24715* (TBGT); Kasaragode Dist.: Badiamukku, 1st October 1982, *R.Ansari 74412* (MH); Idukki Dist.: Peermedu, 2nd December 1941, *K.C. Jacob 86302* (MH); *Ibid.,* Kumarikulam, Periyar Tiger Reserve, $\pm$ 1100 m, 24th February 2002, *Kiran Raj CU*

81066 (CALI); Palaghat Dist.: Poochipara, 9th November 1983, *S.V. 11537* (CALI); *Ibid.,* Near Silent Valley damsite, 4th December 1981, *Sabu & Sathish Kumar SV 10031* (CALI); *Ibid*., way to Poochipara, 10th December 1980, *N.C..Nair 69515* (MH); Pathanamthitta Dist.: Kuttikkanam, 1000m, 21st December 2000, *Kiran Raj CU 92916* (CALI); Wayanad Dist.: Chandanathode 775 m, *Sasidharan 2583* (KFRI); **Karnataka**, Chickmangalur Dist.: Kudramukh valley, 2nd November 1974, *R.S. Raghavan 134374* (BSI) *Ibid*., Kemmangudi, 20th October 1974, *R.S. Raghavan 132524* (BSI); Mysore Dist.: Mucora, on the way to Abbi falls, 20th October 1963, *M.R. Despande 94902* (BSI); *Ibid.,* Castle road, 7th November 1969, *B.M. Wadhwa 119547* (BSI); *Ibid.,* Castle road, October 1902, *G.A Gammie s.n.* (BSI); Uttar Kannada Dist.: Near Jog falls, 27th December 2003, *Kiran Raj CU 92879* (CALI); "South Canara", 10th November 1900, *Agri. Domenstrator 2275* (MH); "North Canara", Birch 2000 ft., *W. A. Talbot 2251* (BSI); *Ibid.,* Maringudi, 21st November 1990, *J.Fernandez s.n.* (BLAT); *Ibid.,* Karvar, October 1919, *Hallberg & MecCan A 307* (BLAT). **Tamil Nadu**, Coimbatore Dist.: Attakatti, 25th January 1962, *J.Joseph 13564* (CAL); *Ibid.*, Sholiyar, 29th December 1963, *K.Ramamoorthy 18194* (CAL); Dharmapuri Dist.: Bodamalai hills, ± 1000m, 26th November 2001, *Kiran Raj CU 92941* (CALI); Nilgiri Dist.: Gudalur, 950 m, 18th November 1972, *E. M. Vajravelu 42824* (MH); *Ibid.,* Gudalur, 17th November 1935, *K.C. Jacob 83119* (MH); Namakkal Dist.: Kollihills, 28th November 2001, *Kiran Raj CU 92942, CU 92943* (CALI); **Andra Pradesh**, Chittor Dist.: Thirumala hills, Akasaganga, *Kiran Raj CU 92833, CU 92834* (CALI). **Goa**, South Goa Dist.: Marmagoa, 15th October 1895, *Talbot 2562* (BSI); *Ibid.,* Madgoa 15th October 1891, *W.A. Talbot s.n.* (CAL); *Ibid.,* Quierm, Keri, 16th October 1996, *MKJ, VC Joshi & S. Rajkumar 231* (GOA); *Ibid.,* Goa University Campus, 1st October 1997, *MKJ, VC. Joshi & S. Rajkumar 1057* (GOA); **Maharashtra**, Satara Dist.: Khandala, November 1918, *C. MecCan 9885* (BLAT); *Ibid.,* Tata's lake, October 1918, *s.coll. A 310* (BLAT); *Ibid.,* Mahabaleshwar, *P.V.Bole 507* (BLAT); *Ibid.,* Panchgani, 19th October 1893, *Woodrow s.n.* (CAL); Vetora, Konkan, October 1918, *s.coll. 33742* (BLAT); "Saurashtra" Sasargir, 5th October 1953, *H. Santapau 16336* (BLAT); Monbay Dist.: Hartapoint, 17th October 1960, *Prain 15572* (BLAT); Borvolli National Park, 21st September 1952, *R.R. Fernasky 594* (BLAT); Savantwadi Dist.: Charatha, October 1968, *B. Parasker 1072* (BLAT); Junnar Dist.: Bhiradikkhund hills, 24th October 1965, *Hemadri.K 107565* (CAL); *Ibid.,* Duvagakhilla plateau,17th April 1965, *Hemadri.K 104245* (CAL); Bhandvara, 2nd December 1957, *P.C. Nanda 1343* (CAL); Bombay, Aerey Milk colony, 23rd December 1956, *S.C.Agarwal 1129* (CAL); Polarahavada, near Tiskani, 27th October 1964, *Bremanda Reddi 101048* (BSI); Amboli, 27th November 1961, *M.Y. Ansari 78547* (BSI); Thane Dist.: Kedarnath hill slopes, 20th January 1969, *K.V. Billore 115488* (BSI); Sindhudurg Dist.: Phonda, 25th

November 1969, *M.Y. Ansari 78546* (BSI); *Ibid.,* 25th October 1969, *K.G. Kulkarni 118974* (BSI); Ratnagiri Dist.: Kankalikudai, 20th October 1970, *B.G. Kulkarni 121784* (BSI); Pune Dist.: Lonavala, Bhoma hills, 11th November 1956, *S.K. Janardhanam 8926* (BSI); "Bombay", 19th October 1896, *G.Woodrow s.n*. (CAL); **Dadra & Nagar Haveli**, Tingra village, 29th September 1963, *M.Y. Ansari 938*76 (CAL); **Madhya Pradesh,** Bilaspur Dist.: Kathigera, 15th December 1964 *C.N.Aron 3985* (CAL); Chande Dist.: 14th December 1889, *J.F.Duthie 9930* (CAL); Pachmarhi 18th February 1991, *J.F.Duthei 10616* (CAL); N. Barka, 6th November 1952, *S.D.N. Tiwari 81* (BLAT); *Ibid.,* Mandla, September 1950, *S.D.N. Tiwari 81A* (BLAT);

16b. Dimeria ornithopoda Trin. var. **gracillima** Bor - Map 15.

D. ornithopoda Trin. var. *gracillima* Bor, Kew Bull. 7(4): 572. 1953; Grass. Burma, Ceylon, India & Pakistan 144. 1960; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210.1989.

Type: India, **Bihar**, 1300 m, 1st October 1873, *C.B. Clarke 21084* B (Lectotype – K !, designated here) (Plate 18).

Annuals. Culms up to 15 cm long, extremely slender, capillary, smooth and glabrous, erect from the base, bearded at nodes. Leaves usually scattered all along the culm; sheaths strongly keeled from apex to base, often longer than the internodes, villous in the upper half with tubercle-based hairs, the lower half with similar hairs or entirely glabrous, shining, striate, hyaline on the margins; ligule ca. 0.5 mm. long, membranous, lacerate; leaf-blades linear-acuminate, 2–4 cm x 1 mm, a promenent mid-rib on lower surface, carried down on the sheath as a keel, sparsely covered with tubercle-based hairs.

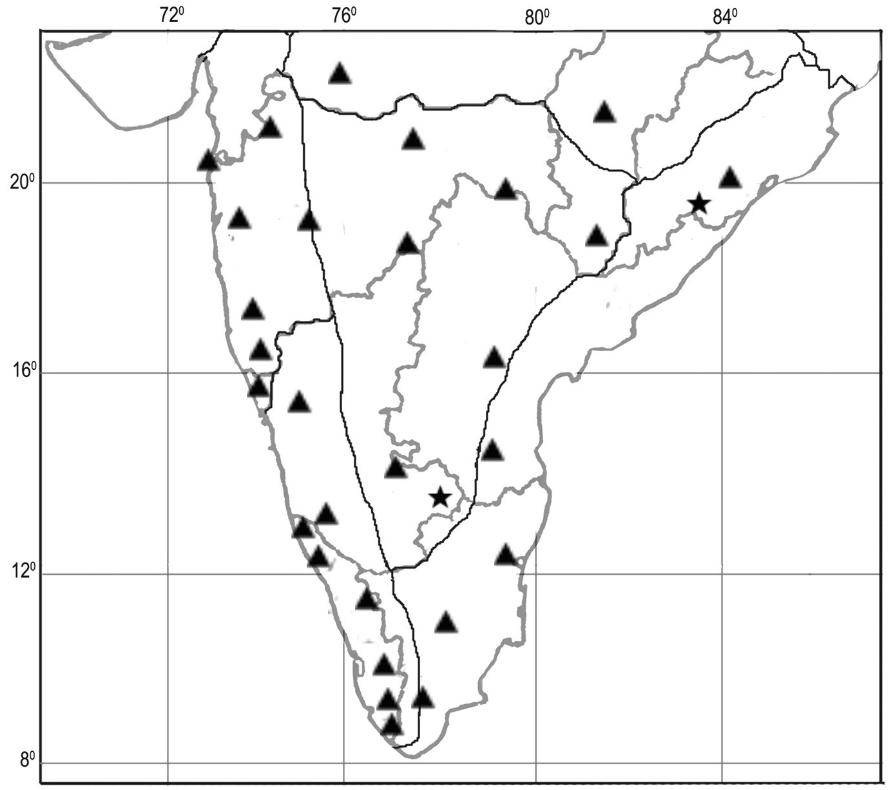
Racemes 2, 3–5 mm long, peduncle hardily exserted; raceme-rachis trigonous, 0.25–0.5 mm wide, wingless or minutely winged along internode, glabrous, angles minutely scabrid, pedicels flat, with concave lip, glabrous. Spikelets linear-oblong or slightly elliptic-oblong, 1–1.5mm long; callus incospicous; lower glume 0.5–0.8 mm long, linear-acute, dorsal surface coarsely scabrid, margins hyaline, shortly hairy on the sides; upper glume 1–1.5 mm long, rounded on the back, slightly keeled at the apex, hyaline on the margins, chartaceous to coriaceous around the mid-nerve; coarsely scabrid along the dorsal surface, sides shortly hairy. Lower floret empty; lemma a short hyaline scale, 0.3–0.5mm long. Upper floret bisexual; lemma 0.2 mm long, narrowly elliptic-acute, cleft at the tip into two short lobes, awned in the sinus, awn 4-5 mm long; column chestnut-coloured, 1mm long, twisted; palea absent; lodicules 2, very small, truncate, toothed; stamens 2; anthers 0.25–0.3 mm long; styles 2; stigmas plumose. Grain terete, sub-compressed, 0.8 mm long.

Distribution: Southern Western Ghat region in Karnataka extending to North Eastern Ghats region (Bihar).

Flowering & Fruiting : September –February.

Habitat & Ecology: Common in hilly tracts on cuttings, rock crevices, hill slopes and grasslands; alt. $\pm$ 700 – 1300 m.

Interrelationships: Close to the typical variety but differs in having geniculate or procumbent culm-base with short leaves.



Map 15. Distribution of *Dimeria ornithopoda* Trin. var. *ornithopoda* (▲) and *D. ornithopoda* Trin. var. *gracillima* Bor (★)

Notes: Bor (1953) described *Dimeria ornithopoda* var. *gracillima* based on three specimens, viz. *C. B. Clarke 21084 B* and *C. B. Clarke 33719 A & C,* all collected from 'Parasnath' in Bihar Dist., India. Since, he has not specified the type in his publication, all these are to be treated as syntypes. Detailed study of the specimens made available from Kew revealed that the specimen - *C. B. Clarke 21084 B* – agree well with the diagnosis of the species and hence it is selected here as the lectotype of the species.

Etymology: The epithet *'grcillima'* derived from Latin means 'very slender' which refers to the raceme structure.

Specimens examined: **Karnataka**, Kolar Dist.: Nandi hills $\pm$ 700m, 5th Januaray 2004, *Kiran Raj CU 92999* (CALI).

16c. Dimeria ornithopoda Trin. var. **khasiana** Bor - Fig 31; Map 16.

D. ornithopoda Trin. var. *khasiana* Bor, Kew Bull. 7(4): 572. 1953; Grass. Burma, Ceylon, India & Pakistan 144. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210.1989; K.M.Matthew, Illustr. Fl. Tamil Nadu Carnatic 4: 762. 1988; K.M.Matthew, Ex. Fl. Cen. Tamil Nadu 603. 1991.

Type: "Khasi Hills", (no date), *Griffith s.n.* (Lectotype - K !, designated here) (Plate 19).

Annuals. Culms up to 15 cm long, slender, almost capillary to fairly robust, smooth and glabrous, terete, erect from the base, bearded at nodes. Leaves usually crowded at base of the culm; sheaths strongly keeled from apex to base, often longer than the internodes, villous in the upper half with tubercle-based hairs, the lower half with similar hairs or entirely glabrous, shining, striate, hyaline on the margins; ligule about 0.5 mm. long, membranous; leaf-blades linear-acuminate, 2–5 cm x 1–2 mm, a prominent midrib on lower surface which runs down the sheath as a keel, sparsely covered with tubercle-based hairs, being particularly marked on the mid-rib below and on the margins, or the hairs present in various densities to almost glabrous, minutely scabrid on both surfaces or somewhat coarsely scabrid on the upper surface, particularly towards the tip.

Racemes 2, 3 – 4 cm long, appressed when young, divergent at maturity, peduncle well exserted; raceme-rachis trigonous, 0.25–0.3 mm wide, wingless or narrowly winged, glabrous, angles minutely scabrid; pedicel short, flat, with concave lip, glabrous. Spikelets narrowly linear-oblong or slightly elliptic-oblong, 3–3.5 mm long; lower glume linear-acute, 2–3 mm long, chartaceous, margins hyaline, dorsal surface scabrid, sides shortly hairy; callus not prominent; upper glume 2.5–3 mm long, slightly keeled at apex, chartaceous to coriaceous, margins hyaline, dorsal surface coarsely scabrid, sides shortly hairy. Lower floret empty; lemma 0.8–1.5mm long, hyaline. Upper floret bisexual; lemma 1–1.5mm long, narrowly elliptic-acute, cleft at the tip into two short lobes, awned in the sinus, awn 4-5 mm long; column chestnut-coloured, 1.5–2 mm long, twisted; palea absent; lodicules 2, very small, truncate, toothed; stamens 2; anthers 0.25–0.5 mm long; styles 2; stigmas plumose. Grain 1.5 mm long.

Chromosome Number: 2n = 14 (Mehra & Kalia, 1975)

Distribution: Peninsular India (Kerala, Maharashtra, Goa, Tamil Nadu) extending to Khasi hills (Assam).

Flowering & Fruiting : September –January.

Habitat & Ecology: Hilly tracts on rocky cuttings, hill slopes and grasslands; alt. 100 –1700 m.

Notes: Bor (1953) described *D. ornithopoda* var. *khasiana* based on three materials, viz. *C. B. Clarke 5625, C. B. Clarke 45095 A,* and *Griffith s. n.,* and failed to specify the holotype. In this context, all these specimens are to be treated as syntypes and the one specimen – *Grifiith s. n.* – which agrees well with the diagnosis of the species is selected here as the lectotype.

Etymology: The varietal epithet is based on the name of the type loacality – Khasi hills, an endemic hotspot of North-Eastern India.

Specimens examined: **Kerala,** Kannur Dist.: Thatummal, 15th December 2000, *Kiran Raj TBG&RI 44930* (CALI). **Tamil Nadu,** Salem Dist.: Solakkad, 27th November 2001, *Kiran Raj CU 92942* (CALI). **Goa,** Mayem Lake, 31st August 1997 *MKJ & S. Rajkumar 909* (GOA).

17. Dimeria trimeni Hook. f. - Fig. 32; Map 16.

D. trimeni Hook. f. in Trimen, Handb. Fl. Ceylon 5: 198. 1900; Bor, Kew Bull. 7(4): 587.1953 (‘trimenii’); Seneratna, Grass. Ceylon 163. 1956; Bor, Grass. Burma, Ceylon, India & Pakistan 144. 1960 (‘trimenii’); Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; H. O. Saxena & Brahmam, Fl. Orissa 4: 2340.

1996 (‘trimenii’); Moulik, Grass. Bamboo. India 285.1997 (‘trimenii’).

Type: “**Ceylon**”, Padunkorale, September 1864, *Thwaites 956 pro parte* (K!) (Plate 20).

Perennials. Culms stout and tufted, erect from the base, branched, up to 80 cm tall, smooth and glabrous below the inflorescence, terete, often hairy at nodes or below the nodes at culm base. Leaves mostly confined at culm-base; sheaths tight clasping the culms, longer than the internodes, striate, the spatheole carrying reduced blades; ligule 0.5–1 mm long, truncate or rounded above, membranaceous; leaf blades linear-acuminate, 10–15 cm x 4–5 mm, erect, somewhat stiff, covered on both surfaces with bulbous based hairs, with a mid-rib prominent below which runs down the sheath as a keel, minutely to coarsely scabrid on both surfaces, coarsely scabrid on the pungent tip.

Racemes 2 rarely 1, 5–6 cm long, peduncle long-exserted; raceme-rachis usually trigonous, but flat on the back, 1–1.5 mm wide, undulate or markedly zig-zag, winged, margins densely pilose, convex adaxially; pedicel cuneate, glabrous or sparsely hairy on the upper margin, lip concave. Spikelets 4–5 mm long (incl. callus); callus ca. 0.5 mm long, bearded, cuneate, firmly compressed, very hairy; lower glume 3.5–4.5 mm long, narrowly oblong-acute, compressed, straight on the back, dorsal surface densely hairy from

base to apex, less so on the sides, narrowly winged at keeled tip, margins hyaline; upper glume 4–5 mm long, straight on the back up to a short distance of the tip, when it curves towards the middle line, keeled and minutely winged on the curved portion, margins hyaline and ciliate., firmer in the dorsal region, usuaaly covered with a dense mat of white hairs, more sparsely hairy on the sides. Lower floret empty; lemma a hyaline scale, oblanceolate-acute, 3 mm long. Upper floret complete, bisexual; upper lemma elliptic-acute, 3 mm long, hyaline, smooth and glabrous, cleft at the tip into two lobes, awned in the sinus, awn perfect, 8–10 mm long, column 2–3 mm long, chestnut-coloured, twisted; palea absent; stamens 2, anthers 2 mm long; style 2; stigma plumose. Grain 2 mm long, sub-compressed.

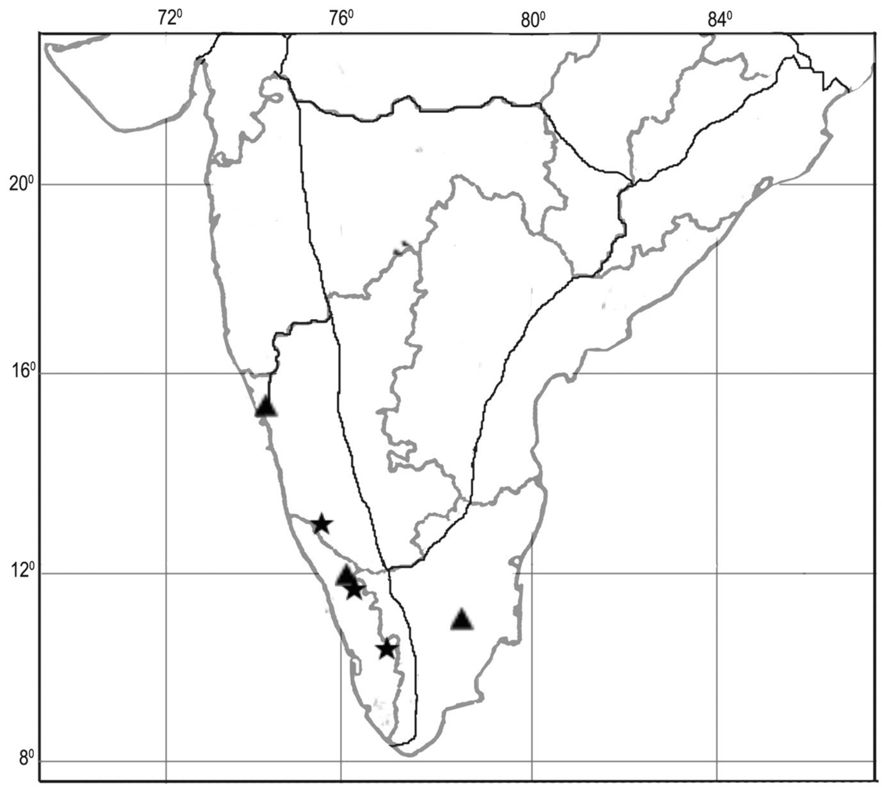
Distribution: Sri Lanka and Southern Western Ghats (Kerala, Karnataka); occurrence in Orissa state is doubtful.

Habitat & Ecology: Marshy grassy hill tops and rocky slops; not common; alt. 1000 – 1200 m.

Flowering & Fruiting: October-December.

Interrelationships: In general morphology, this species resembles with *D. kurumthotticalana s. l.*, but could be readily distinguished by the tufted perennial habit with leaves crowded at base of the culm.

Notes: It is one among the high altitude species of *Dimeria.* Previously confused with Bor's *"D. ceylanica"* (= *D. kurumthotticalna* K. C. Jacob*)* and *D. pubescens* Hack., and the problems of identification have been discussed under *D. pubescens.*



Map 16. Distribution of *Dimeria ornithopoda* Trin. var. *khasiana* Bor (▲), and *D. trimeni* Hook. f. (★)

D. trimeni is considered as a linking species with the members of *Dimeria* sect. *Loriformes*. In general morphology, the species is very close to sect. *Loriformes* with the characters like flattened rachis*.* Due to the presence of features like fuscous spikelets and subcoricaeous nature of glumes etc., the species is included under the sect. *Dimeria.*

Saxena and Brahmam (1997) included this species in Flora of Orissa based on the collections by Jain *et al.* (1975). I couldn't see the above specimen during the course of the present study, and hence the occurrence of *D. trimeni* in Orissa Dist. is doubtful.

Etymology: Named after H. Trimen (1843–1896), a British botanist who was Director of the Royal Botanic Gardens, Paradeniya in 1879.

Specimens examined: **Kerala**, Idukki Dist.: Lokhat gap, 23rd November 2000, *Ravi & Kiran Raj TBG&RI 44559, 44560, 44561* (CALI); Waynad Dist.: Chembra Hills, 28th February 2004, *Kiran Raj CU 93000* (CALI). **Karnataka,** Kodagu Dist.: Madikeri, 2nd December 2002, *Kiran Raj CU 92981* (CALI).

iv. DIMERIA SECT. LORIFORMES Bor ex Kiran Raj et Sivad.

Key to the species of *Dimeria* sect. *Loriformes*

1a. Upper glume with an apical distinct arista or awn (1–2 mm long) at the apex 2

1b. Upper glume without an apical arista or awn 5

2a. Upper glume winged all along the keel ....
....3

2b. Upper glume winged or not; if winged, narrowly at apex only ..
...4

3a. Raceme 1; culms not branched; spikelets 5–5.5 mm long, surface sparsely hairy; upper glume-wing tapering to the base, apex recurved ....**27. D. lawsonii**

3b. Racemes 1–3; culms branched or not; spikelets 6–7.5 mm long, surface densely hairy; upper glume uniformly winged; apex straight ....**20. D. copei**

4a. Raceme 1; culms solitary; raceme-rachis 0.5–0.75 mm wide, margins densely ciliate; spikelets 4–4.5 mm long; callus hairs up to 0.5 mm long; upper glume densely ciliate; anthers 0.5–1 mm long .... **34. D. thwaitesii**

4b. Racemes 2–4; culms tufted; raceme-rachis 0.75–1mm wide; margins sparsely ciliate; spikelets 3–4 mm long; callus hairs 1–1.5 mm long; anthers 1–1.5 mm long ....**32. D. raizadae**

5a. Upper glume winged all along the keel, from base to apex..........6

5b. Upper glume winged or not; if winged, at the apex only. … ……12

6a. Annuals; culms without a rhizome or stolon……. …………………7

6b. Perennials; culms stoloniferous or with thick rootstock ……. ….15

7a. Upper glume-wing corky ………………………………………... ……..8

7b. Upper glume-wing thin or papery………………………………… ….10

8a. Lower glume winged from base to apex ……………………… ……..11

8b. Lower glume winged or not; if winged confined at the apex only..9

9a. Racemes 2–3; spikelets 3–3.5 mm long; upper glume-wing confined to 1/3 of the keel at base …………………… **23. D. jainii**

9b. Racemes 1–2; spikelets 4.5–5.5 mm long; upper glume-wing uniform all along the keel ……………….**18. D. balakrishnaniana**

10a.Culms 10–15 cm long, solitary, smooth; peduncle enclosed in spatheole; raceme always 1, 2–3 cm long ……….. **22. D. fischeri**

10b. Culms 30–40 cm long, usually tufted, usually pubescent; peduncle well exserted from spatheole; racemes usually 2, 5–10 cm long .... **31. D. pubescens**

11a. Peduncle hardly exserted from spatheole; lower glume broadly winged, wing of the lower glume corky; callus (0.5–1.5 mm) long. ....**29. D. mooneyi**

11b. Peduncle well exserted from spatheole; lower glume narrowly or minutely winged, wing of the lower glume not corky but papery; callus ca. 0.5 mm long. ....**19. D. bialata**

12a. Culms usually tufted, few from the base; racemes 1–2, normally exserted from the peduncle; spikelets 3.5–6 mm long 13

12b. Culms slender and capillary, solitary; raceme always single, long exserted from the peduncle; spikelets 3–3.5 mm long .... **26. D. kurzii**

13a. Peduncle well exserted from spatheole; culms up to 1 m high, usually robust; upper glume with a broad or expanded wing at the apex, usually winged form apex to the middle of the keel ....**25. D. kurumthotticalana**

13b. Peduncle hardly exserted or enclosed in spatheole; culms 20–50 cm high, not robust; upper glume wingless or minutely winged at apex. 14

14a. Culms 25–30 cm high; spikelets 5–6 mm long; upper glume acuminate to aristate at apex, minutely winged from the middle upwards along the keel, densely ciliate all along the keel .... **24. D. josephii**

14b. Culms 40–50 cm high; spikelets 3.5–4 mm long; upper glume acute at apex, with or without a minute wing at apex; sparsely ciliate at apex of the keel .... **21. D. deccanensis**

15a. Spikelets subcoriaceous, fuscous; margin of raceme-rachis smooth and glabrous ....**33. D. ravii**

15b. Spikelets coriaceous, not fuscous; margin of raceme-rachis scaberulous and ciliate. 16

16a. Raceme 1; culms branched; leaves scattered. .... **27. D. mahendragiriensis**

16b. Racemes 2; culm not branched; leaves crowded at base. ....**30. D. namboodiriana**

18. Dimeria balakrishnaniana K. Ravikumar, Sreek. & V. Lakshmanan

D. balakrishnaniana K. Ravikumar, Sreek. & V. Lakshmanan, Kew Bull. 45(3): 573. 1990, *emend descr.* Kiran Raj *et* Sivad.; Sasidh., Bio. Doc. Kerala - Fl. Pl. 565. 2004.

Type: India, **Tamil Nadu**, Madurai Dist.: High Wavy's Mountains, Nursery Valley, ± 1600m, 22nd January 1988, *Lakshmanan 87543* (Holo - CAL !; Iso - K, MH !).

Annuals. Culms usually solitary, 30–60 cm long, erect. Leaf-blades linear-lanceolate, 3–8 cm x 2–4 mm, flaccid. Racemes 1–2, subdigitate, 3–6 cm long; raceme-rachis flattened, ca. 1.5 mm wide, winged, margins hairy; pedicels truncate, ca. 0. 5 mm long, flattened. Spikelet ovate-elliptic; callus 0.25 mm long, base obtuse; glumes coriaceous, dissimilar, hairy along keel-wing; lower glume keeled, narrowly winged at apex, wing thin or papery, upper glume keeled, winged all along, wing corky; acuminate or beaked at apex. Lower floret barren; lemma lanceolate, hyaline, ciliate on margin. Upper floret fertile; lemma elliptic, 2-fid, sub-hyaline, 1-veined, awned; awn from a sinus, geniculate, 12 – 15 mm long overall, column ca. 4 mm long, glabrous; palea 0.5 mm long. Lodicules present.

Two varities are found in Peninsular India.

Key to the varieties of *D. balakrishnaniana* K. Ravikumar *et al*.

1a. Raceme 1–2; spikelets 3.5–5.5 mm long; wing of the upper glume apex entire. ………………………………………………… ……………..**18a. D. balakrishnaniana** var. **balakrishnaniana**

1b. Racemes 2; spikelets 5–6 mm long; wing of the upper glume beaked or notched at apex. ……………………………………… ……………………**18b**. **D. balakrishnaniana** var. **sahyadricum**

18a. **Dimeria balakrishnaniana** K. Ravikumar *et al.* var. **balakrishnaniana** - Fig. 33; Plate 21; Map 17.

Type: India, **Tamil Nadu**, Madurai Dist.: High Wavy's Mountains, Nursery Valley, ± 1600m, 22nd January 1988, *Lakshmanan 87543* (Holo - CAL !; Iso - K, MH !).

Annuals. Culms erect, slender sometimes tufted, arise few from base, 12–30 cm high; nodes usually bearded. Leaves scattered; sheath keeled in upper half, rounded below and almost smooth without hairs; ligule membranous, up to 1mm long, obtuse-truncate and fimbriate at apex; leaf blade linear-lanceolate, up to 3–7 cm x 0.5 cm, keeled on midrib below with keel continuous with that of sheath, acuminate at apex, minutely scabrid to almost smooth on lower side, bulbous-based hairs on upper surface and margins towards base.

Racemes 2 rarely 1, 3 – 4 cm long; raceme-rachis flat, ca. 1.5 mm wide, winged, margins sometimes wavy and hairy; pedicels 0.5 mm long, flattened, lip transverse. Spikelets ovate-elliptic, (3.5–)4–5(–5.5) mm long; callus short, densely bearded, callus hairs ca. 1.5 mm long; lower glume oblong-lanceolate, 4–4.5 mm long, coriaceous, shortly acuminate at apex, keeled on back, wingless, scabrid towards apex, glabrous otherwise; upper glume coriaceous, ovate-lanceolate, 5 mm long, keeled on back, broadly winged, wings ca. 5 mm wide, corky in lower 2/3, papery towards apex, pilose along keel and sides, scabrid towards apex, margins ciliate. Lower floret empty; lower lemma thinly hyaline, elliptic-lanceolate, 2–2.5 mm long; margins sparsely ciliate towards apex. Upper floret complete, bisexual; upper lemma sub-hyaline, elliptic-obtuse, 3–3.5 mm long, bifid at apex with acute lobes, awned from sinus; awn 12–15 mm long with a column 4 mm long, twisted and scabrid; palea very short, 0.3 mm long; lodicules 2, small; stamens 2, anthers 1–1.5 mm long; styles 1–1.5 mm long; stigmas 1–1.5 mm long, plumose.

Distribution: Endemic to Southern Peninsular India (Kerala & Tamil Nadu).

Habitat & Ecology: On rock crevices along the wet, grassy slopes; lateritic hillocks; locally abundant; seasonal, post-monsoon specific; alt. 150 – 1600m.

Flowering & Fruiting: November – February.

Variation & Interrelationships: The corky wing of the upper glume sometimes narrow towards base. The keel of the lower glume usually minutely winged at the apex. These variations have been observed in spikelets of different seasons. The species is closely related to *D. mooneyi* Raiz. ex Mooney but distinct in having short callus and wingless lower glume of the spikelet.

D. balakrishnaniana seems morphologically intermediate between *D. bialata* and *D. mooneyi*, which may be distinguished as fallows. The above three taxa have a peculiar ‘corky’ wing along the keel of the upper glume of the spikelet. A comparison of distinguishing features of these species is shown in Table 16.

Notes: The critical examination of the type specimen of *D. balakrishnaniana* revealed the winged nature of the lower glume. These apical narrowly winged nature of the lower glume was not mentioned in the protologue of the taxon (Ravikumar *et al*., 1990) instead of the wingless nature of the lower glume. Also, it was mistakenly pointed out that the lower glume is ‘corky’ winged (*l.c.* p.575) !

Critical study of the several collections from different regions of South India (Kerala & Tamil Nadu) revealed considerable differences between the characters given in the protologue and the actual specimens in general habit, raceme structure (number of racemes varies from 1–2) and spikelet morphology. But these differences can well be accommodated within the circumscription of the taxon. Ravikumar *et al.* (*l.c.*) failed to notice these variations and therefore, an amended description of the species is provided here.

Etymology: Named in honour of Dr. N. P. Balakrishnan, Deputy Director (Retd.), Botanical Survey of India (BSI), Coimbatore.

Specimens examined: **Kerala**, Idukki Dist.: Painavu, Paramada 4th November 1998, *Kiran Raj TBG&RI 38605* (CALI); Kannur Dist.: Cherupara, 100 m, 5th December 2001, *Kiran Raj CU 92951* (CALI); Palakkad Dist.: Chemmanthode 750m, 8th January 2001. *Kiran Raj CU 92922* (CALI); Wayanad Dist.: Vellarimala Hills, ± 600m, 24th

November 2002, *Kiran Raj CU 81090* (CALI). **Tamil Nadu,** Madurai Dist.: Nagamalai, 8th November 2002, *Kiran Raj CU 92978* (CALI).

Table 16. A comparison of major diagnostic features of *Dimeria bialata, D. balakrishnaniana* and *D. mooneyi.*

Species	**Peduncle**	**Raceme number**	**Spikelet length**	**Lower glume**
D. bialata	Long-exserted	2	3.5–4 mm long	Minutely winged at apex
D. balakrishnaniana	Well-exserted	1–2	5–5.5 mm long	Winged (papery) towards apex
D. mooneyi	Little-exserted	1–2	5–6 mm long	Winged (corky) from base to apex

18b. Dimeria balakrishnaniana K. Ravikumar *et al*. var. **sahyadricum** Kiran Raj *et* Sivad. *var. nov.* (*ined*.)

- Fig. 34; Map 17.

A var. typica glumae superioris apice rostrato distinguenda.

Type: India, **Karnataka**, Dakshin Kannada Dist.: Vittal ± 400 m, 28th October 2002, *Kiran Raj CU 81053* (Holo - CALI); *Paratype:* **Karnataka**, Dakshin Kannada Dist.: Vittal ± 400 m, 28th October 2002, *Kiran Raj CU 81054* (CALI).

Annuals. Culms up to 30 cm tall, terete, stiff, erect, smooth, glabrous, upper nodes bearded. Leaves usually scattered; sheaths somewhat loose and slipping from culm, becoming scarious when old, margins hyaline, smooth and glabrous, keeled in upper half;

ligule membranaceous, 0.5 mm long, truncate, ciliate; leaf-blades lanceolate to linear-acuminate, erect, 2–6 cm x 2–3 mm, rounded at base to sheath, margins thickened, very minutely scabrid or smooth on both surfaces, margins scabrid particularly towards stout tip, both surfaces with tubercle-based white hairs to almost glabrous, usually with a few, spaced tubercle-based hairs on margins below.

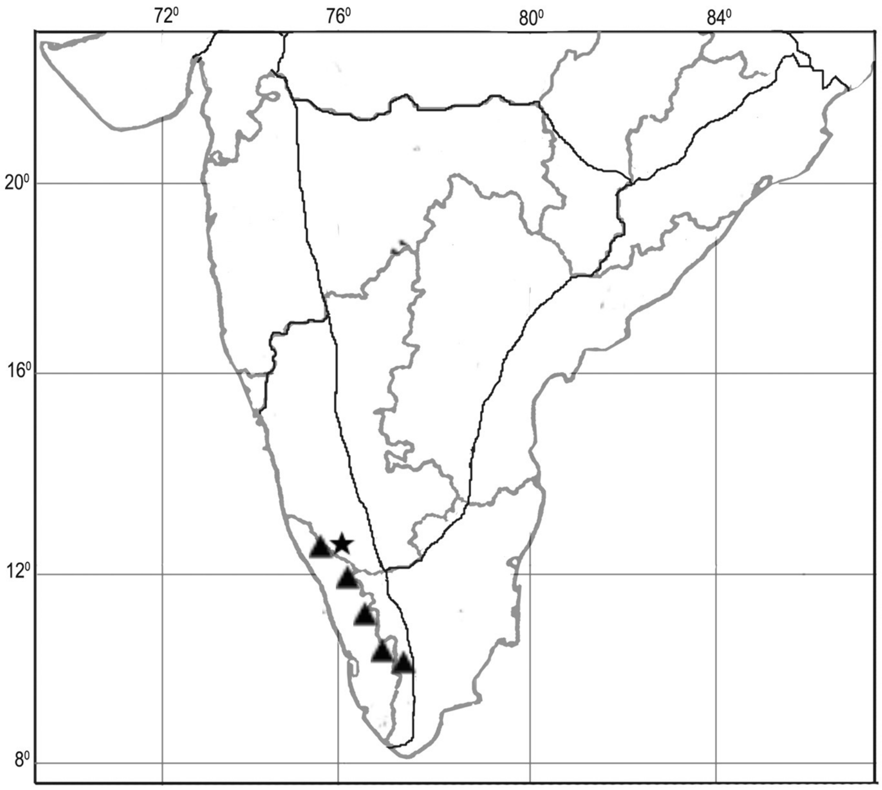
Racemes 1 or 2, ca. 6 cm long, closely pressed when young, divergent at maturity; raceme-rachis linear, flat, 1–1.5 mm wide, winged, thickly or somewhat sparsely ciliate on margin, keeled adaxially; pedicel flat, 0.5 mm long, more or less densely bearded, and concave tip. Spikelets very compressed, 5–6 mm long, 2 mm wide when spread, coriaceous, acuminate, with a short bearded callus 0.5 mm long, not appressed to rachis; lower glume 4.5–5 mm long, narrowly oblong-acuminate, with a wing on back in lower two-thirds, ciliate all along dorsal surface with longer hairs; upper glume 5–6 mm long, shortly beaked or forked near tip, corky winged along keel to 'beak-like' tip, long ciliate all along keel, margins hyaline, and ciliate. Lower floret empty; lemma a hyaline, oblong scale, ciliate on margins near tip, ca. 3 mm long. Upper floret complete; lemma elliptic-acute, 2.5–3.5 mm long, sub-hyaline, cleft at tip into two acute lobes, awn 13–15 mm long, column dark-chestnut, twisted, 4–5 mm long; palea absent;

lodicules 2, truncate, obcuneate, minute; stamens 2; anthers 1.75 mm long; styles 2; stigmas plumose.

Distribution: Endemic Southern Western Ghats (Karnataka). Known only from the type locality.

Habitat & Ecology: In rock clefts and crevices; not common but locally abundant; alt. ± 400 m.

Flowering & Fruiting: November – February.



Map 17. Distribution of *Dimeria balakrishnaniana* Ravikumar *et al*. var. *balakrishnaniana* (▲) and *D. balakrishnaniana* Ravikumar *et al*. var. *sahyadricum* Kiran Raj et Sivad., *var. nov.* (*ined*.) (★)

Interrelationships: The *Dimeria balakrishnaniana* var. *sahyadricum* differs from the typical variety in having two racemes (usually), larger spikelets, and upper glume with an unusually notched or beaked apex.

Etymology: The infra specific epithet '*sahyadricum*' is based on Sahyadri, the Sanskrit name for the Western Ghats, which includes the type locality, a 'hotspot' of India.

19. **Dimeria bialata** C. E. C. Fisch.

D. bialata C. E. C. Fisch., Kew Bull. 1933: 351.1933; Gamble, Fl. Pres. Madras 1713. 1934; Bor, Kew Bull. 7(4): 568. 1952; Bor, Grass. Burma, India & Pakistan 140. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 327. 1984; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Sreek. & V. J. Nair, Fl. Kerala Grass. 84. 1991; Moulik, Grass. Bamboo. India. 281. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 268. 2001; K. G. Bhat, Fl. Uduppi 793. 2002; Sasidh., Bio. Doc. Kerala - Fl. Pl. 565. 2004: T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 789. 2006.

Type: India, "**Madras state**", South Kanara, Siradi, November 1908, *Meebold 10548* (K !)

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *bialata* Roberty, Boissiera 9: 398. 1960, *nom. inval.*

Annuals. Culms usually solitary or few from culm-base, 50–60 cm long, erect. Leaf-blades linear-lanceolate, 3–8 cm x 2–4 mm, Racemes 1–2, sub digitate, 4–6 cm long; raceme-rachis flattened, ca. 1 mm wide, winged, margins hairy; pedicels truncate, ca. 0. 5 mm long, flattened. Spikelet elliptic-lanceolate; callus short, bearded; glumes coriaceous, dissimilar, hairy along keel-wing; lower glume keeled from the middle upwards, usually wingless; upper glume keeled throughout, winged all along; acuminate to aristate at apex. Lower floret barren; lemma lanceolate, hyaline, margins ciliate. Upper floret fertile; lemma elliptic, 2-fid, sub-hyaline, 1-veined, awned; awn from a sinus, geniculate, 8–10 mm long overall, column ca. 3 mm long, glabrous; palea 0.5 mm long. Lodicules present.

Two varieties can be found in Peninsular India.

Key to the species of *Dimeria bialata* C. E. C. Fisch.

1a. Spikelets 3.5 – 4 mm long; apex of the upper glume acute to acuminate ....**19a. D. bialata** var. **bialata**

1b. Spikelets 5.5 – 6.5 mm long, apex of the upper glume acuminate to aristate ....**19b. D. bialata** var. **sivarajanii**

19a. Dimeria bialata C. E. C. Fisch. var. **bialata** - Fig. 35; Map 18.

Type: India, "**Madras state**", South Kanara, Siradi, November 1908, *Meebold 10548* (K !) (Plate 22).

Annuals. Culms slender, smooth, 12–45 cm high; nodes bearded. Leaves mostly confined to culm-base; sheath loose, keeled on upper half, rounded below and almost smooth without hairs; ligule membranous, up to 1mm long, truncate and fimbriate at apex; leaf blade linear-lanceolate, up to 3–7 cm x 2.5 mm, acuminate at apex, keeled on midrib below with keel continuous with that of sheath, minutely scabrid and bulbous-based hairs on both surfaces and along margins.

Racemes 1or 2, ca. 3 cm long, peduncle well exserted; raceme-rachis flat, ca. 1.5 mm wide, winged, and margin sparsely ciliate; pedicels 0.3 mm long, flattened, lip concave. Spikelets elliptic-lanceolate, 3.5–4 mm long; callus short, bearded; lower glume coriaceous, linear-acute, 3–3.25 mm long, shortly acuminate at apex, strongly keeled on back, sometimes narrowly winged on keel, scabrid towards apex, sometimes sparsely hairy; upper glume coriaceous, elliptic-lanceolate, 3.5 mm long, pilose on keel and side, scabrid towards apex, margins ciliate, broadly winged along keel; wings papery, ca. 0.5 mm wide, narrower towards base. Lower floret empty; lower lemma thinly hyaline, elliptic-lanceolate, ca. 2 mm long; margins sparsely ciliate towards apex. Upper floret complete, bisexual; upper lemma elliptic-obtuse, 2.5 mm long, bifid at apex with acute lobes, sub-hyaline, awned from sinus; awn 9–11 mm long with a column 2.5-3 mm long, twisted and scabrid; palea absent; lodicules 2, small; stamens 2; anthers 1mm long; styles 2, stigmas 1–1.5 mm long, plumose. Grain brownish, terete, 1.5 mm long.

Distribution: Endemic to Southern Peninsular India (Kerala, Karnataka & Tamil Nadu).

Habitat & Ecology:, grassy slopes along lateritic plateau; locally abundant; seasonal, post-monsoon specific.

Flowering & Fruiting: November – February.

Notes: Differing mainly from *Dimeria bialata* var. *sivarajanii* by the long-exserted peduncle, and the acuminate upper glume-apex.

Etymology: The specific epithet '*bialata'* derived from Latin means 'both winged', which refers to both the glumes of the spikelet, which are winged.

Specimens examined: **Kerala,** Pathanamthitta Dist.: Kattathipara, ± 1200, 26th November 1999, *Ravi & Kiran Raj TBG&RI 41930* (TBGT, CALI); Kozhikode Dist.: Kakkayam 500 m, 26th October 1999, *Ravi & Kiran Raj TBG&RI 41468* (TBGT, CALI); Kannur Dist.: Nadukani 750m, 22th November 2003, *Kiran Raj CU 92990* (CALI); *Ibid.,* Periya, 29th October 1999, *Ravi & Kiran Raj TBG&RI 41540* (TBGT).

19b. Dimeria bialata C. E. C. Fisch. var. **sivarajanii** (N. Mohanan & Ravi) Kiran Raj *et* Sivad., *comb et stat. nov*. (*ined*.)

- Fig. 36; Map18.

Type: India, **Kerala**, Pathanamthitta Dist.: Kochu Pampa Hills, 4th January 1996, *Ravi TBG&RI 24041* (Holo- TBGT !*;* Iso- MH, KFRI).

D. sivarajanii N. Mohanan & Ravi, Rheedea 6(2): 47. 1996; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 567. 2004; Anilkumar *et al*., Fl. Pathanamthitta 524. 2005.

Annuals. Culms erect, tufted and branched, up to 40 cm tall; nodes bearded. Leaves scattered; sheath keeled on back, margins hyaline, lower ones shorter and slipping from culms, upper ones longer and more or less closely embracing culms, up to 8 cm long, closely beset with bulbous-based hairs except towards base, progressively less hairy towards culms apex, with the upper most ones being more or less glabrous; ligule membranaceous, truncate-fimbriate at apex, ca. 1 mm long; leaf blade linear, elliptic-lanceolate, 15 cm x 5 mm, shortly narrowed and rounded at base, acuminate at apex, with bulbous-based hairs, more so on upper side.

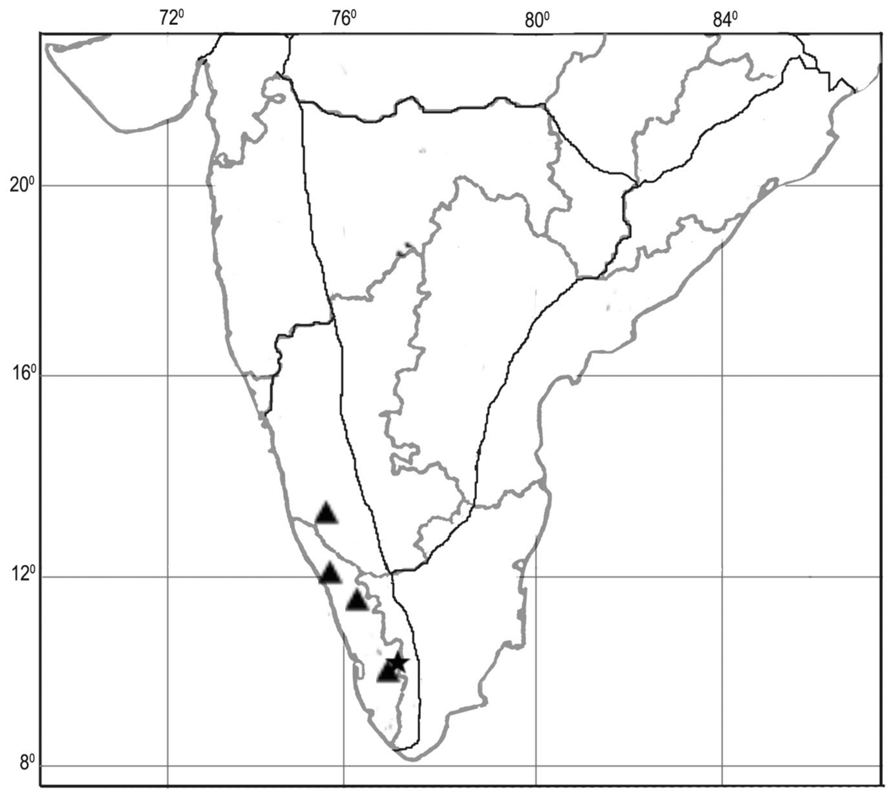
Racemes 1 or 2, ca. 7 cm long, peduncle well exserted; raceme-rachis flattened on back, longitudinally ridged or convex adaxially, broadly winged, 1–1.5 mm wide, margins ciliate; pedicels 0.5–0.75 mm long, lip concave, densely ciliate on outside side. Spikelets elliptic-oblong, 5.5–6.5 mm long (incl. upper glume arista); callus prominent, 0.5–1 mm long, callus hairs up to 1.5 mm long; lower glume oblong-elliptic, 4.5–5.5 mm x 0.5–0.6 mm (incl. arista), subcoriaceous, acuminate-aristate at apex, arista ca. 0.5 mm long, keeled on whole back, keel narrowly winged, densely ciliate on back except towards spinulose apex, minutely scaberulous to sparsely short-ciliate on sides; upper glume oblong-elliptic, 5.5–6.5 mm long (incl. arista), acuminate-aristate at apex, arista 1–1.5 mm long, broadly winged all along keel, wing ca. 0.4 mm wide, coriaceous and opaque ca. 3/5 towards base, thin and papery towards apex, densely ciliate on back except towards spinulose apex, with a few long cilia in upper 1/3 on sides of wing; sides coriaceous, sparsely to moderately ciliate, especially towards wing more or less in middle, sometimes with a few long cilia towards apex; margins hyaline, sparsely short-ciliate in middle. Lower floret empty; lower lemma hyaline, linear-oblanceolate, 2.75–3.75 mm long, broadly cuneate in lower half, acute at apex, margins shortly ciliate; upper lemma oblong-elliptic, 3–4 x 0.75 mm (when spread), 2-fid, lobes acute, sub-hyaline, awned from sinus; awn geniculate, up to 14 mm long, column 3–5 mm long; palea linear-lanceolate, sparsely papillate, with or without 1 or more long cilia; lodicules 2; stamens 2, anthers 1.25–2 mm long; styles ca.0.5 mm long. Grain oblong- elliptic, 2–2.5 x 0.5–0.75 mm, sub compressed, more or less subacute to rounded at apex, brown.

Distribution: Endemic to Kochupampa Hills (Kerala); known only from the type locality.

Habitat & Ecology: Lateritic hill slopes; seasonal, post-monsoon specific; alt. + 1000 m.

Flowering & Fruiting: October – February.

Notes: Mohanan and Ravi (1996) described *D. sivarajanii* against *D. lawsonii* based on the combination of many characters like aristate upper glume apex, 1–2 racemes, broadly winged rachis-margins etc. But the winged nature of the glumes and corky nature of upper glume wing made to place this taxon within the limits of *D. bialata.* It differs slightly from *D. balata* var. *bialata* in having larger spikelets and aristate upper glume apex and hence treated it as a distinct variety of the former and made this combination.



Map 18. Distribution of *Dimeria bialata* C. E. C. Fisch. var. *bialata* (▲) and *D. bialata* C. E. C. Fisch. var. *sivarajanii* (Mohanan & Ravi) Kiran Raj et Sivad.(★)

Etymology: The varietal epithet '*sivarajanii*' is derived from the name of late Prof. V. V. Sivarajan (1944–1995), an internationally known taxonomist of India.

Specimens examined: **Kerala**, Pathanamthitta Dist.: Kochu Pampa Hills ± 100 m, 17th December 1992, *Ravi SNCH 3723* (TBGT); *Ibid*., *Ravi SNCH 3726* (TBGT, CALI).

20. Dimeria copei Ravi - Fig. 37; Plate 23; Map 19.

D. copei Ravi, Blumea 41: 251.1996; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 565. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006.

Type: India, **Kerala**, Alappuzha Dist.: Kalavoor, 3rd December 1992, *Ravi 3655* (Holo- TBGT !; Iso- K, KFRI, MH !)

D. kalavoorensis Ravi, Blumea 41: 251.1996; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 565. 2004. – *Type:* India, Kerala, Alappuzha Dist.: Kalavoor, 3rd December 1992, *Ravi 3654* (Holo-TBGT !; Iso- K, KFRI, MH).

Annuals. Culms erect, slender and tufted, branched, up to 75 cm tall, nodes bearded. Leaves scattered; sheaths keeled on the back, margins broadly hyaline, glabrous, the upper most longest, up to 10 cm long, often with a rudimentary blade; ligule membranaceous, fimbriate-truncate at apex, up to 1 mm long; blades linear, ca. 22 cm x 2 mm, shortly narrowed to base, acuminate at apex, midrib broadly flattened above and keeled below, sparsely ciliate with long bulbous-based hairs on margins, scaberulous on margins towards apex and base.

Racemes 1, 2 or 3, 5-10 cm long; raceme-rachis more or less straight, flattened dorsally and somewhat angled adaxially, 0.6–0.75 mm wide, margins densely ciliate, glabrous or very sparsely short-ciliate on back, sometimes longitudinally ridged with sparse short cilia abaxially; pedicels 0.4–0.5(–0.75) mm long, obliquely concave at apex, ciliate on both sides, densely so on outside. Spikelets oblong-elliptic, 7.5–8 mm long (incl. upper glume-awn); callus prominent, 0.6–0.8 mm long, callus hairs up to 1 mm long; lower glume subcoriaceous, linear-oblong, 5.5–5.75 x 0.6–0.7 mm. acuminate-aristate at apex, arista 0.5–0.6 (–0.75) mm long, keeled on back, keel narrowly winged 1/3 towards apex, ciliate all over, densely so on keel except towards scaberulous apex; upper glume subcoriaceous, oblong-elliptic, 7–7.25 x 1.25 mm, aristate-awned at apex, awn (0.75–)1–1.25 mm long, scaberulous, keeled on back, broadly winged all along keel, wing ca. 0.4 mm wide, densely long-ciliate on back except towards scaberulous apex, sparsely short ciliate on its sides with a few long hairs towards apex, sides subcoriaccous, ciliate in a broad longitudinal line close to keel, margins hyaline, short ciliate in middle. Lower floret empty; lower lemma oblanceolate, ca. 3 mm long, cuneate towards base, acute at apex, hyaline, margins ciliate on above middle. Upper floret complete, bisexual; upper lemma oblanceolate, 3.5–4 x 0.75 mm (when folded), sub-hyaline, 2-fid, awned from sinus; awn 12–14 mm long with a 3.5–4 mm long column, sub-hyaline, sparsely scaberulous; palea small, lanceolate, ca. 0.5 mm long, papillate in upper half; lodicules small, ca. 0.25 mm long; stamens 2, anthers 1.25–2 mm long. Grain oblong-elliptic, 2.5–2.75 x 0.3 mm, subcompressed, apiculate at apex.

Distribution: Hitherto known only from the type locality in Kerala

Habitat & Ecology: Alluvial soil rich, grass fields; alt. $\pm$50 m; seasonal, post-monsoon specific.

Flowering & Fruiting: November – January.

Interrelationships: Resembling *D. lawsonii* (Hook. f.) C. E. C. Fisch. but differing in having longer racemes with the narrowly winged raceme-rachis, densely silky 1 or 2 (or 3) and the upper glume broadly winged all along its keel.

Notes: The distinction made by Ravi (1996) between *D. copei* and *D. kalavoorensis*, based on the presence of stout culms and larger spikelets, protruding in the former species was found to be incorrect based on detailed study of the materials. Actually it represented a variation. Also, it has been observed that the species exhibited seasonal variations in plant size and habit, which is not sufficient to keep them as separate and distinct taxa. The collections of this taxon often contained mixtures of two forms - those with very slender culms, and those with stout culms. The above two ‘species’ of Ravi was found scattered all over the type locality of both, and they are seen growing even from the same clump! Presence of such variants or 'morpho-forms' were also observed among the populations of *D. bialata* C. E. C. Fish. var. *bialata, D. deccanensis* Bor, and *D. kurumthotticalana* K. C. Jacob.

Etymology: The varietal epithet *'copei'* is derived form the name Thomas A. Cope, Royal Botanical Gardens, Kew, who is a world renowned agrostologist.

Specimens examined: **Kerala**, Alappuzha Dist.: Kalavoor, 28th November 2003, *Kiran Raj CU 92992, CU 92993* (CALI).

21. Dimeria deccanensis Bor - Fig. 38; Map 19.

D. deccanensis Bor, Kew Bull. 7(4): 578. 1953 & Grass. Burma, India & Pakistan 140.1960; Manilal, Fl. Silent Valley 352. 1988; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Sreek. & V.J.Nair, Fl. Kerala Grass. 89. 1991; Lakshmin. in B. D. Sharma *et al*., 467. 1996; Moulik, Grass. Bamboo. India 282. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 268. 2001; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006.

Type: India, "**Madras state**", Nileswar, S. Kanara, 9th November 1917, *s.coll.15318* (Holo-K !) (Plate 24).

D. kollimalayana M. Mohanan & M. V. N. Rao, J. Bombay Nat. Hist. Soc. 80: 615. 1984. – *Type:* India, Tamil Nadu, Salem Dist.:

Kollimalai 1200 m, 19th February 1982, *M. Mohanan 56208* (Holo-CAL !, Iso-MH !)

D. kanjirapallilana sensu T. Pullaiah, Fl. Andhra Pradesh 3: 1182. 1997: non K. C. Jacob, 1947.

Annuals, sometimes tufted. Culms up to 70 cm tall, erect or slightly decumbent at base, terete, smooth and glabrous, bearded at nodes; Leaves confined at culm-base; sheaths much shorter than internodes in upper half of culms, much longer than basal internodes, usually rounded and glabrous on lower half, hairy with tubercle-based hairs above, rather loose and slipping from culm at base, tighter higher up; ligule less than 1 mm long, truncate, membranous, ciliate; leaf-blades linear-acuminate, ca. 5 cm x 2–4 mm, covered with sparse tubercle-based hairs, prominent mid-rib, with well-spaced tubercle-based hairs, scabrid on both surfaces.

Racemes 2 rarely 1 or 3, 4–7 cm long, peduncle well exserted; raceme-rachis flattened, ca. 0.75 mm wide, zig-zag, margins glabrous to ciliate, ridged adaxiallly, glabrous; pedicel short, lip concave; Spikelets 3–4.5 mm long, much compressed, callus 0.5 mm long, densely bearded below; lower glume 2.5–3.5 mm long, oblong-acute when spread, strongly compressed, margins hyaline, chartaceus on keel, ciliate along keel in lower two-thirds, scabrid above, often scabrid along sides, particularly towards tip, occasionally villous on sides; upper glume 3.5–4.5 mm long, margins hyaline, densely ciliate along back minutely winged at apex, straight or very slightly curved on back. Lower floret empty; lemma 1.5–2 mm long, oblanceolate, hyaline, margins ciliate in upper half. Upper floret complete, bisexual; lemma elliptic-acute, 1.5–2 mm long, hyaline, 2-fid, awned in sinus; palea absent; awn 6–10 mm long; column dark-coloured, 3–4 mm long; styles 2; stigmas plumose; stamens 2; anthers ca. 1.5 mm long. Grain compressed, 2 mm long, terete, reddish-brown in colour.

Distribution: Endemic to Southern Peninsular India (Andhra Pradesh, Kerala, Karnataka & Tamil Nadu).

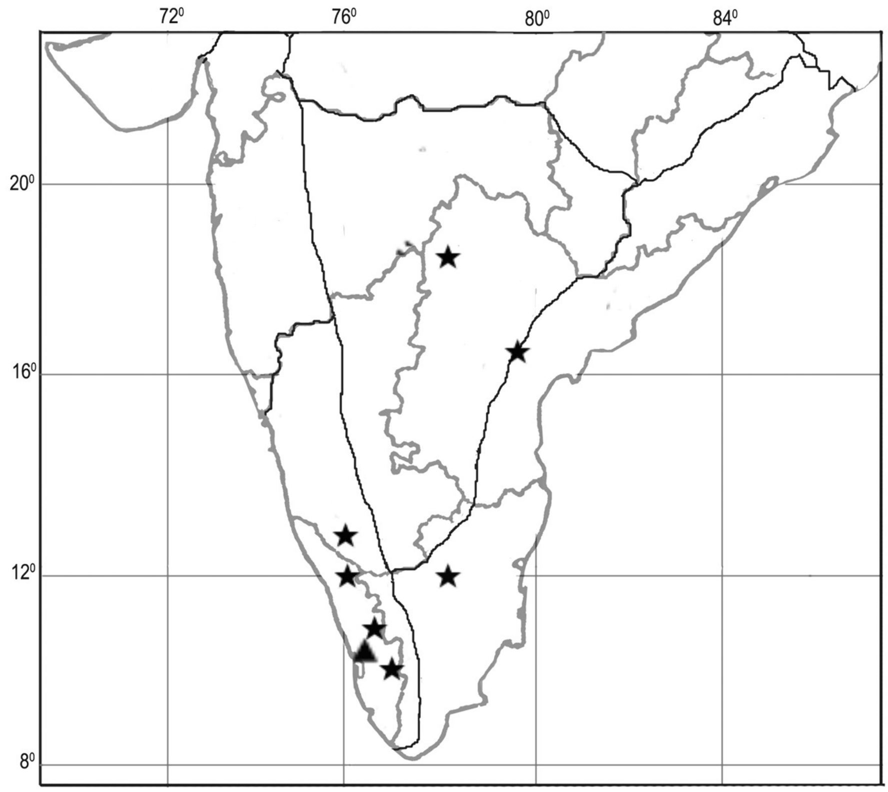
Habitat & Ecology: Lateritic soil in dry grassy plains; locally abundant; seasonal, post-monsoon specific; alt. 500-1200m.

Flowering & Fruiting: November – February.

Variation & Interrelationships: A very variable species, and two forms (tufted and. slender) have been noticed in different seasons or in mixed populations. *D. deccanensis* has affinities with *D. orissae* but differs in following aspects: (1) Usually many culms arise from base, (2) Leaves collected at base of the culm, (3) Minute wing below the apex of the upper glume, and (4) Collar region is usually decorated with ‘bulbous-based’ hairs. It also resembles *D. connivens* Hack. in general morphology, but differs in having a distinct dorsal wing on the upper glume from base to apex.

Notes: On critical observation of the type specimen of *Dimeria kolllimalayana* M. Mohanan & Rao (1984) it was found to be morphological variant of *D. deccanensis*. Also, there is no marked difference between the two in spikelet morphology. Hence, the former is treated here as conspecific with the latter.

Etymology: The specific epithet indicates 'Deccan', the major phytogeographic zone of Peninsular India.



Map 19. Distribution of *Dimeria copei* Ravi (▲) and *D. deccanensis* Bor (★)

Specimens examined: **Kerala**, Idukki Dist.: Paramada, Painavu, 22nd December 2000, *Kiran Raj CU 92919* (CALI); Palakkad Dist.: Way to south Walakkad, 9th November 1983, *Sathish Kumar SV*

11541 (CALI); *Ibid.,* Chemmanthode, 9th January 2001, *Kiran Raj CU 92923* (CALI); Pathanamthitta Dist.: Charupara, Kokkathode + 800 m, 18th November 2000, *Kiran Raj CU 92911* (CALI); Kannur Dist.: Parassinikadavu 14th December 2000, *Ravi & Kiran Raj TBG&RI 44919* (TBGT, CALI); *Ibid.,* Ezhom, 6th October 2002, *Kiran Raj CU 92845* (CALI); Kasaragode Dist.: Chemprakam, Hosedurg, 29th October 1999, *Kiran Raj TBG&RI 41503* (TBGT, CALI); *Ibid.,* Periya, 4th December 2001, *Kiran Raj CU 92948* (CALI); Wayanad Dist.: Ampumala hills, 8th January 2002, *M. Sivadasan 81033* (CALI). **Andhra Pradesh**, Medhak Dist.: Pocharam 12th November 1992, *T.Pullaiah & M.S.Gayathri 12024* (SKU).

22. Dimeria fischeri Bor - Fig. 39; Map 20.

D. fischeri Bor, Kew Bull. 7(4): 564.1953 & Grass. Burma, India & Pakistan 140.1960; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Sreek. & V. J. Nair, Fl. Kerala Grass. 89. 1991; Moulik, Grass. Bamboo. India 282. 1997; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006.

Type: India, "**Madras State**", Mahendragiri, no date, *C.E.C. Fischer 133* (K !) (Plate 25).

Annuals. Culms up to 10 cm tall, few to many, erect, smooth and glabrous, terminal node hardly exserted from spatheole, nodes bearded; Leaves usually confined at culm-base; sheath rather loose and slipping from culms, definitely keeled, smooth and glabrous, margins hyaline; ligule very short, 0.5 mm long, membranous, lacerate, ciliate at tip; leaf blades linear-acuminate, 1–7 cm x 1–4 mm, rounded at sheath-base, glabrous on both surfaces except towards base of upper surface, margins or just inside margins with long bulbous-based hairs, smooth to very minutely scabrid on both surfaces.

Raceme solitary, 2–3 cm long, peduncle hardly exserted, raceme-rachis flat, 0.75 mm wide, winged, margins ciliate; pedicels very short, flattened, thick, lip concave, ciliate on outer edge, densely bearded at upper margin. Spikelets 3.5–4 mm long; callus 0.5 mm long, densely bearded, compressed; lower glume linear-acute, 3.5 mm long (excl. callus), coriaceous, narrow, margins hyaline, densely hairy all along keel; upper glume 3–4 mm long, excluding callus, 2 mm wide when spread, very strongly compressed, keeled, winged all along keel from just above base, very thin on margins but much firmer at keel, densely ciliate on whole length of wing. Lower floret empty; lemma a hyaline scale, oblanceolate, 2 mm long, ciliate on upper half of margins. Upper floret bisexual; upper lemma ca. 2 mm x 1 mm, hyaline, 2-fid, lobes subacute, awned from sinus, awn perfect, ca. 10 mm long, column 3–5 mm long, twisted dark-coloured; palea absent; lodicules 2, minute; stamens 2; anthers ca. 0.8 mm long; styles 2; stigmas plumose.

Distribution: Southern Western Ghats (Kerala & Tamil Nadu).

Flowering & Fruiting: November – February.

Variation & Interrelationships: This species superficially resembles *D. kurzii* by the presence of solitary raceme. The distinction from the latter is mainly the presence of a keel-wing from base to apex of the upper glume.

Habitat & Ecology: Sub-gregarious on lateritic hillocks; locally abundant; seasonal, post-monsoon specific.

Etymology: Named after C. E. C. Fischer (1874–1950), Indian-born Forester, who collected the type specimen of the species.

Specimens examined: **Kerala**, Kannur Dist.: Poinachi, 30th November 1998, *Ravi & Kiran Raj TBG&RI 39725* (TBGT, CALI); *Ibid.,* Paramba, 8th December 2001, *Kiran Raj CU 92959* (CALI); *Ibid.,* Madaippara, 7th October 2002, *Kiran Raj CU 81040* (CALI); Kasaragode Dist.: Chemprakanam, 16th December 2001, *Kiran Raj CU 92962* (CALI); *Ibid.,* Mavungal, Periya, 16th October 2002, *Kiran Raj CU 92839* (CALI).

23. Dimeria jainii Sreek., V. J. Nair & N. C. Nair - Fig. 40; Map 20.

D. jainii Sreek., V. J. Nair & N. C. Nair, Curr. Sci. 52(6): 259. 1983; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Sreek.& V.J.Nair, Fl. Kerala Grass. 90. 1991; Moulik, Grass. Bamboo. India 285. 1997; Sasidh., Bio. Doc. Kerala - Fl. Pl. 566. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006.

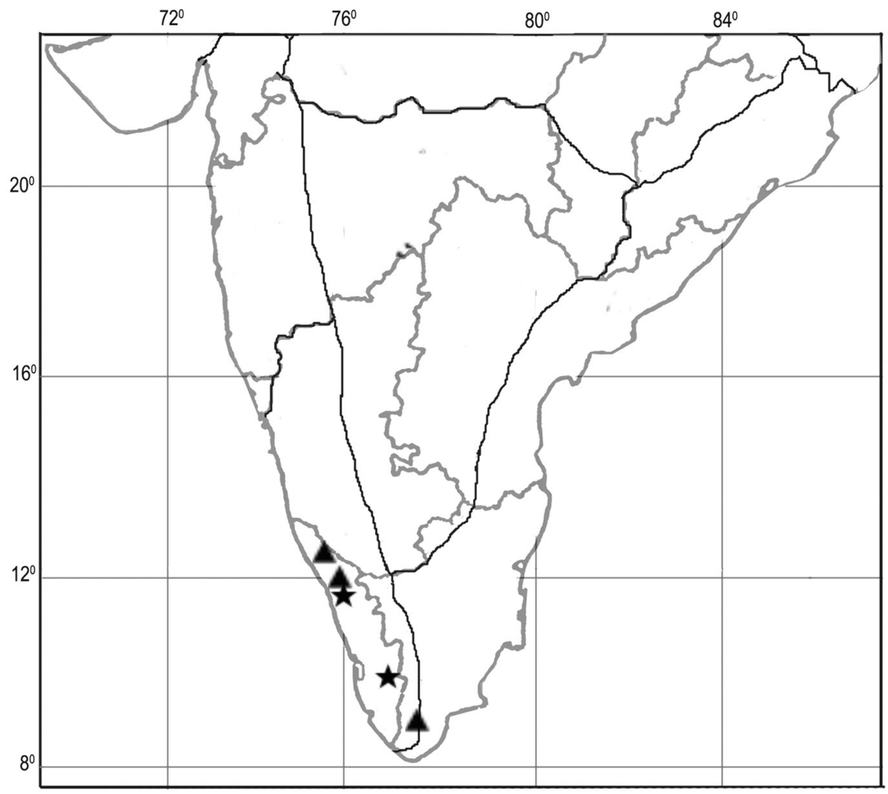
Type: India, **Kerala**, 'Calicut Dist.': Pokkunnamalai, Near Nanminda, ± 850 m, 29th October 1981, *P. V. Sreekumar 71814* (Holo -CAL!; Iso- K, MH !) (Plate 26).

Annuals. Culms erect, slender, sometimes tufted, 12–30 cm high; nodes glabrous, sometimes bearded in upper half. Leaves usually confined at culm-base; sheath keeled in upper half, rounded below and almost smooth without hairs, 1–5 cm long, shorter than internodes, slightly keeled, villous with tubercle based hairs; ligule membranous, up to 1mm long, obtuse-truncate and fimbriate at apex. blade linear-lanceolate, up to 2–7 cm x 0.3 cm, keeled on midrib below with keel continuous with that of sheath, acuminate at apex, minutely scabrid to almost smooth on lower side, bulbous-based hairs on upper surface and margins.

Racemes 3, rarely 2, ca. 3 cm long, peduncle hardly exserted; raceme-rachis flat, ca. 0.8 mm wide, margins ciliate; pedicels 0.5 mm long, flattened, lip concave. Spikelets ovate-acuminate, 3–3.5 mm long; callus short, densely bearded, callus hairs up to 1.5 mm long; lower glume coriaceous, linear-lanceolate, 2–3 mm long, shortly acuminate at apex, keeled on back, wingless, densely ciliate, scabrid towards apex; upper glume coriaceous, ovate-lanceolate, 3.5 mm long, strongly compressed, keeled on back, broadly winged, wings ca.

5 mm wide, corky in lower 2/3, wing narrower from middle upwards and absent at apex, keel and sides pilose, scabrid towards apex, margins ciliate, cilia 1–2 mm long. Lower floret empty; lower lemma thinly hyaline, elliptic-lanceolate, 1.5–2mm long; margins sparsely ciliate towards apex. Upper floret complete, bisexual; upper lemma hyaline, elliptic-obtuse, 1.75–2 mm long, bifid at apex with acute lobes, awned from sinus; awn 10–12 mm long with a column 3 mm long, twisted and scabrid; palea very short, 0.2 mm long; lodicules 2, small; stamens 2; anthers 0.5 mm long; styles 0.5 mm long; stigmas 0.5 mm long, plumose.

Distribution: Southern Western Ghats (Kerala).



Map 20. Distribution of *Dimeria fischeri* Bor (▲) and *D. jainii* Sreek. *et al.* (★)

Habitat & Ecology: Lateritic hill-slopes; locally abundant; alt. 100 – 300 m; seasonal, post-monsoon specific.

Flowering & Fruiting: October – January.

Notes: It is easily distinguished from other species by its smaller spikelets with a peculiar upper glume wing. The broad corky wing confined only in the lower 2/3 of the dorsal keeled portion of the glume.

Etymology: Named in honour of Dr. S. K. Jain, former Director, Botanical Survey of India (BSI), and a well known agrostologist of India.

Specimens examined: **Kerala**, Kozhikode Dist.: Pookkunnamala ± 350 m, 26th October 1999, *Ravi & Kiran Raj TBG&RI 41455* (TBGT, CALI); Pathanamthitta Dist.: Charupara, 18th November 2000, *Kiran Raj CU 92913* (CALI); Kannur Dist.: Parassinikadavu, 5th December 2001, *Kiran Raj CU 92950* (CALI).

24. Dimeria josephii Ravi & N. Mohanan

- Fig. 41; Plate 27, D-F; Map 21.

D. josephii Ravi & N. Mohanan, *Rheedea* 11(2): 90. 2001*;* Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 567. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006.

Type: India, **Kerala**, Palakkad Dist.: Nenmara, ± 70 m, 24th November 1998, *Ravi TBG&RI 39542* (Holo – TBGT !; Iso - CAL, CALI !, K, MH).

Annuals. Culms densely tufted, filiform, 20–30 cm tall; nodes glabrous. Leaves mostly confined to culm-base; sheath up to 8 cm long in upper ones, keeled on back all along, less prominently so in upper ones, beset with bulbous-based hairs, mostly in upper half, less prominently so in upper ones; ligule a short membrane ca. 0.25 mm long, obtuse-truncate and fimbriate at apex; blade linear-lanceolate, 4–5 cm x 4 mm, slightly narrowed into a rounded base, acuminate at apex and beset with long, bulbous-based hairs on margins and near margins on upper side and sparsely so on lower side.

Racemes 2 rarely 1, 3–5 cm long, peduncle usually well exserted; raceme-rachis flattened, ca. 1 mm wide with a longitudinal convex ridge along adaxially, margins broadly winged, ciliate; pedicel short, ca. 0.25 mm long, densely ciliate on outside and sparsely so or not on inside; lip concave. Spikelets 5–6 mm long including ca. 0.5 mm long callus; lower glume linear-oblong, 3–4 mm long, acuminate-aristate at apex, keeled on back and densely ciliate on keel with hairs considerably longer upwards, up to 1.5 mm long and sparsely hairy on thinner sides, margins ciliate especially in lower half; upper glume linear-elliptic, 5–5.5 mm long, acuminate-aristate at apex, keeled on back with keel slightly flattened into a slender wing above middle, ciliate on keel with hairs considerably longer upwards, up to 2 mm long, sparsely hairy on sides, especially towards base. Lower floret empty; lower lemma thinly hyaline, linear, oblong-elliptic, 2–3 mm long, margins sparsely ciliate except towards base. Upper floret complete, bisexual; upper lemma hyaline, elliptic, 3–3.5 mm long, bifid at apex with acute lobes and awned from sinus; awn 13–16 mm long with a column 4–6 mm long; palea hyaline, lanceolate, 0.5-0.75 mm long, sparsely papillate on outside, sometimes with 1 or 2 long hairs; lodicules 2, ca. 0.5 mm long, truncate apex, apically toothed, cuneate at base; stamens 2; anthers 0.75–1 mm long; styles ca. 0.5 mm long; stigmas ca. 0.3 mm long. Grain linear-oblong, ca. 2 mm long, subcompressed, reddish-brown in colour.

Distribution: Endemic to Southern Western Ghats confined to Central Kerala; known only from the type locality.

Habitat & Ecology: Hill slopes; on rock crevices; seasonal, post-monsoon specific; alt + 300m.

Flowering & Fruiting: October – December.

Variation & Interrelationships: D. josephii differs from *D. kurumthotticalana s. l.* in having acuminate-aristate glumes and densely ciliate keel of the both glumes and minutely winged lower glume. The species is close to *D. orissae* Bor, but distinct in having narrower (ca. 1 mm wide) rachis, larger (5–6 mm long) spikelets with a longer, longer (13–16 mm long) upper glume - awns with longer (4-6 mm long) column, and longer (0.75–1 mm long) anther (Ravi *et al*., 2001).

Etymology: Named after Dr. J. Joseph (1928-2000), former Deputy Director of Botanical Survey of India.

Specimen examined: **Kerala**, Palakkad Dist.: Nenmara, 20th December 2003, *Kiran Raj CU 92870* (CALI).

25. **Dimeria kurumthotticalana** K. C. Jacob

D. kurumthotticalana K. C. Jacob, J. Bombay Nat. Hist. Soc. 47: 49. 1947; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Sreek. & V. J. Nair, Fl. Kerala Grass. 96. 1991; Ravi & Anilkumar, Rheedea 2(2): 106. 1992; Anilkumar *et al*., Fl. Pathanamthitta 573. 2005; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 792. 2006.

Type: India, "**Travancore**", Peermedu, 3200 ft., December 1941, *K. C. Jacob 86320 A* (MH !)

D. ceylanica Bor, Kew Bull. 7(4): 562. 1953; Senaratna, Grass. Ceylon 161. 1956; Bor, Grass. Burma, India & Pakistan 140.1960; B. D. Sharma et al., Fl. Karnataka 327. 1984; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; V.J.Nair in A. N. Henry, Chithra & N. P.

Balakr., Fl. Tamilnadu 3: 109. 1989; Moulik, Grass. Bamboo. India 281.1997; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006. – *Type:* Sri Lanka, *Thwaites 956 pro part*e (K !)

D. sreenarayane Ravi & Anilkumar, Rheedea 2 (2): 101.1992 ('sreenarayanii'); Moulik, Grass. Bamboo. India 285.1997; Sasidh., Bio. Doc. Kerala - Fl. Pl. 567. 2004 – *Type:* India, Kerala, Idukki Dist.: Peermedu, Kuttikkanam, 30th December 1991, *Anil Kumar* 3297 (Holo- MH !; Iso - CAL, KFRI)

D. pubescens auct. non, Hack., 1889: C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 176. 1994.

Annuals. Culms usually tufted, 30–100 cm long, erect. Leaf-blades linear-lanceolate, 10–20 cm x 2–4 mm, Racemes 1–2, sub digitate, 6–10 cm long; raceme-rachis flattened, ca. 1 mm wide, winged, margins hairy; pedicels truncate, ca. 0. 5 mm long, flattened. Spikelet elliptic-lanceolate; callus short, bearded; glumes coriaceous, dissimilar, hairy along keel-wing; lower glume keeled from middle upwards, narrowly winged at apex; upper glume keeled in upper half, winged in upper half, acuminate to aristate at apex. Lower floret barren; lemma lanceolate, hyaline, margins ciliate in upper half. Upper floret fertile; lemma elliptic, 2-fid, sub-hyaline, 1-veined, awned; awn from a sinus, geniculate, 8–12 mm long overall, column ca. 3 mm long, twisted, glabrous; palea 0.5 mm long. Lodicules present.

Notes: Bor (1953) described *D. ceylanica* based on the collections from Sri Lanka. Ravi (1992) recognised another species as '*D. sreenarayane'* from Central Kerala. The critical examination of the type specimens of both has revealed that both of them are conspecific to *D. kurumthotticalana.*

The evidence for uniting these taxa may be summed up as fallows:

1. The populations of species existed in two morphological forms, viz. one with long culm and slender habit, and the other with short and tufted culms habit.

2. In addition to the above forms, several intermediates were also found.

3. In one and the same raceme, the lowest spikelets sometimes have the upper glume-wing extending narrowly along the whole length of the keel, a feature mentioned in *D. sreenarayane* (Ravi & Anilkumar, 1992) and the upper spikelets have the upper glume-wing confined only at apex.

Based on the above observations, *D. ceylanica* and *D. sreenarayane* can be considered as the morphological variants of *D. kurumthotticalana*. The critical analysis of the type specimens of above three taxa was also revealed that there was no marked difference in the spikelet morphology of them. Bor (1953) mentioned that ‘tip of the upper glume recurved’ as a key character in *D. ceylanica*, but this character was also variable.

Etymology: The specific epithet is based on the name “Kurumthottical”, which is the name of the author’s (K. C. Jacob) ancestral home.

Two varieties of the species are found in Peninsular India.

Key to the varieties of *Dimeria kurumthotticalana* K. C. Jacob

1a. Culms 20–60 cm high, raceme 1(–2); collar region sparsely hairy with tubercle-based hairs. .... … **25a. D. kurumthotticalana** K.C. Jacob var. **kurumthotticalana**

1b. Culms up to 1m high; racemes always 2; collar region densely hairy with tubercle-based hairs. ....**25b. D. kurumthotticalana** K. C. Jacob var. **idukkiensis**

25a. Dimeria kurumthotticalana K. C. Jacob var. **kurumthotticalana** – Fig. 42; Plate 28, A; Map 21.

Type: India, “**Travancore**”, Peermedu, 3200 ft., December 1941, *K. C. Jacob 86320 A* (MH !)

Annuals. Culms slender, erect or geniculate, 35–60 cm high; nodes bearded. Leaves scattered; sheath loose, slipping from culm, tight above, distichous below, keeled in upper half, rounded below, usually covered with thick mat of hairs or almost smooth in lower half; ligule membranous, up to 1mm long, truncate and fimbriate at apex; leaf blade linear-lanceolate, up to 20 cm x 2.5–3 mm, keeled on midrib below with keel continuous with that of sheath, acuminate at apex, minutely scabrid and bulbous-based hairs on both surface and on margins.

Racemes 1 rarely 2, divergent, 6–10 cm long, straight or curved, peduncle long-exserted; raceme-rachis flat or slightly convex on dorsal side, ca. 1 mm wide, ciliate along wings, hardly winged, without an intramarginal line; pedicels alternately arranged, 0.3 mm long, flattened, concave on upper margin. Spikelets elliptic-lanceolate, 4.5–5 mm long; callus short, bearded; lower glume coriaceous, linear-acuminate, 4–4.5 mm long, strongly keeled in upper third of back, and rounded below, narrowly winged along keel, scabrid in upper half and densely hairy; upper glume coriaceous, elliptic-acuminate, 4.5–5 mm long, strongly compressed and keeled in upper half, rounded on back in lower half, with acuminate tip sometimes slightly recurved, winged in upper half, tip of wing always acuminate, margins ciliate along dorsal side. Lower floret empty; lower lemma thinly hyaline, oblanceolate-acute, 2.5 mm long; 1-nerved, margins sparsely ciliate on upper half. Upper floret complete, bisexual; upper lemma hyaline, elliptic-acute, 3 mm long, bifid at apex with acute lobes, awned from sinus; awn 9-11 mm long with a column 2.5–3 mm long, twisted and scabrid; palea 0.5 mm long; lodicules 2, small;

stamens 2; anthers ca. 2mm long; styles 2; stigmas plumose. Grain reddish-brown, subcompressed, 1.5 mm long.

Distribution: Sri Lanka and South India (Kerala, Tamil Nadu).

Habitat & Ecology: Rocky hill slopes, grassy hill-slopes; locally abundant; seasonal, post-monsoon specific; alt. 50–1000 m.

Flowering & Fruiting: November – February.

Variations & Interrelationships: D. kurumthotticalana is found to be highly variable in general morphology. Much variation has been observed in the vegetative characters, based on the nutrient availability of the soil where it grows (see '*Notes*'). The striking varying feature in the floral character is 'upper glume-tip' of the spikelet which may be recurved or not.

D. kurumthotticalana is somewhat similar to *D. pubescens* and *D. trimeni* in the vegetative as well as spikelet morphology.

Specimens examined: **Kerala**, Kannur Dist.: Periya, 13th December 1997, *Ravi & Kiran Raj TBG&RI 36929* (TBGT, CALI); *Ibid.,* Pilapalla, 2nd December 2001, *Kiran Raj CU 92944* (CALI); *Ibid.,* Chemeni 60m, 3rd December 2001, *Kiran Raj CU 92946* (CALI); Pathanamthitta Dist.: Kokkathode, 22nd December 2000, *Kiran Raj CU 92918* (CALI); *Ibid.,* Charupara ± 800 m, 18th November 2000, *Kiran Raj CU 92910* (CALI); *Ibid.,* Kattathipara, ± 1000 m, 13th November 2001, *Kiran Raj CU 92927* (CALI)l; Idukki Dist.: Kalvary mount, 1210 m, 16th November 2000, *Kiran Raj CU 92908* (CALI); **“Madras state”**, Chickenalli, 1000 m, November 1908, *Meebold 10755* (DD).

25b. **Dimeria kurumthotticalana** K. C. Jacob var. **idukkiensis** (Ravi & Anilkumar) Kiran Raj *et* Sivad. *comb.* et *stat. nov.* (*ined*.)

- Fig. 43; Map 21.

Type: India, **Kerala**, Idukki Dist.: Peermedu, Kuttikkanam, 19th October 1991, *Anil Kumar 3190* (Holo – MH !; Iso – TBGT !; CAL, KFRI).

Dimeria idukkiensis Ravi & Anilkumar, Rheedea 2 (2): 1992; Sasidh., Bio. Doc. Kerala - Fl. Pl. 586. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 791. 2006.

Annuals. Culms erect, slender or tufted, unbranched, up to 1 m tall, smooth; usually bearded at nodes; Leaves scattered all along culm; sheath closely investing internodes, prominently keeled on back towards apex, up to 6.5 cm long; blade linear-lanceolate, acuminate, slightly rounded at base, provided with long tubercle-based hairs on margins and veins, prominently so on lower surface, membranous, more or less greenish when dry, up to 5 cm x 5 mm; ligule membranous, fimbriate at truncate apex, 1 mm long.

Racemes 2, 3–4cm, slightly divergent; raceme-rachis flattened, ca. 0.75 mm wide, winged, wing1 mm broad more or less straight on back, angled adaxially and zig-zag; margins sparsely shortly ciliate;

pedicels short, 0.5–0.75 mm long, thick, lip concave. Spikelets elliptic-oblong, 4.5–5.5 mm long awned; callus 0.75 mm long, acute; lower glume linear-elliptic, 3.5 x 0.5 mm; acute, apex shortly curved, keeled; keel narrowly winged on upper two-thirds, scaberulous along back and sides, especially towards apex and base, ciliate on keel in lower half, sometimes shortly towards margins below middle; upper glume elliptic-oblong, 4.25–5.25 x 0.75 mm; acute to shortly acuminate, keeled, prominently winged in upper $1/3^{rd}$ to $2/5^{rd}$ of keel with long ciliate hairs along back from above or below middle except tip, margins sparsely ciliate towards middle. Lower floret empty; lower lemma oblanceolate, ca. 2.5 mm long, acute at apex, cuneate at base, hyaline, margins sparsely ciliate in upper half. Upper floret complete, bisexual; upper lemma elliptic-lanceolate, bifid at apex, awned from sinus; awn geniculate, ca. 12 mm long with a chestnut brown 4–5 mm long column; palea absent; lodicules 2, small; stamens 2, anthers 1 mm long; ovary 0.5 mm long, stigma plumose. Grain reddish-brown, 1.5 mm long.

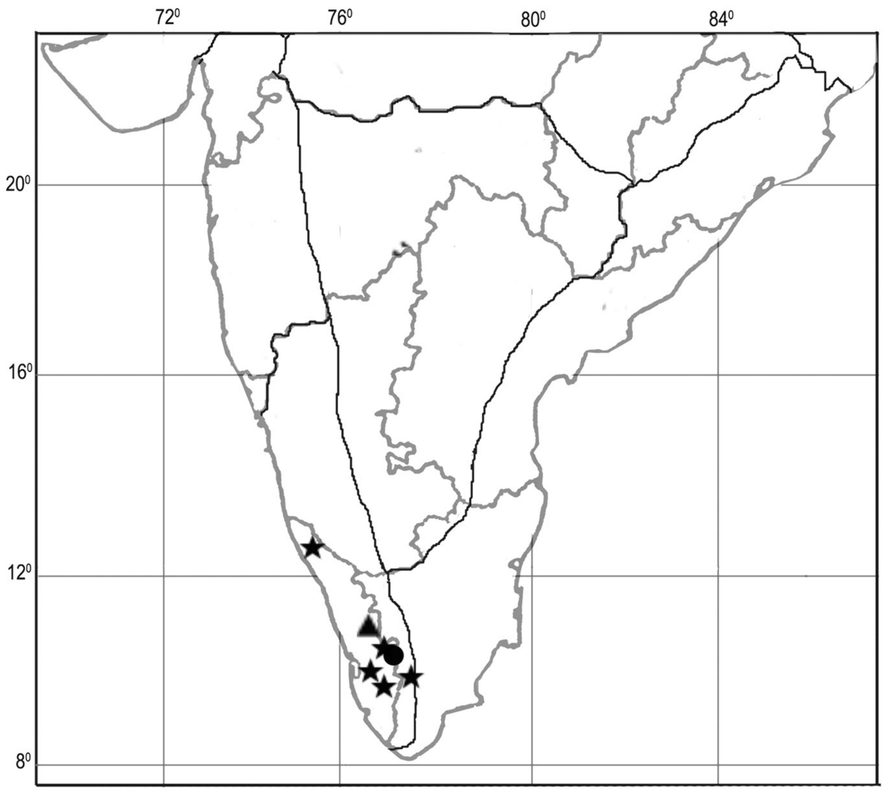
Distribution: Endemic to Southern Western Ghats regions of Kerala (Idukki and Pathanamthitta districts).

Habitat & Ecology: Rocky surfaces in small pockets of soil along the margins of forests; locally abundant; alt. 600 –1000 m.

Flowering & Fruiting: October – February.

Notes: The distinction from the typical variety is not sharp.

Etymology: The varietal epithet is indicative of the name Idukki District of Kerala State, to which the type locality belongs to.



Map21. Distribution of *Dimeria josephii* Ravi & Mohanan (▲), *D. kurumthotticalana* K. C. Jacob var. *kurumthotticalana* (★), and *D. kurumthotticalana* K. C. Jacob var. *idukkiensis* Ravi & Anilkumar (Kiran Raj et Sivad.) (●)

Specimens examined: **Kerala**, Pathanamthitta Dist.: Kuttikanam, 1100 m, *Kiran Raj CU 92901, CU 92902* (CAL); *Ibid.,* Arable land, Kokkathode, 16th November 2000, *Kiran Raj CU 92908* (CALI); *Ibid.,* Ponnambalamedu, 5th January 1996, *Ravi TBG&RI 24051* (TBGT). Idukki Dist.: Kodikuthi 300m, 13th November 2000, *Kiran Raj CU 92903* (CALI); *Ibid.,* Peermedu 820 m, 15th November 2000, *Kiran Raj CU 92904* (CALI); *Ibid.,* Painavu 910 m, 16th November 2000, *Kiran Raj CU 92906* (CALI); *Ibid.,* Udumbumchola, 21st December 2000, *Kiran Raj CU 92917* (CAL).

26. Dimeria kurzii Hook.f. - Fig. 44; Plate 29, C; Map 22.

D. kurzii Hook.f., Fl. Brit. India 7: 103. 1896; Ridley, Fl. Malay Peninsula 192. 1925; Bor, Kew Bull. 7(4): 565. 1953, Grass. Burma, India & Pakistan 142.1960.

Type: Burma, **Pegu**, Irrawady and Sittang Valley, 27th December 1870, *S. Kurz 2741* (K !)

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *kurzii* Roberty, Boissiera 9: 398. 1960, *nom. inval.*

Annuals. Culms very slender, capillary, terete, smooth and glabrous, up to 60 cm tall, erect from base, several-noded, with terminal internode long-exserted from sheath, bearded at nodes. Leaves ascending; sheaths smooth and shining in their lower halves, with many tubercle-based hairs from grooves between veins in upper half, sharply keeled on upper half, round on back and shiny on lower half, rather loose at base; ligule membranous, 0.5–1 mm long, upper margin ciliate; leaf blades linear-acute, 4–8 cm x 2–3.5 mm, covered on both surfaces, with tubercle-based hairs, margins with same type of hairs, coarsely scabrid on margins near tip, minutely scabrid on both surfaces.

Raceme 1, 3.5–5 cm long, peduncle long exserted; raceme-rachis flattened, ca. 0.75 mm wide, narrowly winged, thickly ciliate all along each margin; pedicel short, flat, hairy along outer margins, and concave tip. Spikelets 3–3.5 mm long, very compressed, oblong, with a very short bearded callus; lower glume very narrow, oblong-acute, strongly compressed, 2.5 mm long, very shortly aristate or without an arista, densely ciliate on keel and sides with short white hairs; upper glume oblong-acuminate, 3–3.5 mm long, strongly compressed, keeled, densely ciliate on two lateral nerves and on keel, with a few longer hairs towards tip. Lower floret empty; lemma 1.5 mm long, hyaline. Upper floret bisexual; lemma 2 mm long, narrowly elliptical, 2-fid at apex, lobes sub-hyaline, awn 12–18 mm long, column 4 mm long; palea absent; lodicules 2, small; stamen 2, anthers 0.6 mm long; styles 2; stigmas plumose.

Distribution: Myanmar and Southern Western Ghats (Kerala). It is the first report for the species from South India.

Habitat & Ecology: Lateritic and rocky hills; on rock crevices; seasonal, post-monsoon specific.

Flowering & Fruiting: October – December.

Notes: D. kurzii is related to *D. fischeri* from which it can be easily distinguished by its long exserted peduncle, smaller spikelets, and wingless upper glumes, or with a minute wing along the dorsal keel at the apex.

Etymology: Named after S. Kurz (1834–1878), German botanist who was in the Dutch East Indian army and Curator of the Calcutta Herbarium.

Specimen examined: **Kerala,** Kannur Dist.: Chalingal, on the way to Periya, 7th December 2001, *Kiran Raj CU 92958* (CALI).

27. Dimeria lawsonii (Hook. f.) C. E. C. Fisch. - Fig. 45; Map 22.

D. lawsonii (Hook. f.) C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Bor, Kew Bull. 7(4): 566. 1953; Bor, Grass. Burma, Ceylon, India and Pakistan 142. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 327. 1984; V.J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamilnadu 3: 109. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Sreek. & V. J. Nair, Fl. Kerala Grass. 97. 1991; Kesh.Moorthy & Yogan., Fl. Coorg 537.1990; Subramanian, Fl. Thenmala 448. 1995; Moulik, Grass. Bamboo. India 282. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 271. 2001; Ravi & N. Mohanan, Comm. Trop. Sub-trop. Sedge. Grass. 137. 2002; K. G. Bhat, Fl. Uduppi 795. 2003; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 586. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 792. 2006.

Type: Type: “Madras state”, Waynadu, 24th November 1888, *Lawson 22* (Holo – K!) (Plate 30).

D. pusilla Thw., Enum. Pl. Zeyl. 369. 1864. var. *lawsonii* Hook. f., Fl. Brit. India 7: 103. 1897; C. E. C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934 – *Type:* "Madras state", Waynadu, 24th November 1888, *Lawson 22* (Holo – K!)

D. avenacea sensu M. Mohanan & A. N. Henry, Fl. Thiruvananthapuram 537. 1994: non C.E.C. Fisch., 1932.

Annuals. Culms slender and tufted, up to 45 cm long, erect to decumbent at base and soft-hairy to glabrous; nodes sparsely bearded. Leaves all along culm; sheath up to 8 cm long, keeled on back, glabrous; ligule membranous, ca. 0.5 mm long, and fimbriate at apex; leaf blade linear-acuminate, ca. 10 cm x 3 mm, long-acuminate at apex, shortly narrowed to base and sparsely hairy with bulbous-based hairs, especially towards base and margins.

Racemes 1 rarely 2, 6–8 cm long, peduncle well exserted, raceme-rachis 0.75 mm wide, flattened on back, convex on face, winged and ciliate on margins; pedicel short, ca. 0.2 mm long, concave at apex and hairy. Spikelets oblong-elliptic, 4.5–7 mm long (incl. 1–2 mm long upper glume-arista); callus 0.2–0.3 mm long, bearded; lower glume elliptic to oblong-elliptic, 3.75–5 long, acuminate-aristate at apex, subcoriaceous, keeled on back, keel very narrowly winged in upper half and densely hairy with long, silky hairs except towards spinulose apex; upper glume subcoriaceous, elliptic-lanceolate, 4.5–6.75 mm long including 1–2 mm long arista, keeled and winged on back, wing somewhat broad, in upper 1/3 to almost 1/2 tapering to below middle or almost to base and densely long-ciliate with silky hairs on margin except towards scaberulous, aristate apex, sparsely to moderately densely hairy on sides, margins hyaline, and sparsely short-ciliate. Lower floret empty; lower lemma hyaline, oblanceolate, ca. 0.2 mm long, acute at apex, margins sparsely ciliate in upper half. Upper floret complete, bisexual; upper lemma hyaline, elliptic, ca. 2.5 mm long, bifid at apex and awned from sinus; awn up to 12 mm long with column 3–4 mm long; palea hyaline, ca. 0.5 mm long and papillate; lodicules 2, ca. 0.25 mm long; stamens 2; anthers 1 mm long; styles ca. 0.6 mm long; stigmas ca. 0.6 mm long. Grain linear-oblong, 2–2.25 x ca. 0.3 mm, compressed, acute at apex and pale brown.

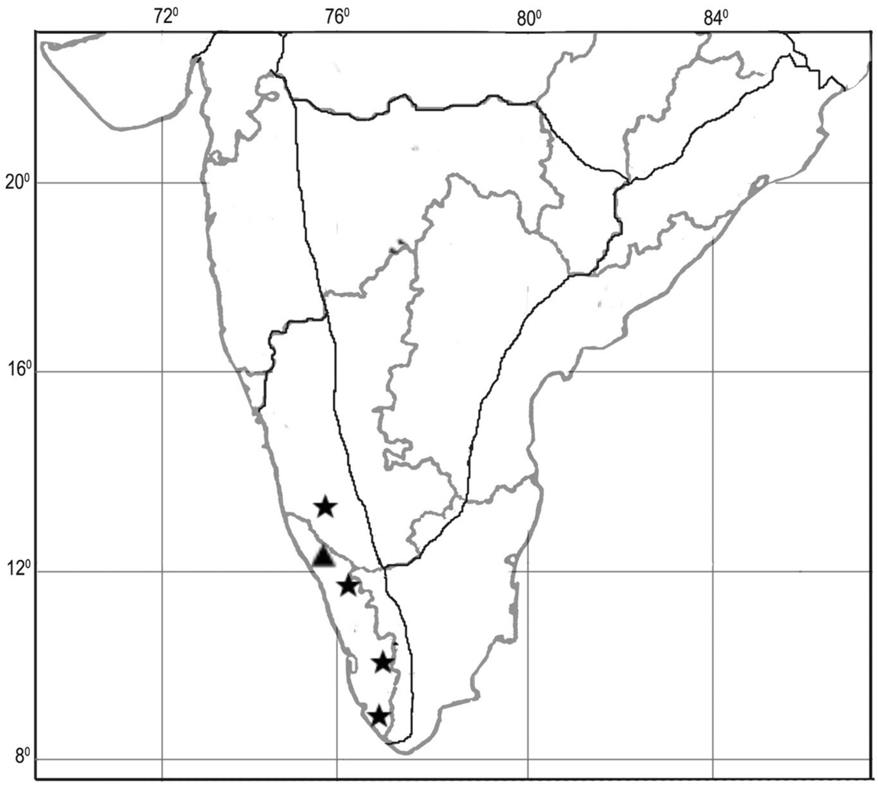
Distribution: Endemic to Southern Western Ghats (Kerala, Karnataka)

Habitat & Ecology: Common in hilly tracts on cuttings, roadsides, hill slopes and at low elevations on sandy soil near coasts.

Flowering & Fruiting: September – January.

Variations & Interrelationships: The wing of the upper glume sometimes does not reach the base of the glume. Culm-length may also vary from place to place based on the fertility of the soil.

The species closely resembles *D. avenacea* (Retz.) C.E.C.Fisch. in general mophology but differs from it in having very short callus (0.3 mm *vs.* 1.5 mm), smaller spikelets and shortly-awned upper glume.



Map 22. Distribution of *Dimeria kurzii Bor* (▲), and *D. lawsonii* (Hook. f.) C. E. C. Fisch. (★)

Etymology: Named after M.A. Lawson (1840–1896), who was a British botanist and the Director of Cinchona Plantations, Nilgiris in 1885.

Specimens examined: **Kerala**, Thiruvananthapuram Dist.: Bonaccord forest margins, 14th November 1996, *Ravi 31758, 31759, 31774* (TGBT); *Ibid.,* Bonaccord 450 m, 22nd November 2001, *Kiran Raj CU 92935* (CALI); *Ibid.,* Ponmudi, 3rd January 2002, *Kiramn Raj 92969* (CALI); Wayandu Dist.: Banasuramala, 12th December 2001, *Kiran Raj CU 81018* (CALI); Pathanamthitta Dist.: Kuttikanam 1100 m, 15th November 2001, *Kiran Raj 92932* (CALI); **Karnataka,** Uttara Kannada Dist.: Jog falls, 27th December 2003, *Kiran Raj CU 92875* (CALI).

28. Dimeria mahendragiriensis Ravi, H. O. Saxena & Brahmam

- Fig. 46; Map 23.

D. mahendragiriensis Ravi, H. O. Saxena & Brahmam, Rheedea 5(2): 142.1995; H. O. Saxena & Brahmam, Fl. Orissa 4: 2337. 1996.

Type: India, **Orissa,** Ganjam Dist.: Mahendragiri, 22nd November 1979, *Saxena & Brahmam 3880* (Holo – RRL , Iso – TBGT !).

Perennials. Culms erect, slender and branched, stoloniferous, rooting at nodes; nodes mostly ciliate. Leaves scattered; sheath up to 6 cm long, lower ones longer than internodes and slipping from culm, keeled on back, margins hyaline, glabrous or sparsely ciliate with bulbous-based hairs; ligule membranaceous, truncate at apex, 1–1.5 mm long; leaf blade linear-lanceolate to elliptic, more or less rounded at base, acuminate at apex, up to 10 cm x 4 mm, flattened on mid-rib above and keeled below, ciliate with bulbous-based hairs towards base, prominently so on margins on upper surface and scaberulous on margins towards lip.

Raceme 1 rarely 2, 3–5 cm long, peduncle well exserted; raceme-rachis flattened on back, ca. 0.75 mm wide, prominently ridged adaxially, margins distinctly winged, wings ciliate; pedicels ca. 0.5 mm long, lip concave, thickly ciliate on outside and sparsely inside. Spikelets elliptic, 4–5 mm long; callus ca. 0.5 mm long, callus hairs up to 0.75 mm long; lower glume oblong-elliptic, acute-aristate at apex, 3–3.5 x 0.5–0.6 mm (when folded), strongly keeled on back, keel narrowly winged in upper half, ciliate on keel except towards scaberulous apex, and sparsely short-ciliate on sides; upper glume subcoriaceous, oblong-elliptic, acute-aristate at apex, 4–4.5 x 1(–1.2) mm (when folded), broadly winged on keel; wing narrowed to base, papery towards apex and corky below, densely ciliate on back except towards scaberulous apex with a few longer hairs on sides in upper half; sides subcoriaceous, sparsely ciliate; margins hyaline, shortly ciliate in middle. Lower floret empty; lower lemma oblanceolate, acute at apex, cuneate at base, hyaline, 2–2.5 mm long, margins sparsely ciliate on upper half. Upper floret complete, bisexual; upper lemma elliptic, bifid at apex with acute lobes, 2.5–3 x 0.5 mm (when folded), awned from sinus; awn up to 10 mm long with a 3 mm long column; palea linear-elliptic, 0.5 – 0.75 mm long, papillate in upper half and long-ciliate towards apex; lodicules 2, cuneate at base; stamens 2; anthers 1.5 mm long; styles 2, ca.1 mm long; stigmas 2, ca. 1 mm long. Grain subcompressed, acute to subacute at apex, 1.75-2 mm long.

Distribution: Restricted to Mahendragiri Hills, one of the centres of endemism on Eastern Ghats in Orissa State; known only from the type locality.

Habitat & Ecology: Rocky hill-slopes; alt. $\pm$ 550 m.

Flowering & Fruiting: October – January.

Interrelationships: D. mahendragiriensis is close to *D. lehmanii* (Nees) Hack., but distinct in having solitary racemes, lower glume keeled all along the back and narrowly winged towards the tip, wing of the upper glume papery towards apex and corky below and longer awn.

Note: The species could not be collected during the present study.

Etymology: The specific epithet is based on the name of the type locality – Mahendragiri Hills, Orissa State, India.

29. Dimeria mooneyi Raiz. ex Mooney

D. mooneyi Raiz. ex Mooney, Suppl. Bot. Bihar & Orissa 263. 1950; Bor, Kew Bull. 7(4): 569. 1953, Grass. Burma, Ceylon, India and Pakistan 142. 1960; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; V. J. Nair in A. N. Henry, Chithra & N. P. Balakr., Fl. Tamil Nadu 3: 110. 1989; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Moulik, Grass. Bamboo. India 281. 1997; K. G. Bhat & Nagendran, Sedges & Grasses 269. 2001; K. G.

Bhat, Fl. Uduppi 795. 2003; Anilkumar *et al.,* Fl. Pathanamthitta 573. 2005; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006.

Type: India, **Orissa**, Sambalpur Dist.: Sonabera village, 700m, September 1949, *H. F. Mooney 3652* (Holo-K !, Iso-DD !)

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *mooneyi* Roberty, Boissiera 9: 398. 1960, *nom. Inval.*

Annuals. Culms usually slender or few from base, 10–20 cm long, erect. Leaf-blades linear-lanceolate, 2–6 cm x 2–3 mm. Racemes 1–2, sub digitate, 2–4 cm long; raceme-rachis flattened, ca. 1.5 mm wide, winged, margins hairy; pedicels truncate, ca. 0. 5 mm long, flattened, lip concave; callus prominent. Spikelet ovate-elliptic; callus short, bearded; glumes coriaceous, dissimilar, distinctly keeled, winged; wing corky, and hairy. Lower floret barren; lemma lanceolate, hyaline, margins ciliate in upper half. Upper floret fertile; lemma elliptic, 2-fid, sub-hyaline, 1-veined, awned; awn from a sinus, geniculate, 13–15 mm long overall, column ca. 4 mm long, twisted, glabrous; palea 0.5 mm long. Lodicules present.

Two varieties can be found in Peninsular India.

Key to the varieties of *Dimeria mooneyi* Raiz. Ex Mooney

1a. Callus ca.1 mm long, glume wings ciliate towards apex only, wing of the lower glume broader at middle and narrowed towards base and apex. ....**29b. D. mooneyi** var. **borii**

1b. Callus ca. 0.5 mm long, glume wings ciliate from base to apex, wing of the lower glume uniform. .... **29a**. **D. mooneyi** var. **mooneyi**

29a. Dimeria mooneyi Raiz. ex Mooney var. **mooneyi**

- Fig. 47; Plate 28, B; Map 23.

Type: India, **Orissa**, Sambalpur Dist.: Sonabera village, 700m, September 1949, *H. F. Mooney 3652* (Holo-K !, Iso-DD !) (Plate 31).

Annuals. Culms up to 20 cm tall, terete, stiff, erect, smooth and glabrous, 3–6-noded, bearded at upper nodes. Leaves usually confined to culm-base; sheaths somewhat loose and slipping from culm, becoming scarious when old, margins very hyaline, smooth and glabrous, keeled in upper half; ligule membranaceous, truncate ca. 1 mm long, ciliate; blades lanceolate to linear-acuminate, 2–6 cm x 2–3 mm, rounded at base, margins thickened, very minutely scabrid or smooth on both surfaces, clothed on both surfaces with tubercle-based white hairs to almost glabrous, usually with a few, tubercle-based hairs on margins below, tapering to a stout point.

Raceme 1 or 2, silky, 2–3 cm long, closely pressed together at first, eventually divergent; raceme-rachis linear, flat, 1.5 mm wide, winged, thickly or somewhat sparsely ciliate on margin, 5.5 cm long, keeled on ventral surface; pedicel flat, 0.5 mm long, densely bearded, lip concave. Spikelets 5–6 mm long, coriaceous, with bright green markings near tip; callus 0.5–1 mm long, not appressed to rachis, short bearded; lower glume 4.5–5 mm long, narrowly oblong-acuminate, with a corky wing on back all along or in lower two-thirds, ciliate all along dorsal surface with hairs getting longer towards tip; upper glume 5–6 mm long, very thickly winged along keel, wing corky throughout except at tip, long ciliate all along keel, margins hyaline and ciliate. Lower floret empty; lemma linear-oblong ca. 3 mm, hyaline, margins long ciliate near apex. Upper floret complete; lemma hyaline, 2.5–3.5 mm long, elliptic-acute, cleft at tip into two acute lobes; awn 13–15 mm long; column dark-chestnut coloured, twisted, 4–5 mm long; palea absent; lodicules 2, truncate, ob-cuneate, minute; stamens 2; anthers 1.75 mm long; styles 2; stigmas plumose.

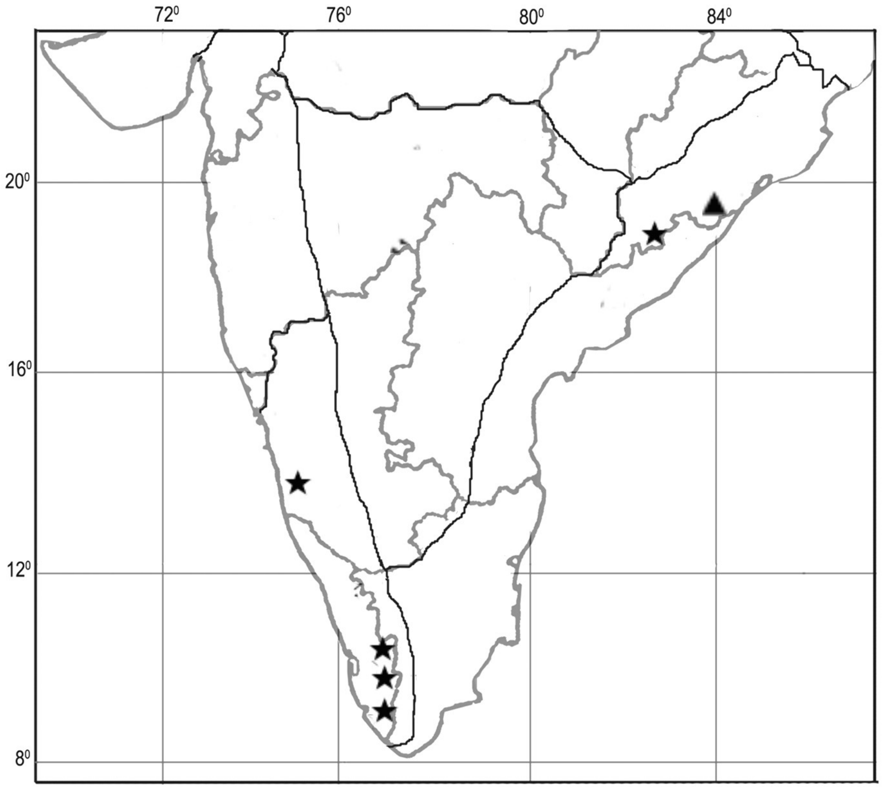
Distribution: Endemic to Peninsular India (Kerala, Karnataka, Tamil Nadu and Orissa).

Habitat & Ecology: In clefts and rock crevices; locally abundant; seasonal, post-monsoon specific; alt. 150 – 400 m.

Flowering & Fruiting: November – February.

Variation & Interrelationships: The corky wing of the lower glume is sometimes narrower towards base. This variations has been observed in spikelets of different seasons. The species closely resembles *Dimeria balakrishnaniana* but differs mainly in having broadly winged lower glume.

Notes: Raizada (1948) had first described the species from Orissa state based on the collections of Mooney. The name was invalid due to the lack of Latin diagnosis, and later it was validly published by Mooney (1950).



Map 23. Distribution of *Dimeria mahendragiriensis* Ravi et al. (▲), and *D. mooneyi* Raiz. ex Mooney var. *mooneyi* (★)

Etymology: Named after Dr. H. F. Mooney (1898 – 1964), who first collected the specimens based on which the species is described as new to science.

Specimens examined: **Kerala**: Idukki Dist.: Peermedu, 28th November 1996, *Ravi TBG&RI 24761, 24744, 24748* (TBGT, CALI); *Ibid.,* Kodikuthi 300m, 22nd December 2000, *Kiran Raj CU 92920* (CALI); Pathanamthitta Dist.: Ranni, Manipilavu, 13th November

2001, *Kiran Raj CU 92928* (CALI); *Ibid.,* Poojapura, 14th November 2001, *Kiran Raj CU 92929* (CALI); Thiruvananthapuram Dist.: Bonaccord 480m, 2nd January 2002, *Kiran Raj CU 92966* (CALI); **Karnataka**, Uduppi Dist.: Kollur, 29th December 2003*, Kiran Raj 96110* (CALI).

29b. Dimeria mooneyi Raiz. ex Mooney var. **borii** (Sreek. *et al*.) Kiran Raj et Sivad. - Fig. 48; Map 24.

D. mooneyi Raiz. ex Mooney var. *borii* (Sreek., V.J.Nair & N.C.Nair) Kiran Raj *et* Sivad. *comb.* et *stat. nov.* (ined.)

Type: India, **Kerala**, 'Calicut Dist.': Kanjeerakkadavu, near Kakkayam, ± 900 m, 26th November 1981, *P. V. Sreekumar 71855* (Holo – CAL, Iso - K, MH !) (Plate 32).

Dimeria borii Sreek., V. J. Nair & N.C. Nair, J. Econ. Taxon. Bot. 3: 657.1982; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 209. 1989; Moulik, Grass. Bamboo. India 283. 1997; Sasidh., Bio. Doc. Kerala - Fl. Pl. 565. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 790. 2006. -- *Type:* India, Kerala, 'Calicut Dist.': Kanjirakkadavu, near Kakkayam, ± 900 m, 26th November 1981, *P. V. Sreekumar 71855* (Holo – CAL; Iso - K, MH !)

Annuals. Culms 10–15 cm tall, terete, stiff, erect, smooth and glabrous, bearded at upper nodes. Leaves scattered; sheaths somewhat loose and slipping from culm, margins hyaline, smooth and glabrous or more or less covered in upper half with bulbous-based hairs, keeled in upper half; ligule membranaceous, truncate, less than 1 mm long, ciliate; leaf-blades lanceolate to linear-acuminate, 2–6 cm x 2–3 mm, rounded at sheath base, margins thickened, very minutely scabrid or smooth on both surfaces, margins scabrid particularly towards the stout tip, erect, clothed on both surfaces with tubercle-based white hairs to almost glabrous, usually with a few, spaced tubercle-based hairs on the margins below.

Racemes 2, 3–5 cm long, sometimes peduncle hardily exserted; raceme-rachis linear, flat, 1.5 mm wide, winged, sparsely ciliate on margin, keeled on ventral surface, pedicels flattened, 0.4 mm long, lip concave, more or less densely bearded. Spikelets very compressed, 5–5.5 mm long, 2 mm wide when spread, coriaceous, with bright green markings near tip; callus ca. 1 mm long, cuneate, bearded, not appressed to rachis; lower glume 4–4.5 mm long, narrowly oblong-acuminate, with a corky wing all along back or in lower two-thirds, wing ciliate towards apex; upper glume 5–5.5 mm long, broadly winged along keel; wings corky in lower 2/3, papery towards apex, long ciliate along keel towards apex, margins hyaline and ciliate. Lower floret empty; lemma oblong, ca 3 mm long, hyaline, margins ciliate near tip. Upper floret complete; lemma hyaline, 2.5–3.5 mm long, elliptic-acute, cleft at tip into two acute lobes, awn 13–15 mm long; column dark-chestnut coloured, twisted, 4–5 mm long; palea absent; lodicules 2, truncate, ob-cuneate, minute; stamens 2; anthers 1.75 mm long; styles 2; stigmas plumose.

Distribution: Endemic to Southern Western Ghats (Kerala).

Habitat & Ecology: Dry lateritic hill-slopes; growing in the crevices of rocks; locally abundant; seasonal, post-monsoon specific.

Flowering & Fruiting: November – February.

Notes: Sreekumar *et al*. (1982) described *D. borii* against *D. mooneyi* based on the combination characters like glabrous nodes, raceme-rachis width ca. 1 mm, 4 mm raceme length etc. But all these features are quite variable and not sufficient to regard as a separate species, but place this taxon within the limits of *D. mooneyi.* It differs slightly from *D. mooneyi* var. *mooneyi* in having a long callus (1mm long) and hence treated it as a distinct variety of the former and made this combination.

Etymology: Named after N. L. Bor (1893–1972), a well known agrostologist who first extensively studied the genus *Dimeria* s. str. in Indian sub-continent.

Specimens examined: **Kerala,** Pathanamthitta Dist.: Charupara, 27th November 1996, *Ravi TBG&RI 24731* (TBGT, CALI); *Ibid.,* Kokkathode, 18th November 2000, *Kiran Raj CU 92912* (CALI).

30. Dimeria namboodiriana Ravi & N. Mohanan

- Fig. 49; Map 24.

D. namboodiriana Ravi & N. Mohanan*,* Rheedea 7(1): 1. 1997; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 567. 2004; Anilkumar *et al*., Fl. Pathanamthitta 574. 2005; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 792. 2006.

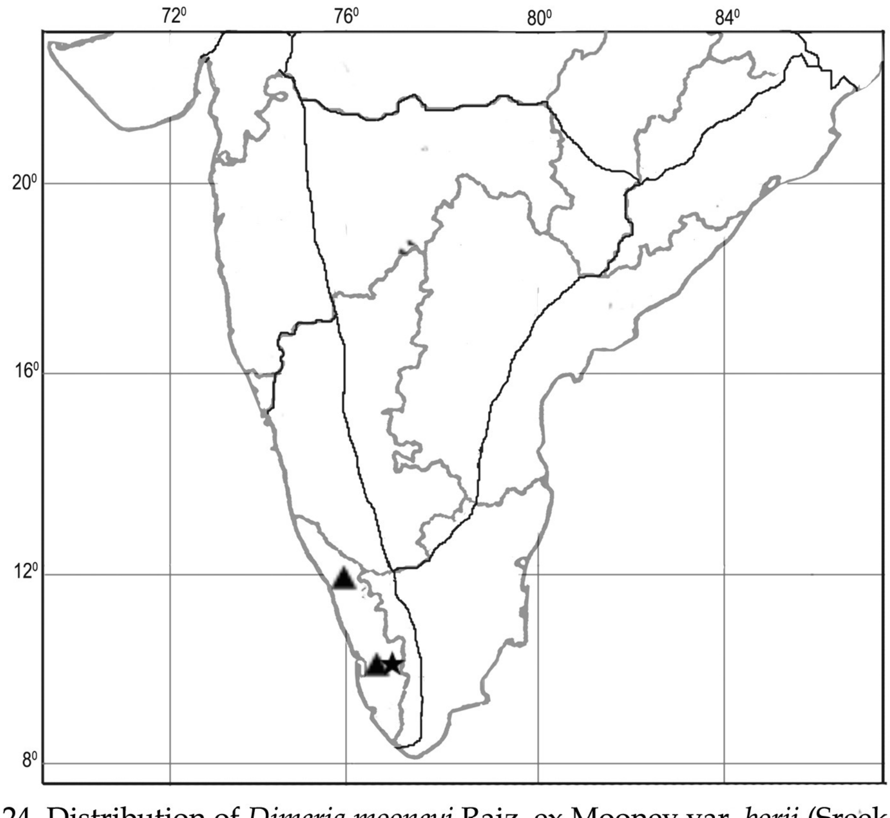
Type: India, **Kerala**, Pathanamthitta Dist.: Ponnambalamedu, 1100 m, 5th Januray 1996, *Ravi TBG&RI 24050* (Holo - TBGT !; Iso - K, KFRI, L, MH).

Perennials. Culms smooth, branched, up to 50 cm tall, tufted with runners, roots produce solitary to densely at nodes. Leaves stiff and erect, ascending, mainly confined towards culm-base; sheath more or less distichous towards base, up to 10 cm long, strongly keeled, striate and thickly ciliate with bulbous-based hairs to almost glabrous towards the apex of the culm; ligule membranaceous, ca. 1 mm long, truncate, fimbriate at apex; blade elliptic-lanceolate, 20 cm x 7 mm, slightly narrowed to rounded base, acuminate at apex, densely ciliate with bulbous-based hairs all over, more prominently on upper side, sparsely ciliate, hairs up to 4 mm long.

Racemes 2, divergent, up to 8 cm long; raceme-rachis ca. 1.5 mm wide, straight, flattened on back, shortly raised and convex adaxially, fuscous, broadly winged, margins sparsely short-ciliate; pedicel flat, 0.25–0.5 mm long, thickly ciliate on outside, sparsely inside. Spikelets fuscous, oblong-elliptic, 4.5–5.75 mm long; callus 0.25–0.4 mm long, thickly bearded with hairs up to 0.4 mm long; lower glume elliptic-oblong, 3.5–4 x 0.75–1 mm, acute-aristate at apex, keeled on back and keel winged; wing broadest above middle tapering to both ends, margins sparsely to moderately ciliate except towards scaberulous apex; sides coriaceous, minutely scaberulous especially towards apex; upper glume more or less oblong-elliptic, 4–5.5 x 1–1.25 mm, keeled on back and keel broadly winged all along; wing 0.3 mm wide, 2/3 base corky, papery towards apex, straight on back in lower 2/3 and then abruptly incurved into an acuminate-aristate apex, margins sparsely to moderately ciliate except towards scaberulous apex; sides subcoriaceous, minutely scaberulous especially in lower half and sparsely short-ciliate towards wing; margin hyaline, sparsely ciliate in middle. Lower floret empty; lower lemma hyaline, oblanceolate, 2.25–3.25 x 1 mm (when unfolded), acute at apex, cuneate towards base, margins sparsely ciliate middle upwards. Upper floret complete, bisexual; upper lemma oblanceolate, 3.5–4 mm x 0.75 mm (when folded), sub-hyaline, bifid with acute lobes at apex, sparsely short-ciliate towards apex or not, awned from sinus; awn up to 10 mm long with a column up to 3.5 mm long, scaberulous; palea short, more or less elliptic, ca. 0.5 mm long, acute at apex and papillate; lodicules 2, ca. 0.3 mm long, apically toothed; cuneate at base; stamens 2; anthers 2–2.25 mm long. Grain oblong-elliptic, ca. 2 x 0.5 mm, subacute at apex.

Distribution: Restricted to Sabarigiri Hills, Central Kerala; Known only from the type locality.

Habitat & Ecology: Marshy rocky hill-tops; growing in rock crevices; alt. $\pm$ 1000 m.



Map 24. Distribution of *Dimeria mooneyi* Raiz. ex Mooney var. *borii* (Sreek. et al.) Kiran Raj et Sivad. (▲), and *D. namboodiriana* Ravi & Mohanan (★)

Flowering & Fruiting: November – February.

Interrelationships: The species resembles to *D. ballardii* Bor, but is distinct in having flattened, broadly winged and strap-shaped, wider up to 1.5 mm wide rachis, smaller 4.5–5 mm long spikelets, upper glume-wing papery above and corky below.

Notes: D. namboodiriana and *D. mahendragiriensis* are the only known perennial species in Peninsular India having flattened raceme-rachis and the spikelets with corky upper glume wing.

Etymology: Named after Prof. (Dr.) A.N. Namboodiri, former Director of the Tropical Botanic Garden and Research Institute (TBGRI), Thirunvananthapuram, Kerala and a well known biologist in South India.

Specimens examined: **Kerala**, Pathanamthitta Dist.: Kakki hills ±1000 m, 17th February 2003, *Kiran Raj CU 92997* (CAL).

31. Dimeria pubescens Hack. - Fig. 50; Map 25.

D. pubescens Hack. in A. DC., Monogr. Phan. 6: 83. 1889; Hook. f., Fl. Brit. India 7:105.1897; Bor, Kew Bull. 7(4): 580. 1953; Bor, Grass. Burma, Ceylon, India & Pakistan 140. 1960; Ramamoorthy in Saldanha & Nicolson, Fl. Hassan Dist. 725. 1976; B. D. Sharma *et al*., Fl. Karnataka Analysis 328. 1984; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Kesh.Moorthy & Yogan., Fl. Coorg 537. 1990; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8: 176. 1994; Moulik, Grass. Bamboo. India. 284. 1997.

Type: ‘**Ceylon’**, (no date), *Thwaites 956, pro parte* (K !) (Plate 33).

Dimeria avenacea (Retz.) C.E. C. Fisch. subvar. *pubescens* Roberty, Boissiera 9: 398. 1960, *nom. inval.*

Annuals. Culm up to 40 cm tall, terete, pubescent all along, nodes glabrous or bearded, branching at nodes with all branches ending in an inflorescence. Leaves scattered all long culm; sheaths keeled on dorsal surface, tight, striate, covered with sparse tubercle-based hairs, or glabrous in lower half; ligules 1.5 mm long, membranous, ciliate on upper margin; leaf blades linear-acute, up to 6 cm x 5 mm wide, ascending, rather stiff, dark-green above, lighter green below, covered on both surfaces with sparse, tubercle-based hairs, prominent mid-rib on upper surface well-marked below, minutely scabrid on both surfaces and also on margins.

Racemes 2 rarely 1, 5–6 cm long, slightly divergent, raceme-rachis straight or zig-zag, flattened, 1–1.5mm wide, with marked intramarginal line, markedly convex below, winged, margins ciliate; pedicels short, cuneate, lip concave. Spikelets 5–6 mm long, firmly compressed, gaping widely at anthesis; lower glume 4–5 mm long, compressed, almost keeled, oblong acute or sometimes mucronate at apex, narrowly winged just below tip, ciliate all along back and on margins; upper glume 5 mm long, 2.5 mm wide when spread, broadly winged from tip to base, or sometimes wing much narrowed towards base, ciliate whole length of wing and with few long hairs at tip. Lower floret empty; lemma lanceolate-acute, hyaline scale, ca. 3.5 mm long. Upper floret complete, bisexual; lemma hyaline, 3 mm long, bifid at tip, awned; awn about 8–12 mm long; column chestnut coloured, 1.5–2 mm long, twisted; palea very small, ca. 0. 5 mm long, very hyaline; lodicules 2**,** cuneate, toothed; stamens 2; anthers 2 mm long; styles 2; stigmas plumose.

Distribution: Highlands of Peninsular India, Sri Lanka.

Habitat & Ecology: Wet rocky, grassy hill-slopes; not common; seasonal, post-monsoon specific

Flowering & Fruiting: November–February.

Variations & Interrelationships: This species is rather variable in general morphology and several forms can be distinguished, usually based on a single character without any correlation with others or with distribution. Based n the length of the spikelet the variant fall apart into two forms - tufted plants having larger spikelets measuring 5.5–6 mm long, and smaller plants with spikelets measuring 4.5–5 mm long. Both forms occur in all over the distributional range of species.

Although, the ‘pubescent’ nature of the glumes may be variable, truly heteromorphic spikelets have never been encountered. Number of racemes may also vary from one to two. The nature of the upper glume-wing sometimes varies from broadly winged to narrowly wing. Sometimes, the keel of the lower glume may be minutely winged towards apex. These morphological variations have been observed in the spikelets the plants of same population.

This species has generally been confused with *D. trimeni* from which it usually differs by the combination of following characters: Annual tufted herb, leaves usually scattered all along the culm, raceme-rachis very broad (up to1.5 mm width), and upper glume broadly or narrowly winged all along the keel uniformly.

The species also resembles *D. kurumthotticalana*, but it is distinct from it in having always paired racemes, broad upper glume -wing all along the keel and pubescent culms and spikelets.

Notes: The recognition of the type of *D. pubescens* Hack. (K !) has made some confusion on the identity of the species. Earlier, the type sheet contained specimens of *D. trimeni* and *D. pubescens* with the collection number '*CP 956'.* At Kew (K), the specimens were later separated and remounted on separate sheets and they represented the type specimens of the two species. Because of this confusion, Clayton (1997) may erroneously synonymised the species *D. trimeni* under *D. pubescens.* He also synonymosed *D. kurumthotticalana* under *D. pubescens* Hack, which is believed to be based on the study of only very limited number ofspecimens.

Etymology: The specific epithet is based on the 'pubescent' nature of the culm.

Specimens examined: **Kerala**, Palakkad Dist.: Chemmanthode ± 800 m, 9th January 2001, *Kiran Raj CU 92924* (CALI); Kannur Dist.: Chittipara, 25th November 1999, *Ravi 41914* (CALI); Kummannoor, 25th November 1999, *Kiran Raj TBG&RI 41914, 41917* (TBGT, CALI); Thiruvananthapuram Dist.: Bonaccord, 22nd November 2001, *Kiran Raj CU 92936* (CALI); *Ibid.*, Bonaccord 480 m, 2nd January 2002, *Kiran Raj CU 92967* (CALI); Kozhikode Dist.: Kakkayam 500m, 18th January 2002, *Kiran Raj CU 92973* (CALI). **Karnataka,** Shimoga, October 1908, *A. Meebold 10751* (CAL), *Ibid.*, Aglatti, Nov.1908, *A. Meebold 10754* (CAL); Kodagu Dist.: Talakaveri, 2nd December 2002, *Kiran Raj CU 92980* (CALI). **Madhya Pradesh**, Pachmarhi, 4000 ft, 14th November 1960, *P.C. Nanda 2290* (CAL). **Bihar**, Burhan Hill top, 9th December 1955, *S.C.Agarwal 209* (CAL).

32. Dimeria raizadae V. J. Nair, Sreek. & N. C. Nair

- Fig. 51; Plate 27, A–C; Map 25.

D. raizadae V.J. Nair, Sreek. & N.C. Nair, Ind. Jour. For. 6 (2): 163. 1983; Karth., S. K. Jain, M. P. Nayar & Sanjappa, Fl. Ind. Enum. Monocot. 210. 1989; Moulik, Grass. Bamboo. India 285.1997;

Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 567. 2004; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 793. 2006.

Type: India, **Kerala**, 'Calicut Dist.': Pokkunnamalai, near Nanminda, ± 850 m, 29th October 1981, *P V. Sreekumar 71812* (Holo - CAL!, Iso- K, MH !)

D. eradii Ravi Rheedea 5(1): 39. 1995; Moulik, Grass. Bamboo. India 285.1997; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 567. 2004 – *Type*: India, Kerala, Malappuram Dist.: Tenhipalam, 29th November 1992, *Ravi 3641* (Holo – TBGT !; Iso – MH !, KFRI)

Annuals. Culms slender, sometimes tufted, glabrous, up to 40 cm long; nodes ciliate or glabrous. Leaves mostly basal and forming a dense carpet; sheath up to 7 cm long, keeled on back, lower ones sparsely ciliate with bulbous based hairs towards apex, glabrous otherwise, upper ones more or less glabrous and longer towards apex of culm; ligule membranous, more or less fimbriate at apex, 0.5–0.75 mm long; blade ca. 9 cm x 4 mm, narrowly elliptic-lanceolate, acute to acuminate at apex, slightly cuneate or rounded at base, ciliate with bulbous-based and simple hairs on lower surface, margins scaberulous towards apex.

Racemes 2 or 3 rarely 1 or 4, divergent, 8–10 cm long, peduncle well exserted; raceme-rachis 0.6–1 mm wide, more or less flexuous, compressed and ridged adaxially, broadly winged, margins ciliate; pedicels short, ca. 0.3 mm long, lip truncate. Spikelets 3–4.5 mm long (incl. upper glume-arista); callus cuneate, ca. 0.25 mm long, callus hairs 0.5–0.75 mm long; lower glume 2.5–

3 x 0.3–0.4 mm (when folded), elliptic-oblong, acuminate-aristate at apex, keeled on back; keel narrowly winged and ciliate except towards apex, sides subcoriaceous, margins sparsely but prominently scaberulous, hyaline, sparsely ciliate below middle; upper glume 3–4.2 mm long including 1 mm long arista; 0.6 mm broad (when folded), oblong-oblanceolate to oblong-elliptic, acuminate-aristate at apex, keeled on back; keel winged 1/3 towards apex, scaberulous throughout and ciliate except at apex, a few cilia above middle longer, sides subcoriaceous, sparsely ciliate near keel, margins hyaline and ciliate in middle. Lower floret empty; lower lemma ca. 2 x 0.7 mm, hyaline oblanceolate, acute at apex, cuneate at base, 1-nerved, margins ciliate from below middle upwards. Upper floret complete, bisexual; upper lemma ca. 2 x 0.7 mm (when folded), oblanceolate, hyaline, 2-fid at apex, lobes acute, awned from sinus; awn scaberulous, 6.5–7.5 mm long; column ca. 2.5 mm long; palea small, ca. 0.4 mm long, papillate; lodicules 2; stamens 2; anthers 1.5–1.75 mm long; styles ca. 0.3 mm long; stigmas ca. 0.5 mm. Grain oblong-elliptic, sub-compressed, 1–1.25 mm long.

Distribution: Endemic to Southern Western Ghats: Kerala (Malappuram, Kannur, Kasaragode & Wayanad).

Habitat & Ecology: In dry open grasslands and grassy hill slopes; locally common; seasonal, post-monsoon specific; alt. 50–100m.

Flowering & Fruiting: November-February.

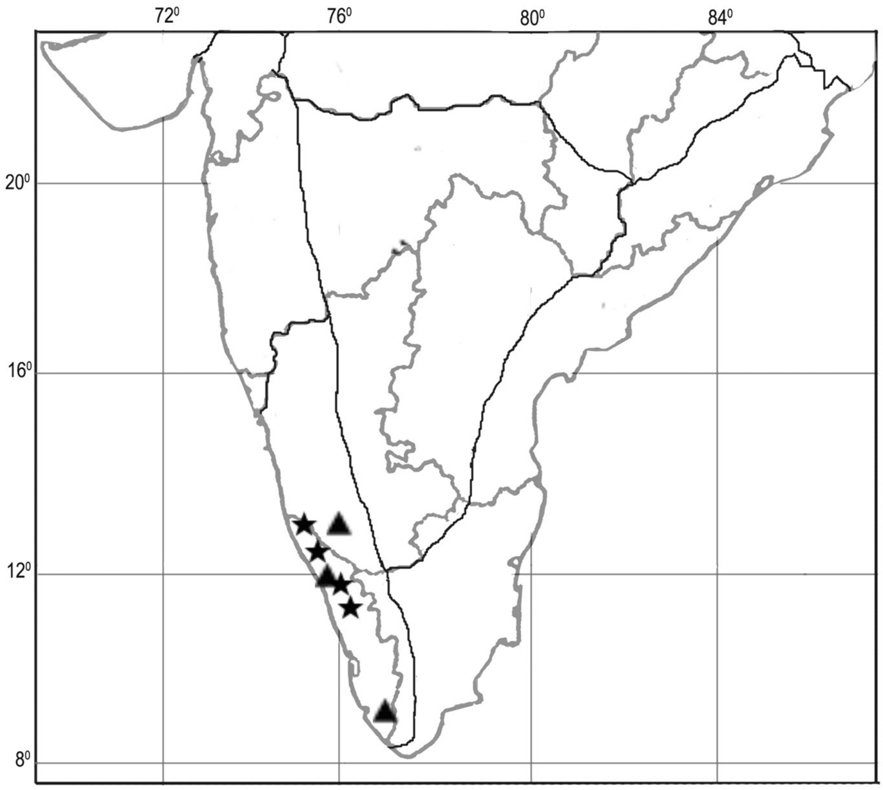
Variation & Interrelationships: Number of racemes varies from 1 to 4. This species is similar to *Dimeria thwaitesii* Hack., but markedly differs from it in having tufted habit and shortly exserted peduncle. The latter is also distinct in having single raceme, wider rachis and smaller spikelets.

Notes: The plants with tufted habit and well-exserted racemes have been recognised earlier as "*Dimeria eradii"* (Ravi, 1995), but they seem to fit in the range of variations of *D. raizadae* V. J. Nair *et al*. This grass species are commonly found along lateritic plateaus in Northern Kerala and forms a very conspicuous component of the vegetation during post-monsoon season (November-December).

Etymology: The specific epithet is in honour of Prof. M. B. Raizada, a well-known agrostologist of India.

Specimens examined: **Kerala**, Malappuram Dist.: Nilambur, 26th November 1998 *Kiran Raj CU 39610* (CALI); *Ibid*., Calicut University Campus 25th November 2001 *Kiran Raj CU 81017* (CALI); *Ibid.,* Perithalmanna 50m, 15th December 1996 *Ravi TBG&RI 33021, 33022* (TBGT); Kozhikkode Dist.: Pokkunnamala 350m, 26th October 1999, *Ravi TBG&RI 41448, 41449, 41450* (TBGT, CALI); *Ibid.,* Olavanna, 16th December 1997, *Ravi TBG&RI 36996* (TBGT, CALI); *Ibid.,* Mankavu, Gruvayoorappan College Campus, 28th

December 2002 *Kiran Raj CU 81028, CU 81029* (CALI); Kannur Dist.: Koothuparmbu 80m, 27th November 1998, *Ravi & Kiran Raj TBG&RI 39668* (TBGT, CALI); *Ibid.,* Kummannoor, Thaliparamba, 22nd November 2003, *Kiran Raj CU 92867* (CALI); *Ibid.,* Parassinikadavu, 14th December 2000, *Kiran Raj TBG&RI 44918* (TBGT, CALI); Kasaragode Dist.: Mavungal, 6th October 2002, *Kiran Raj CU 81037* (CALI).



Map 25. Distribution of *Dimeria pubescens* Hack. (▲), and *D. raizadae* V. J. Nair et al. (★)

32. Dimeria ravii Kiran Raj, Sivad. et Jomy, *sp. nov*. (*ined*.)

- Fig. 52; Map 26.

Dimeriae fuscescenti similis, racemi rhachidi applanata (1-1.25 mm lata), marginibus leavibus, pedicellis compressis differt.

Type: India, **Kerala**, Idukki Dist.: Periyar Tiger Reserve, *s.date*. *Jomy 14504* (KFRI, CALI)

Perennials. Culms robust, erect or geniculate from base, up to 70 cm long, sometimes rooting at nodes; nodes shortly bearded. Leaves scattered; sheath much longer than internodes, very loose, keeled, smooth, pilose in upper third with bulbous-based hairs; ligule membranous, up to 1mm long, ciliate on truncate apex; blade linear-acute, up to 4–15 cm x 2–4 mm, keeled on midrib below with keel continuous with that of sheath, acuminate at apex, rounded at base, coarsely scabrid on nerves of both surfaces and margins, bulbous-based hairs on upper surface and margins.

Racemes 2, 5–12 cm long, peduncle well exserted; raceme-rachis flattened, 1–1.25 mm wide, broadly winged, straight, margins smooth; pedicels 0.5 mm long, compressed, lip concave, glabrous. Spikelets linear oblong, 4.5–5 mm, closely appressed to rachis, glumes widely diverging at anthesis; callus 0.5 mm long, bearded at lower edge; lower glume linear-oblong, acuminate at apex, 4.5 mm long, coriaceous, straight on back and keeled towards apex, thin to hyaline at sides, scabrid all along back; upper glume coriaceous, ca. 5 mm long, oblong-elliptic, acute at apex, strongly compressed, straight on back, keeled, winged all along keel, broadly winged in upper half. Lower floret empty; lower lemma thinly hyaline, oblanceolate, 1.5–2 mm long, acute at apex, margins ciliate towards apex. Upper floret complete, bisexual;

upper lemma hyaline, elliptic-obtuse, ca. 3mm long, bifid at apex with acute lobes, awned from sinus; awn 12–14 mm long with a dark twisted 3 mm long column; palea absent; lodicules 2, small; stamens 2; anthers 2.5-3 mm long; styles 2, short; stigmas plumose.

Distribution: Southern Western Ghats: Thekkady (Kerala); known only from the type locality.

Habitat & Ecology: Not known.

Flowering & Fruiting: September–December ?

Notes: I could not collect any living specimens during the present study. All observations were made on the basis of a single specimen (*Jomy 14504*), which is deposited at CALI. The specimen closely resembles *D. fuscescens* Trin. (*Dimeria* sect. *Dimeria*) in spikelet morphology but distinct in having flattened rachis (1–1.25 mm wide) with smooth margin.

Etymology: New species is named in honour of Prof. N. Ravi, former Head of the Department of Botany, S. N. College, Kollam, Kerala, and a well known agrostologist of South India.

34. Dimeria thwaitesii Hack. - Fig. 53; Plate 28, C; Map 26.

D. thwaitesii Hack. in A. DC., Monogr. Phan. 6: 78. 1889; C. E. C. Fisch. in Gamble, Fl. Pres. Madras 1713. 1934; Bor, Grass. Burma, Ceylon India Paksitan 144. 1960; Sreekumar & Nair, Fl. Kerala

Grass. 100. 1991; Clayton in Dassan. *et al*., Rev. Handb. Fl. Ceylon 8:177.1994; Moulik, Grass. Bamboo. India 284. 1997; Ravi & N. Mohanan, Comm. Trop. Sub-trop. Sedge. Grass. 142. 2002; Sasidh., Biodiv. Doc. Kerala - Fl. Pl. 587. 2004; Anilkumar *et al*., Fl. Pathanamthitta 574. 2005; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 793. 2006.

Type: "**Ceylon**", Dambulla, March 1868, *Thwaites CP 3965* (Iso-K !)

D. pusilla Thw., Enum. Pl. Zeyl. 369. 1864. var. *pallida* Thw. ex Hook. f., Fl. Brit. India 7: 103.1896. – *Type:* same as *D. thwaitesii*

D. acutipes sensu Manilal & Sivar., Fl. Calicut 339. 1982: non Bor, 1953.

Annuals. Culms tufted, slender and erect, ca. 50 cm tall, terete and glabrous; nodes bearded. Leaves scattered, sometimes sub-basal; sheath up to 8 cm long, keeled on back, striate and glabrous; blade linear-oblong, 5–11 cm x ca. 2.5 mm, acuminate at apex, slightly narrowed to base and sparsely hairy with bulbous-based hairs above towards margins; ligule membranous, up to 1 mm long and truncate-fimbriate at apex.

Racemes 1, rarely 2, 4–6 cm long, peduncle hardly exserted; raceme-rachis trigonous-flattened, 0.6 mm wide, convex and slightly ridged adaxially, narrowly winged, margins ciliate. Spikelets more or less elliptic, 4–6 mm long (incl. 1–1.5 mm long upper glume-arista); callus ca. 0.25 mm long, truncate base, bearded; lower glume oblong-elliptic, 3–3.5 x 0.4 mm, subcoriaceous, acuminate-aristate at apex, keeled on back, keel narrowly winged towards apex and densely to moderately hairy on sides; upper glume elliptic, 4–4.75 x 0.6 mm, subcoriaceous, acuminate-aristate at apex with arista 1–1.5 mm long, keeled on back, keel narrowly but distinctly winged below arista and densely to moderately hairy on sides. Lower floret empty; lower lemma hyaline, oblanceolate, ca. 1.5 mm long, acute at apex, cuneate at base margins sparsely ciliate on upper half. Upper floret complete, bisexual; upper lemma hyaline, elliptic, ca. 2.5 x 0.4 mm (when folded), bifid at apex with acute lobes, awned from sinus, awn 7–8 mm long with column 2.5–3 mm long and scaberulous; palea small, linear, ca. 0.5 mm long, papillate; lodicules 2, small; stamens 3; anthers ca. 0.75 mm long; styles ca. 0.5 mm long; stigmas ca. 0.5 mm long, plumose. Grain linear-oblong, 1.6–2 x ca. 0.25 mm, acute at apex.

Distribution: Sri Lanka and Southern Western Ghats (Kerala).

Flowering & Fruiting : October – December.

Habitat & Ecology: Common in hilly tracts on cuttings, rock crevices, shallow wet soils on rocks; alt. 50 –1100 m.

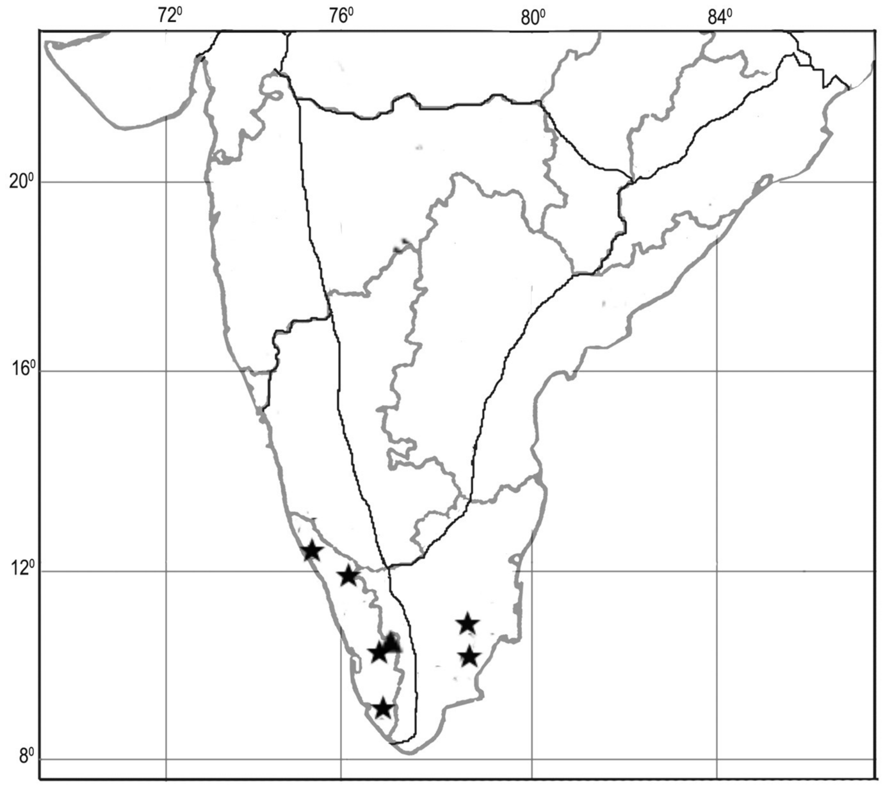
Interrelationships: Resembling *D. raizadae* V. J. Nair *et al.*, but distinct from it in having slender culms, solitary racemes, longer spikelets with densely ciliate glumes and smaller anthers. Also resembles *D. acutipes* Bor, but differing in 1mm long callus, oblique pedicel and larger spikelets.

Vernacular Name: “Neyypullu” (Malayalam)

Etymology: Named after G. H. K. Thwaites (1812–1882), who was a British botanist and the Director of Royal Botanic Gardens, Peradeniya.

Specimens examined: **Kerala**, Kollam Dist.: Kulathupuzha November 1993, *M. A. Lawson 128* (CAL). Pathanamthitta Dist.: Kuttikanam 1100 m, 15th November 2001 (CALI). Idukki Dist.: Pooyamkutty riverside, 16th December 1988, *P. Bhargavan 89960* (MH). Trissur Dist.: Peechi, Chattupara ± 300m, 25th October 1988, *Sasidharan 5155* (KFRI). Kozhikode Dist.: Pokkunamala ± 300m, 18th Januray 2002, *Kiran Raj CU 92972* (CALI). Kannur Dist.: Madappura, 14th December 2000, *Kiran Raj TBG&RI 44914* (TBGT, CALI); *Ibid.,* Parappa, 28th October 2002, *Kiran Raj CU 81048* (CALI); *Ibid.,* Madaippara, 8th October 2002, *Kiran Raj CU 92845* (CALI); *Ibid.,* Ezhimala, 7th December 2001, *Kiran Raj CU 92956, 92957* (CALI). “**Travancore**”, 1000 m, 15th November 1928, *V. Narayanswami 1627* (CAL). “**Cochin**”, Kavalay, Novmeber 1910, *G. Meebold 12324* (CAL). **Tamil Nadu,** Pudukottai Dist.: Maruthamalai, 25th Novenmber 2001, *Kiran Raj CU 92939* (CALI);

Sivaganga Dist.: Karaikudi, 8th November 2002, *Kiran Raj CU 92979* (CALI).



Map 26. Distribution of *Dimeria ravii* Kiran Raj, Jomy et Sivad., sp. nov. (*ined.*) (▲), and *D. thwaitesii* Hack. (★)

RAVIA Kiran Raj & Sivad. *gen. nov.* (*ined.*)

Genus novum Dimeriae similis, pedicello longo labello obliquo, callo longo pilis flavide aureis secus unum latus dense obtecto, uterque glumis crustaceis dorsaliter rotundatis apice echinato alato, lemmatis superioris arista valida columna longa differt.

Type: Ravia santapaui (M. R. Almeida) Kiran Raj & Sivad.

Annual. Culms slender; leaves mostly confined to the base, sheaths loosely arranged, keeled all along the back; ligule membranous, fimbriate at apex; leaf blades linear-subulate.

Racemes 1 or 2, usually unequal and intertwined; rachis triqueterous wiry and twisted; pedicel-lip extremely oblique and glabrous. Spikelets laterally compressed, distantly arranged along the tough rachis, 8-10 numbers on each raceme; callus strongly oblique, pungent base, densely covered with golden-yellow or yellowish-brown colored hairs; lower glume cartilaginous except at margins, glabrous, thickened but not keeled; and rounded on back with echinate apex, auricled along both sides of the apical margin; upper glume cartilaginous, rounded on back with echinate apex, auricled along the margin on both sides at the apical portion. Upper floret complete, bisexual; upper lemma linear elliptic, short, 2–2.5 mm x ca. 1mm, hyaline, 2-fid, deeply clefted, with a long stout awn from the sinus; column chestnut brown coloured, 10 – 12 mm long bristle pale and barbed.

Etymology: The new genus is named in honour of Prof. N. Ravi, a dedicated teacher of Plant taxonomy and a well-known agrostologist of Kerala, India. His silent, but serious efforts were instrumental in kindling interest in plant taxonomy primarily among the young students and botanists of South India.

Occurrence & Distribution: Monotypic: Endemic to Southern Western Ghats.

Ecology & Habitat: Usually found in dry lateritic rocky slopes; more or less sub-gregariously grows during the post monsoon season; 50-120 m altitude above MSL.

Phenology: Sprouting starts in September; Flowering in November – December; fruiting in December – January.

Chromosome numbers: Data not available.

Notes: Ravia is distinct from *Dimeria* by having a very long callus with pungent base, keel-less glumes with dorsally echinate apex and apically auricled margin, upper glume with apical long hairs, and upper lemma having a stout awn with a long column.

Generic relationships: The close resemblance of inflorescences in their general morphology and the occurrence of species of the two genera *Dimeria* and *Ravia* in the same geographical region indicate the relationship of the two despite the differences in their floral characters. A detailed comparison of the significant morphological features is given in table 17.

The spikelets of *Ravia* showed certain morphological similarities with *Pogonachne*, an endemic monotypic genus of the Northern Western Ghats in having non-divergent racemes with few spikelets (8–10) in each raceme, glumes dorsally rounded and the upper lemma with a stout awn. It differed from the latter in having a tough, non articulated raceme-rachis, smaller (5-6 mm) spikelets with a long callus (2 mm), an upper glume without a median 'tuft of hairs' along the dorsal side but with a few long hairs at the tip, and with a hyaline margin; and reduced lower floret without a lower palea, and the upper floret with two stamens.

Table 17. Comparison of morphological characters of *Dimeria* R. Br. and *Ravia* Kiran Raj & Sivad. (*ined.)*

	Dimeria	***Ravia***
1.	Spikelets cartilaginous	Spikelets chartaceus or coriaceous
2.	Callus short (0.5–1 mm long), truncate, and shortly bearded or glabrous.	Callus long (1.5–2 mm long), oblique, pungent base, densely covered with golden-yellow hairs.
3.	Glume-margins not auricled.	Glume-margins auricled at apex.
4.	Glumes dorsally keeled throughout or towards apex, winged or not.	Glumes not keeled, wingless.
5.	Upper lemma sub-hyaline, ca. 3–3.5mm long, shortly clefted.	Upper lemma hyaline, ca. 2 mm long, deeply clefted.
6.	Awn slender, 5–15 mm long with a column 1–4 mm x 1 mm.	Awn stout, 20–30 mm long with a column 10 – 12 mm x 2 mm.

35. Ravia santapaui (M. R. Almeida) Kiran Raj & Sivad.

– Fig. 54; Plate 34; Map 27.

R. santapaui (M. R. Almeida) Kiran Raj & Sivad., *comb. nov.* (*ined*.)

Type: "North Kanara", Mirjan Flat, 300 ft., October 1919, *Sedgwick & Bell 6875* (Holo – K !, designated here; Iso – BSI !)

Dimeria santapaui M. R. Almeida, J. Bombay Nat. Hist. Soc. 66(3): 510. 1970. – *Type:* "North Kanara", Mirjan Flat, 300 ft., October 1919, *Sedgwick & Bell 6875* (Holo – BLAT, not found; Iso – BSI !, K- cibachrome photograph !) (Plate 35).

D. keralae N. C. Nair, Sreek. & V. J. Nair, J. Bombay Nat. Hist. Soc. 80(3): 626. 1984; T. S. Nayar *et al.,* Fl. Pl. Kerala – Handb. 792. 2006. – *Type*: India, Kerala State, Kannur Dist.: Paramba, ± 150 m, 16 November 1981, *P.V. Sreekumar 71717* (Holo – CAL !; Iso – MH !) .

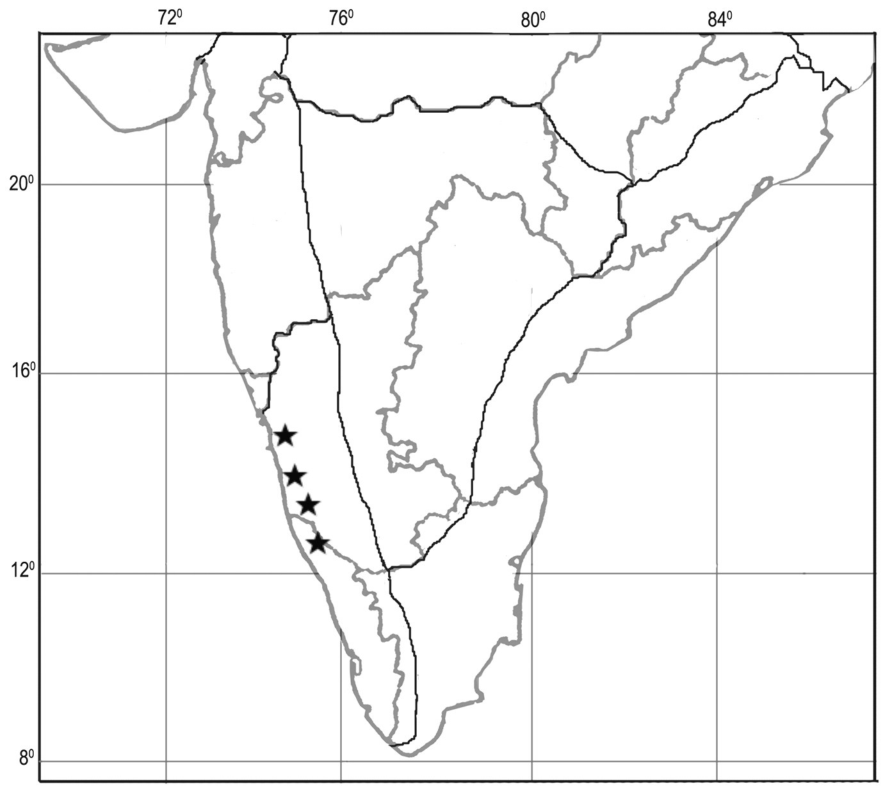
Herbaceous annuals. Culms 15–30 cm tall, slender, erect or sometimes bent at right angle to the axis at extreme apical node; nodes bearded. Leaves mostly confined to the base; sheaths 3–5 cm long, shorter than internodes, loosely arranged, keeled all along the back, glabrous; blades linear-subulatus, 2–5 cm x 1–2 mm, keeled on the midrib below, continuous with that of the sheath, acuminate at apex, glabrous or covered with few tubercle-based hairs along the margins. Ligule membranous, up to 1 mm long, ovate and fimbriate at apex. Racemes 1–2, usually unequal, sometimes intertwined, 2–5 cm long; rachis triqueterous, c. 0.25 mm broad, glabrous; pedicels 1–1.5 mm long, oblong, lip extremely oblique and glabrous. Spikelets linear oblong-oblanceolate, 8–12 in each raceme, 5–6 mm long, cuneate at base, distantly arranged along the rachis. Callus 1.5–2 mm long, extremely acute at base, oblique at the tip, covered with golden-yellow or yellowish-brown colored hairs along one angle, hairs up to 1.5 mm long; lower glume cartilaginous, more or less linear-oblong, 4–4.5 mm long, glabrous, thickened and rounded on back with echinate apex, margin coriaceous, auricled along the margin on both sides towards the tip; upper glume cartilaginous, oblong-lanceolate, 5–5.5 mm long, glabrous, rounded on back with echinate apex, auricled along the margin on both sides and with a few long hairs at the tip. Lower floret empty; lemma hyaline, oblanceolate, 3–4 mm long, 1-nerved, sparsely ciliate on the upper margin; palea absent. Upper floret bisexual, lemma hyaline, oblanceolate, subcoriaceous, 1-nerved, inconspicuous on upper half, 3–4 mm long, bifid at apex with acute lobes, with a stout awn from the sinus; awn simple, scaberulous, 22–30 mm long, very stout, and geniculate; column 10–12 mm long, twisted, chestnut brown coloured, bristles pale and scabrid; palea very minute, c. 0.5 mm long, hyaline, ovate-lanceolate, without nerves, shortly ciliate along margins; lodicules 2, c. 0.4 x 0.2 mm, 2–3-lobed at apex; stamens 2, anthers 1–1.5 mm long, pale yellow to reddish, filaments short, c. 1 mm long; ovary c. 0.5 mm long; styles short, slender, stigma c. 1 mm long, narrow, pinkish, plumose; grain linear-oblong, 2–2.5 x ca. 0.4 mm, subcompressed, apex acute-apiculate, brown.

Flowering & Fruiting. September to December.

Distribution: Endemic to Southern Western Ghats (Kerala, Karnataka); 50 – 120 m above sea level. The occurrence of the species in Maharashtra (Salunkhe, 1995) is doubtful.

Habitat & Ecology: *Ravia santapaui* sprouts and establishes more or less sub-gregariously during the post monsoon season; usually found in dry lateritic rocky slopes, sometimes on wet laetrile hillocks along with other endemic grasses like *Bhidea bursiana* Bor, *Danthonidium gammei* (Bhide) C. E. Hubb., *Dimeria bialata* C. E. C. Fisch., *Glyphochloa acuminata* (Hack.) Clayton, and *Arundinella* spp.

The species appears in two variant forms, i.e. one shorter (15– 20 cm long) and the other longer (25–30 cm long) (Plate 34 B, C).



Map 27. Distribution of *Ravia santapaui* (M. R. Almeida) Kiran Raj et Sivad., (*ined.*) (★)

Notes: A critical morphological study of *Dimeria santapaui* M. R. Almeida (1970) and *D. keralae* N. C. Nair *et al.* (1984) revealed their uniqueness in having several characteristics that differed from that of the genus *Dimeria,* and also found that both are conspecific.

The description of "*D. santapaui"* given in the protologue (Almeida, 1970) didn't perfectly match with the illustration provided thereon. The stout rachis with single raceme and spikelets with the glumes having the apical winged margin are the important diagnostic features of *D. santapaui* as given in the protologue. But the 'apical winged margin' of both glumes as mentioned in the description of *D. santapaui* was not shown in the drawings of both the glumes; instead a 'keel-wing', a feature, which is characteristic of the genus *Dimeria* alone, was shown. The main and unique characteristic feature of having an 'apical winged margin' of the glumes in *D. santapaui* was also not given in the table comparing the characters of *D. keralae* and *D. santapaui,* provided by N.C. Nair & al. (1984) in the protologue of *D. keralae*. Instead, they mistakenly pointed out the features in *D. santapaui* like "wingless lower glume" which actually means the absence of keel on the lower glume and "keel-wing of the upper glume" which indicated the presence of distinct keel with a wing.

During the study of the type specimens of *D. santapaui* (Isotype - BSI) and *D. keralae* (Holotype - MH), it was found that in both species, glumes of the spikelets are keel-less with echinate apex and having an apical auricled (not winged) margin. The detailed study of recent collections including those from the type localities of both the species and the type specimens indicated that *D. santapaui* and *D. keralae* are conspecific and showed variations only number of racemes and spikelet size, which are variable in the members of the sub-tribe. Hence, the latter is merged with the former.

The holotype was reported (Almeida, 1970) to have been deposited in BLAT, but it is presently not available there. One specimen (*Sedgwick & Bell 6875*) at K (Isotype) was bearing a '*determinavit*' slip annotated on 29th July 1968 by M. R. Almeida, the author of *Dimeria santapaui* as "*Dimeria kanarensis* sp. nov." (see Plate 35). A detailed literature survey revealed that no species of *Dimeria* with such a specific name has been hitherto published by anybody. Probably this might have been the earlier name proposed for *D. santapaui* by the author. The basis of such a determination on the type specimen of his own earlier species (*D. santapaui*) is ambiguous and quite surprising. Besides, it was stated in the protologue under the English version that the Isotype with the collection number *'6875 A'* is deposited in K. But the specimen available at Kew (K) is bearing the number *'6875'*, and not *'6875 A'.* The existence of a specimen bearing *'6875 A'* is not known. There is one specimen (*Sedgwick & Bell 6875*) mentioned as Isotype available at BSI, but it was not mentioned in the protologue and this specimen which is actually an Isotype of

Dimeria santapaui is designated as the Holotype of *Ravia santapaui* (M.R. Almeida) Kiran Raj et Siavd., *comb. nov.* (*ined*.).

Specimens examined. **Kerala,** Kannur Dist.: Paramba, $\pm$ 150 m, 17th November 1981, *P. V. Sreekumar 71727* (MH); *Ibid*., 30th October 1999, *Ravi TBGT 41566* (TBGT, CALI); *Ibid*., Periya, $\pm$ 50 m, 18th November 1981. *P. V. Sreekumar 71755* (MH); *Ibid*., 18th November 1999, *Ravi & Kiran Raj TBGT 41541, 41542* (TBGT, CALI); Kasaragode Dist.: On the way to Bandaduka, $\pm$ 110 m, 6th October 2002, *Kiran Raj CU 92838* (CALI); **Karnataka,** Dakshin Kannada Dist.: Mangalore, $\pm$ 100 m, 18th December 2001, *Kiran Raj CU 81019* (CALI); Uttar Kannada Dist.: Mirjan, $\pm$ 120 m, 7th October 2003, *Kiran Raj CU 92989* (CALI).

Chapter 6. SUMMARY

Dimeriinae Hack., a little known palaeotropical subtribe of Poaceae, which belonged to the tribe Andropogoneae under the subfamily Panicoideae was hitherto represented by a single genus - *Dimeria* R. Br., which is considered as an enigmatic member of the tribe Andropogoneae. During the present study a new genus, viz. *Ravia* Kiran Raj et Sivad. (*ined*.) has been established, thereby enhancing the number of genera of the subtribe to 2. During the last eight years (2000-2008) intensive and extensive field trips and studies were conducted and recognized 35 species and 7 varieties. The taxonomic revision contains nomenclatural history followed by comparative morphology, phytogeography, ecology, systematic position, taxonomic and phytogeographic analyses and the taxonomic treatment. This is the first comprehensive study on the taxonomy and morphology of the subtribe. The new and significant findings and contributions of the present study are summed up below:

New genus established : 1

Ravia Kiran Raj et Sivad. (*ined.*)

New species described: 3

1. *Dimeria agasthyamalayana* Kiran Raj & Ravi

2. *D. veldkampii* Kiran Raj & Sivad.
3. *D. ravii* Kiran Raj, Sivad. & Jomy (*ined*.)

New varieties described: 2

1. *Dimeria hohenackeri* Hochst. ex Pilger var. *kodagensis* Kiran Raj et Sivad. (*ined.*)
2. *D. balakrishnaniana* K. Ravikumar *et al*. var. *sahyadricum* Kiran Raj et Sivad. (*ined.*).

New status and combinations of names established: 4

1. *D. bialata* C. E. C. Fisch. var. *sivarajanii* (Mohanan & Ravi) Kiran Raj et Sivad., *comb. et stat. nov.*
2. *D. kurumthotticalana* K.C. Jacob var. *idukkiensis* (Ravi & Anilkumar) Kiran Raj et Sivad., *comb. et stat. nov.*
3. *D. mooneyi* Raiz. ex Mooney var. *borii* (Sreek. *et al*.) Kiran Raj et Sivad., *comb. et stat. nov.*
4. *Ravia santapaui* (M. R. Almeida) Kiran Raj et Sivad., *comb. nov.*

New synonyms recognized: 8

1. *Dimeria eradii* Ravi = **D. raizadae** V. J. Nair *et al*.
2. *Dimeria kollimalayana* M. Mohanan & A.V.N. Rao = **D. deccanensis** Bor
3. *D. ceylanica* Bor = **D. kurumthotticalana** K.C. Jacob

4. *D. sreenarayanii* Ravi & Anilkumar = **D. kurumthotticalana** K.C. Jacob.

5. *D. blatterii* Bor = **D. stapafiana** C. E. Hubb. ex Pilger

6. *D. kalavoorensis* Ravi = **D. copei** Ravi

7. *D. chelariensis* Ravi = **D. copeana** Sreek. *et al*.

8. *D. ornithopoda* Trin. var. *megalantha* Bor = **D. ornithopoda** Trin. var. **ornithopoda**

Rediscovery of the species after the type collection: 5

1. *D. balakrishnaniana* K. Ravikumar *et al*. (after 20 years)
2. *D. copei* Ravi (after 12 years)
3. *D. mahendragiriensis* Ravi *et al.* (after 14 years)
4. *D. namboodiriana* Ravi & N. Mohanan (after12 years)
5. *D. pubescens* Hack. (after 45 years)

New record for India : 1

Dimeria aristata Hack.: Collected from Southern Western Ghats (Kerala); formerly recorded only from Sri Lanka.

New record for South India : 2

1. *Dimeria trimeni* Hook. f.: Collected from Southern Western Ghats (Kerala); formerly recorded only from Orissa.
2. *D. kurzii* Bor: Collected from Northern Kerala; formerly recorded from Madhya Pradesh.

Amended description of the Subtribe Dimeriinae Hack. (*ined.*)

Earlier workers recognised only one genus, viz. *Dimeria* R. Br. under the subtribe Dimeriinae. Present study recognised one more genus, viz. *Ravia* Kiran Raj et Sivad., which in turn needed an amended description to the subtribe and has been provided here.

Revision of infrageneric classification of *Dimeria* R. Br. and lectotypification (*ined*.)

A revised infra-generic classification has been proposed in the present study, which contains the following four sections under the genus Dimeria, and their type clearly specified:

1. *Dimeria* sect. *Annulares* Bor

    Type: D. woodrowii Stapf

2. *Dimeria* sect. *Capillares* Bor ex Kiran Raj *et* Sivad.

    Type: *Dimeria hohenackeri* Hochst. ex Miq. (designated here)

3. *Dimeria* sect. *Dimeria*

    Type: Dimeria acinaciformis R. Br.

4. *Dimeria* sect. *Loriformes* Bor ex Kiran Raj *et* Sivad.

    Type: Dimeria pubescens Hack. (designated here)

Unique fruit/seed dispersal mechanisms

Three interesting fruit/seed dispersal mechanisms, viz. anemochory, epizoochory and anemogeochory and in anemogeochory two subtypes namely bradychory and tachychory are noticed among the members of Dimeriinae.

REFERENCES

Adanson, M. 1763. *Familles des Plantes,* Vol. 2. Vincent, Paris.

Ahemedulla, M. 2000. Endemism in Indian flora. *In:* N.P. Singh, D.K. Singh, P. K. Hajra, & B. D. Sharma (Eds.). *Flora of India-Introductory volume*. Part 2. Botanical Survey of India, Calcutta.

Ahemedulla, M. & M. P. Nayar 1987. *Endemic Plants of Indian Region*. Botanical Survey of India, Calcutta.

Avdulov, N. P. 1931. Karyo-sytematische Untersuchung der Familie Gramineen. *Bull. Appl. Bot. Suppl.* 44: 1-428.

Almeida, M. R. 1970. Three new grasses from the former Bombay Presidency. *J. Bombay Nat. Hist. Soc*. 66: 510-513.

Anonymous. 1961. *Handbook of agriculture*. Indian Council of Agricultural Research, New Delhi.

Anonymous. 2002. *Oxford School Atlas*. Oxford University Press. New Delhi.

Balakrishnan, N. P. 1996. Phytogeographical divisions - General considerations. *In:* P. K. Hajra *et al*. (Eds.), *Flora of India-Introductory volume.* Part 1. Botanical Survey of India, Culcutta.

Barker, N. P., Linder, H. P., & E.H. Harley. 1995. Polyphyly of Arundinoideae (Poaceae): evidence from rbcL sequence data. *Systematic Botany* 20: 423–435.

Beauvois, A. & M. F. J. de Palisot. 1812. *Essai d'une nouvelle agrostographie.*. Paris.

Bertel, H & P. Wagner. 1998. A catalogue of the Herebarium specimens from Captain Cook's first and second expeditions housed in the Copenhagen herbarium (C). *Allertonia* 7(5): 307-361.

Bhat, K. G. & C. R. Nagendran. 2001. *Sedges and grasses (Dakishna Kannada & Uduppi District)*. Bishen Singh Mahendrapal Singh, Dehradun.

Bhide, R. K. 1911. New and revised species of Gramineae from Bombay. *J. Proc. Asiact. Soc. Bengal* 7: 513-520.

Bor, N. L. 1953. Notes on Asiatic grasses XI. The genus *Dimeria* R. Br. in India & Burma. *Kew Bull*. 7(4): 553-592.

Bor, N. L. 1960. *The grasses of Burma, Ceylon, India & Pakistan*. Pergamon Press, Oxford. pp. 136-138.

Bridson, D. & L. Forman. 1998. *The herbarium Handbook*. Ed. 3. Royal Botanic Gardens, Kew, London.

Britto, S. J. 1989. On the occurrence of *Dimeria acutipes* Bor (Gramineae) in Tamil Nadu. *J. Bombay Nat. Hist. Soc.* 86(2): 274-277.

Brown, R. 1810. *Prodromus florae Novae Hollandiae et insulae Van-Diemen*, Vol.1. J. Johnson, London.

Brown, R. 1814. *General Remarks, Geographical and systematical notes on the Botany of Terra Australis*, vol. 2. G. & W. Nichol., London.

Brown, W. V. 1958. Leaf anatomy in grass systematics. *Bot. Gaz.* 119: 170–178.

Campbell, S. C. 1985. The subfamilies and tribes of Gramineae (Poaceae) in the Southeastern United States. *J. Arnold Arbor.* 66: 123–199.

Camus, E. G. & A. Camus. 1923. Graminées. *In*: M.H. Lecompte & H. Humbert (Eds.), *Flore Général de L'Indo-Chine,* Vol. 7. Masson, Paris.

Caro, J. A. 1982. Sinopsis taxonomica de las gramineas argentines. *Dominguezia* 4: 1-51.

Cerling T. E., J. M. Harris, B. J. Mcfaden, M. G. Leakey, J. Quade, V. Eisenmann & J. R. Ehlerniger. 1997. Global vegetation change through the Miocene/Pliocene boundary. *Nature* 389: 153-158.

Celarier, R. P. 1956. Cytotaxonomy of Andropogoneae. I. Subtribe Dimeriinae & Saccharinae. *Cytologia* (Tokyo) 21: 272-291.

Celarier, R. P. & J. R. Harlan. 1956. Andropogoneae in Oklahoma. *Taxon* 5: 183-186.

Chen, S.-L., B. Sun, L. Liu, Z. Wu, S. Lu, D. Li, Z. Wang, Z. Zhu, N. Xia, L. Jia, G. Zhu, Z. Guo, G. Yang, W. Chen, X. Chen, S.M. Phillips, C. Stapleton, R. J. Soreng, S. G. Aiken, N. N. Tzvelev, P. M. Peterson, S. A. Renvoize, M. V. Olonova, & K. H. Ammann. 2006. *Dimeria* R. Br. *In:* Z.-Y. Wu, P. H. Raven & D.-Y. Hong (Eds.). *Flora of China*, vol. 22 (Poaceae). Science Press, Beijing, Peoples Republic of China and Missouri Botanical Garden Press, St. Louis, Missouri, U.S.A. pp. 207-210.

Christopher, J. 1978. Studies on the cytology and phylogeny of south Indian grasses IV. Subtribe Panicoideae. *Cytologia* 43: 273-287.

Clark, L. G. 2004. The grasses (Poaceae): Robert Brown and now. *Telopea* 10(2): 505.

Clark, L. G., W. Zhang & J. F. Wendel. 1995. A phylogeny of the grass family (Poaceae) based on *ndhf* sequences. *Syst. Bot*. 20: 436-460.

Clayton, W. D. 1969. A Revision of the Genus *Hyparrhenia*. *Kew Bull. Add. Ser.* II. H. M. Stationery Office, London.

Clayton, W. D. 1972. The awned genera of the Andropogoneae. Studies in the Gramineae 31. *Kew Bull.* 27: 457–474.

Clayton, W. D. 1973. The awnless genera of the Andropogoneae. Studies in the Gramineae 33: *Kew Bull.* 28: 49–58.

Clayton, W. D. & T. A. Cope. 1980. The chorology of Old World species of Gramineae. *Kew Bull*. 35: 135 – 170.

Clayton, W. D. 1981a. Evolution and distribution of grasses. *Ann. Missouri Bot. Gard.* 68: 5–14.

Clayton, W. D. 1981b. Notes on the tribe *Andropogoneae* (Gramineae). *Kew Bull.* 35(4): 823–828.

Clayton, W. D. 1987. Miscellaneous notes on panicoid grasses. *Kew Bull.* 42: 401-403.

Clayton, W. D. 1994. *Dimeria* R. Br. *In:* M. D. Dassanayake & F. R. Foseberg (Eds.), *A Revised Hand Book to the Flora of Ceylon, vol.* VIII. Smithsonian Institution Press, Washington. pp.171-178.

Clayton, W. D. & S. A. Renvoize. 1986. *Genera Graminum. Grass genera of the World. Kew Bull. Add. Ser*. XIII. Royal Botanic Gardens, Kew.

Clifford, H. T. & L. Watson. 1977. *Identifying Grasses: Data, Methods and Illustrations.* Queensland University Press, Brisbane.

Cooke, T. 1958. Gramineae. *In: Flora of the Presidency of Bombay*. Vol. III. Botanical Survey of India, Culcutta. Pp. 462-463.

Connar, H. E. 1981. Evolution of reproductive systems in the Gramineae. *Ann. Missouri Bot. Gard.* 68: 48–74.

Cunningham *et al*. 2003. *Environmental science – A global concern*. McGraw-Hill Inc., London.

Dabadghao, P. M. & K. A. Sankaranarayanan. 1973. *The grass cover of India*. Indian Council of Agricultural Research, New Delhi.

Dahlgren, R. M. T., H. T. Clifford & P. F. Yeo. 1985. *The families of monocotyledons - structure evolution and taxonomy.* Springer-Verlag, Berlin.

Daniels, R. J. R. 1997. Taxonomic uncertainties and conservation assessment of the Western Ghats. *Curr. Sci.* 73(2): 169-170.

Davidse, G. 1987. Fruit dispersal in the Poaceae. *In:* T.R. Soderstrom, K. W. Hilu, C. S. Campbell & M.E. Barkworth (Eds.). *Grass systematics and Evolution.* Smithsonian Press, Washington D.C.

Davis, J. I. & R. L. Soreng. 1993. Phylogenetic structure of the grass family (Poaceae) as inferred from Chloroplast DNA restriction site variations. *Amer. J. Bot*. 80: 1444-1454.

Desai, M. J. 1992. New records for Gujarat flora from Bansda Forest. *J. Econ. Taxon. Bot.* 16(3): 551-552.

Despandae, U. R. 1984. The genus *Heteropogon* in India. *Bull. Bot. Surv. India* 30: 120-125.

De Wet, J. M. J. & J. R. Harlan. 1970. Apomixis, Polyploidy, and Speciation in *Dichanthium*. *Evolution* 24: 270-277.

De Wet, J. M. J. 1981. Grasses and the cultural history of man. *Ann. Missouri Bot. Gard*. 68: 87-103.

Doyle J. A. & M. J. Donoghue. 1986. Seed plant phylogeny and the origin of angiosperms: an experimental cladistic approach. *Bot. Rev.* 52: 321-431.

Ehleringer, J. R. 1991. Climate change and evolution of C4 photosythesis. *Trends. Ecol. Evol.* 6: 95-99.

Ehleringer, J. R., T. E. Cerling & M. D. Dearing. 2002. Atmospheric CO_2 as a global change driver influencing plant-animal interactions. *Integrative and Comparative Biology* 42(3): 424.

Fischer, C. E. C. 1934 & 1936. Gramineae. *In:* Gamble, J. S., *Flora of the Presidency of Madras.* Adlard & Sons Ltd., London. Part X & Part XI.

Gayathri, M. S. & T. Pullaiah. 1996. On the occurrence of *Dimeria kanjirapalliana* K. C. Jacob (Poaceae) in Andhra Pradesh. *J. Bombay Nat. Hist. Soc.* 80(1): 122-123.

Gould, F. W & T. R. Soderstrom. 1974. Chromosome numbers of some Ceylon grasses. *Canad. J. Bot*. 52: 1075-1090.

Good, R. 1974. *The geography of the flowering plants*. Longman Group Ltd., London.

GPWG (Grass Phylogeny Working Group). 2000. A phylogeny the grass family (Poaceae), as inferred from eight character sets. *In:* S. W. L. Jacobs & J. Everett (Eds.), *Grasses: Systematics and evolution.* CSIRO, Melbourne. pp. 3-7.

GPWG. 2001. Phylogeny and subfamilial classification of the Poaceae. *Ann. Missouri Bot. Gard.* 88: 373-457.

Hackel, E. 1887. Gramineae. *In:* A. Engler & K. Prantl (Eds.), *Die Naturlichen Pflanzenfamilien.* Wilhelm Engelman, Leipzig. II, 2: 1-98.

Hackel, E. 1889. Dimerieae *In:* A. De Candolle, *Monographiae Phanerogamarum* Masson, Paris. 6: 76-90.

Hartely, W. 1950. The global distribution of the tribes of Gramineae. *Austral. Jour. Agr. Res*. 1: 355 - 373.

Hartely, W. 1958. Studies on the origin, evolution and distribution of the Gramineae 1. The tribe Andropogoneae. *Austral. J. Bot*. 6: 116-128.

Hayek, A. 1925. Zur Systematik der Gramineen. *Ost. Bot*. Z. 74: 249.

Henry, A. N., V. Chithra & N. P. Balakrishnan. 1989. *Flora of Tamil Nadu Analysis.* Botanical Survey of India, Calcutta. Ser. 1, Vol. 3.

Heywood, V. H., R. K. Brummitt, A. Culham & O. Seberg. 2007. *Flowering plant families of the World.* Royal Botanic Gardens, Kew.

Hilu, K. W. 2007. A century of progress in grass systematics. *Kew Bull.* 62: 355-373.

Hilu, K. W. & J. L. Johnson. 1991. Chloroplast DNA re-association and grass phylogeny. *Plant Syst. Evol.* 176: 21–31.

Hilu, K. W. & K. Wright. 1982. Systematics of Gramineae: a cluster analysis study. *Taxon* 31: 9–36.

Holmgren, N. H. & B. Angell. 1986. *Botanical illustration: Preparation for publication.* New York Botanic Gardens, New York.

Holmgren, P. K., N. H. Holmgren & L. C. Barnett (Eds.), 1990. *Index Herbariorum* Part I: *The Herbaria of the World* (ed. 8). New York Botanic Garden, New York.

Hooker, J. D. 1897. *Dimeria* R. Br. *In*: *Flora of British India*. Vol 7. L. Reeve & Co., Brook nr. Ashford. pp. 103-106.

Jacob, K. C. 1947. Some new species of South Indian Plants. *J. Bombay Nat. Hist. Soc*. 47(1): 47-51.

Jacobs, F. B., J. D. Kingston & L. L. Jacobs. 1999. The origin of grass dominated ecosystems. *Ann. Missouri Bot. Gard.* 86(2): 590-643.

Jain, S. K. 1967a. Notes on Indian grasses. VI. The genus *Cynodon* Rich. ex Pers. in India. *Bull. Bot. Surv. India* 9:134-154.

Jain, S. K. 1967b. Notes on Indian grasses. VII. The genus *Oropetium* Trin. in India. *Bull. Bot. Surv. India* 9: 284-285.

Jain, S. K. 1970. The genus *Manisuris* L. (Poaceae) in India. *Bull. Bot. Surv. India* 12: 6-17.

Jain, S. K. 1972. The genus *Arthraxon* P. Beauv. (Poaceae) in India. *J. Ind. Bot. Soc*. 51:165-183.

Jain, S. K. 1986. The grass genera of India – A synoptic account of uses and phytogeography. *Bull. Bot. Surv. India* 28: 229-240.

Jussieu, A. L. de. 1789. *Genera Plantarum*. Herissant et Theophilum Barrois, Paris.

Judd, W. S., C. S. Campbell, E. A. Kellogg & P. F. Stevens. 2002. *Plant systematics – A phylogenetic approach*. 2 ed. Sinaur Associates, Sunderland.

Karthikeyan, S. 1971. A contribution to the family Gramineae of the Flora of the Presidency of Madras. *Bull. Bot. Surv. India* 13: 171.

Karthikeyan, S., S. K. Jain, M. P. Nayar & M. Sanjappa. 1989*. Florae Indicae Enumeratio: Monocotyledonae.* Botanical Survey of India, Culcutta.

Kellogg, E. A. 1998. Relationships of cereal crops and other crops. *Proc. Nat. Acad. of Sci.* (USA). 95: 2005-2010.

Kellogg, E. A. 2000. Molecular and morphological evolution in the Andropogoneae. *In:* S. W. L. Jacobs & J. Everett (Eds.), *Grass Systematics and evolution.* CSIRO publishing, Melbourne. pp. 149-158.

Kellogg, E. A. & C. S. Campbell. 1987. Phylogenetic analysis of the Gramineae. *In:* T. R. Soderstrom, K. W. Hilu, C. S. Campbell & M. E. Barkworth (Eds.), *Grass Systematics and Evolution.* Smithsonian Institution Press, Washington D.C. pp 310-322.

Kellogg, E. A. & L. Watson. 1993. Phytogenetic studies of large Data set. I. Bambusoideae, Andropogonodae & Pooideae (Gramineae). *Bot. Rev.* 59(4): 273-343.

Keng, Y. L. 1939. The gross morphology of Andropogoneae. *Sinensia* 10: 274-339.

Kiran Raj, M. S., M. Sivadasan & N. Ravi. 2003. Grass diversity of Kerala – Endemism and its phytogeographical significance. *In:* M. K. Janarthanam & D. Narasimhan (Eds.), *Plant diversity, Human welfare and Conservation*. Goa University, Goa. pp. 8-30.

Kiran Raj, M. S. & M. Sivadasan. 2008. A new species of *Dimeria* (Poaceae, Panicoideae, Andropogoneae) form Goa, India. *Novon* 18: 183-186.

Krishnan, M. S. 1968. *Geology of India and Burma.* Higginbothams Pvt. Ltd., Madras.

Kunth, C. S. 1833. *Enumeratio Plantarum*. Vol. 1. *Agrostographia Synoptica.* J. G. Cottae, Tubingen.

Mabberley, D. J. 1997. *The plant book*: *a portable dictionary of the higher plants*. (Ed. 2). Cambridge University Press, London.

Malhotra, S. K. & S. Moorthy. 1974. A note on the distribution of some plants in Chandrapur district (Maharashtra State). *J. Bombay Nat. Hist. Soc.* 70(3): 599-601.

Mani, M. S. 1974. (Ed.) *Ecology and biogeography of India*. The Hague, The Netherlands.

Manilal, K. S. 1987. *Dimeria deccanensis* Bor, a new record for Kerala. *Ind. J. Pl. Sci*. 5(1): 33-34.

Manilal, K. S. & V. V. Sivarajan. 1982. *Flora of Calicut*. Bishen Singh Mahendrapal Singh, Dehradun.

Mathews, S., R. E. Spangler, R. J. Mason-Gamer & E. A. Kellogg. 2002. Phylogeny of Andropogoneae inferred from phytochrome B, GBSSI, and NDHF. *Int. J. Plant Sci.* 163: 441-450.

Mathews, S., R. C. Tsai & E. A. Kellogg. 2000. Phylogenetic structure in the grass family (Poaceae): evidence form the nuclear gene phytochrome B. *Amer. J. Bot.* 87: 96-107.

Mitra, S. & Mukherjee, S. K. 2007. Reassessment and diversity of endemic angiospermic genera of India. *J. Econ. Taxon. Bot.* 31: 163-176.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 463: 853-858.

Meher Homji, V. M. 2001. *Bioclimatology and Plant geography of Peninsular India*. Scientific Publishers, Jodhpur.

Mehrotra, A. & S. K. Jain. 1980. Endemism in Indian grasses – Tribe Andropogoneae. *Bull. Bot. Surv. India* 22: 51-58.

Mehra, P. N. & V. Kalia. 1975. IOPB Chromosome number Reports. XLIX. *Taxon* 24: 501-516.

Metcalfe, C. R. 1960. *Anatomy of the Monocotyledons*. I. *Gramineae.* Clarendon Press, Oxford.

Mohanan, N. & N. Ravi. 1996. *Dimeria sivarajanii* (Poacaeae), a new species From Kerala, India. *Rheedea* 6(2): 47-50.

Mohanan, M. & A. V. N. Rao. 1984. A new species of *Dimeria* R. Br. (Poaceae) from Kollimalai, South India. *J. Bombay Nat. Hist. Soc*. 80(3): 615-617.

Mohanan, N. & A. N. Henry. 1994. *Flora of Thiruvananthapuram*. Botanical Survey of India, Culcutta.

Mooney, H. 1950. *Supplement to the botany of Bihar and Orissa.* Catholic Press, Ranchi.

Moore, A. C. 1960. *The grasses - Earth's green wealth*. McMillan Company, New York.

Murthy, G. V. S., P. Venu & M. Sanjappa. 1996. Physiography. *In:* P. K. Hajra *et al.* (Eds.), *Flora of India – Introductory volume*, Part I. Botanical Survey of India, Culcutta. pp. 1-15.

Moulik, S. 1997. *The grasses and bamboos of India.* Vol. 1. Scientific Publishers, Jodhpur. pp. 278-286.

Nair, N. C., P. V. Sreekumar & V. J. Nair. 1984. *Dimeria keralae* (Poaceae): a novelty from Kerala, India. *J. Bombay Nat. Hist. Soc.* 80(3): 626-629.

Nair, V. J. & S. Thomas. 2001. Poaceae. *In*: N. P. Singh & D. K. Singh (Eds.), *Floristic diversity and conservation strategies in India*, Vol. IV. *Angiosperms (selected groups): Economic botany and Ethno-botany*. Botanical Survey of India, Culcutta & Ministry of Environment and Forests, New Delhi. pp. 1675-1725.

Nair, V. J., P. V. Sreekumar & N. C. Nair. 1983. *Dimeria raizadae*: a new species of Poaceae from Kerala, India. *Ind. J. For..* 6 (2): 163-165.

Nayar, M. P. 1980. Endemic flora of Peninsular India and its significance. *Bull. Bot. Surv. India* 22: 12-23.

Nayar, M. P. 1996. *Hotspots of endemic plants of India, Nepal, and Bhutan*. Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram.

Nayar, M. P. 1997. Hotspots of Plant diversity in India – Strategies. *In:* P. Pushpangadan, K. V. Santhosh & K. Ravi (Eds.), *Conservation and economic evaluation of biodiversity*. Vol 1. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 59-80.

Nayar, M. P. 1998. Looking beyond 'hotspots' – supplementary strategies of identifying 'warmspots'. *In:* International Conference on *Conservation of tropical species: Communities and Ecosystems.* December 2-6. Thiruvananthapuram. (Abstract) p.20

Nayar, M. P & M. Ahemedulla. 1984. Phytogeographical significance of endemic genera (Angiosperms) in Peninsular India and Sri Lanka. *Bull. Bot. Surv. India* 26: 65-70.

Nayar, T. S., A. Rasiya Beegam, M. Mohanan & G. Rajkumar. 2006. *Flowering plants of Kerala – A handbook*. Tropical Botanic Garden and Research Institute, Thiruvanananthapuram.

Parrotta, J. A. 2001. *Healing plants of Peninsular India*. CABI Publishing, USA.

Pijl, L. van der. 1972. *Principles of Dispersal in Higher Plants*. ed. 2. Springer-Verlag. Berlin.

Pilger, R. 1940. Gramineae III. Unterfamililie Panicoideae. *In:* H. G. A. Engler & K. A. E. Prantl, Nat. Pflanzenfam. Leipzig. ed. 2, 14e: 109.

Pipermo, D. R. & H. D. Sues. 2005. Dinosaurs dined on grass. *Science* 310 (5751):1126 – 1128.

Pohl, R. W. 1987. Man and grasses: a history. *In*: Soderstrom T. R., K. W. Hilu, C. S. Campbell, & M. E. Barkworth (Eds.), *Grass systematics and evolution*. Smithsonian Institution Press, Washington, D. C.

Prasad V., C. A. E. Strömberg, H. Alimohammadian & A. Sahni. 2005. Dinosaur Coprolites and the Early Evolution of Grasses and Grazers. *Science* 310: 1177 – 1180.

Prat, H. 1932. L'epidermae des Graminees. *Ann. Sci. Nat. Bot.* Ser. 10, 14: 117-324.

Pullaiah. T. 1997. *Dimeria* R. Br. *In: Flora of Andhra Pradesh*. Vol. 3. Scientific Publishers, Jodhpur. p.1349.

Radford, A. E., W. C. Dickson, J. R. Massey & C. R. Bell. 1974. *Vascular plant systematics.* Harper & Row, New York.

Raghavan, R. S. *et al.* 1981. Additions to the Cooke's flora of the Bombay Presidency. *Rec. Bot. Sur. India.* XXI. 1:199.

Raizada, M. B. 1948. Some interesting plants from Orissa. *J. Bombay Nat. Hist*. Soc. 48: 667-679.

Rangacharyulu, D. & K. N. Rao. 1991. On the occurrence of two rare plants from Eastern Ghats. *Ind. Bot. Rep.* 9(1): 38-39.

Rao, R. R. 1984. *Biodiversity of India - Floristics Approach*. Bishen Singh Mahendra Pal Singh, Dehradun.

Raunkaiaer, C. 1934. The life forms of plants and statistical plant geography. Clarendon press. Oxford.

Ravi, N. 1995. Two new species of *Dimeria* R. Br. (Poaceae) from Kerala, India. *Rheedea* 5(1): 37-42.

Ravi, N. 1996. Another new species of *Dimeria* R. Br. (Poaceae) from Kerala, India. *Blumea* 41(1): 251-256.

Ravi, N. & N. Anilkumar. 1992. New and interesting species of *Dimeria* R. Br. (Poaceae) from Kerala, India. *Rheedea* 2(2): 101-107.

Ravi, N., N. Mohanan. 1997. *Dimeria namboodiriana*, another new species of Poaceae from Kerala, India. *Rheedea* 7(1):1-4.

Ravi, N. & N. Mohanan. 2002. *Common tropical and sub-tropical sedges and grasses - An illustrated account.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. (Indian edition).

Ravi, N., N. Mohanan & M. S. Kiran Raj. 2001. Three new species of Poaceae from South India. *Rheedea* 11(2): 87-96.

Ravi, N., H. O. Saxena & M. Brahmam. 1995. *Dimeria mahendragiriensis* – A new species of Poaceae from Orissa, India. *Rheedea* 5(2): 142-144.

Ravikumar, K., P. V. Sreekumar & V. J. Nair. 1990. *Dimeria balakrishnaniana* – a new grass from Tamil Nadu, India. *Kew Bull.* 45(3): 573-575.

Reeder, J. R. 1957. The embryo in grass systematics. *Amer. J. Bot.* 44: 756–768.

Ridd, M. F. 1971. South-east Asia as part of Gondwanaland. *Nature* 234: 531-533.

Ridley, H. N. 1925. *The Flora of Malay Peninsula.* Vol. 5. L. Reeve & Co. Ltd., London.

Roberty, G. 1960. Monographie Systematique des Andropogonies du globe. *Boisseria* 9: 398-401.

Roy, G. P. & B. K. Shukla. 1983. A contribution to the grass flora of Madhya Pradesh. *J. Econ. Taxon. Bot*. 4: 567-586.

Roux, L. G. Le & E. A. Kellogg. 1999. Floral development and the formation of unisexual spikelets in the Andropogoneae (Poaceae). *Amer. J. Bot.* 86: 354-366.

Salunkhe, C. B. 1995. *Studies in grasses of South Western Maharashtra*. Ph. D. Thesis (unpublished). Shivaji University, Kohlapur.

Sasidharan, N. *Biodiversity Documentation of Kerala,* Part 6: *Flowering plants.* KFRI Hand book No. 17. Kerala Forest Research Institute, Peechi.

Saxena, H. O & M. Brahmam. 1996*. Flora of Orissa* Vol. 4. Orissa Forest Department, Bhuvaneswar.

Senaratna, S. D. J. E. 1956. *The Grasses of Ceylon*. Peradeniya Manual No. 8. Govt Press, Ceylon.

Sendulsky, T. 1993. First report of ballistochory in the Poaceae. *Ann. Missouri Bot. Gard*. 80: 518-521.

Sharma, B. D., N. P. Singh, R. S. Raghavan & U. R. Despande. 1984. *Flora of Karnataka Analysis*. Ser. 2. Botanical Survey of India, Culcutta.

Sharma, B. D., S. Karthikeyan & N. P. Singh (Eds.), 1996. *Monocotyledones.* Botanical Survey of India, Culcutta.

Schuster, M. R. 1976. Plate tectonics and its bearing on the geographical origin and dispersal of angiosperms. *In:* C. E. Beck (Ed.), *Origin and early evolution of angiosperms*. Columbia University Press, USA.

Simon, B. K. 1990. *A key to Australian grasses*. Queensland Department of Primary Industries Information, Brisbane.

Simpson, B. B. & M. M. Ogorzaly. 2001. *Economic botany*. McGraw-Hill Inc., New York.

Singh, M. P., B. S. Singh & S. Dey. 2002. *Plant diversity & Taxonomy*. Daya Publishing House, New Delhi.

Soreng, R. J., & J. I. Davis. 1998. Phylogenetics and character evolution in the Grass Family (Poaceae): Simultaneous analysis of morphological and chloroplast DNA restriction site character sets. *Bot. Rev.* 64: 1–85.

Sreekumar, P. V., V. J. Nair & N. C. Nair. 1981. *Dimeria copeana*, a new grass from Kerala, India. *J. Bombay Nat. Hist. Soc.* 78(3): 577-579.

Sreekumar, P. V., V. J. Nair & N. C. Nair. 1982. *Dimeria borii* (Poaceae): a new species from Kerala, India. *J. Econ. Taxon. Bot.* 3(2): 657-658.

Sreekumar, P. V., V. J. Nair & N. C. Nair. 1983. *Dimeria jainii* (Poaceae): a novelty from Kerala, India. *Curr. Sci.* 52(6): 259-260.

Sreekumar, P. V. & V. J. Nair. 1991. *Flora of Kerala - grasses*. Botanical Survey of India, Culcutta. Pp. 80-101.

Stafleu, F. A. & R. S. Cowan .1976-1988. *Taxonomic Literature*, ed. 2. *Regnum Veg*. 94, 98, 105, 110, 112, 115, 116. Bohn, Scheltema & Holkema, Utrecht-Junk, The Hague.

Stapf, O. 1896. *Woodrowia* Stapf *In:* J. D. Hooker, *Flora of British India*, Vol. 7. Reeve & Co., Brook. Nr. Ashford. p. 241.

Stearn, W. T. 1992. *Botanical Latin*, ed. 4. Newton Abbot, Devon.

Stebbins, G. L. 1956. Taxonomy and evolution of genera with special reference to the family Gramineae. *Evolution* 10: 235.

Stebbins, G. L. 1972. The evolution of the grass family. *In:* V. B. Younger & C. M. Mckell (Eds.), *The biology and utilization of grasses*. Academic Press, Inc., New York & London. pp.1-17.

Stebbins, G. L. 1981. Co-evolution of grasses and herbivores. *Ann. Missouri Bot. Gard.* 68: 75-84.

Stebbins, G. L. & B. Crampton. 1961. A suggested revision of the grass genera of temperate North America. *Advances in Botany (Lectures and Symposia, IX Int. Bot. Congr.)* 1: 133–145.

Steudel, E. G. 1855. *Synopsis Plantarum Glumacearum*, Vol.1. Gramineae. J. B. Metzier, Stuttgart.

Sukumar, R., H. S. Suresh & R. Ramesh. 1995. Climate change and its implications on Tropical montane ecosytems in Southern India. *Journal of Biogeography* 22 (2): 533-536.

Sur, P. R. 2001. A revision of the genus *Ischaemum* Linn. (Poaceae) in India. *J. Econ. Taxon. Bot*. 25(2): 407-438.

Sur, P. R. 2004. A taxonomic revision of the genus Lophopogon Hack. (Poaceae) in India. *J. Econ. Taxon. Bot*. 28(3): 545-548.

Thorne, R. F. 2000. The classification and geography of the monocotyledon subclasses Alismatidae, Lillidae and Commelinidae. *In:* Soreng R. J. & S. J. Pennington (Eds.), *Monocotyledons – Systematics and evolution.* Royal Botanic Garden, Kew.

Trinius, C. B. 1820. *Fundamenta Agrostographiae*. Apud J. G. Heubner, Vienna. 167p & t. 14.

Tsvelev, N. N. 1989. The system of grasses (Poaceae) and their evolution. *Bot. Rev.* 55: 141–204.

Ved Prakash & S. K. Jain. 1979. Poaceae: Tribe Garnotieae. *Fasc. Fl. India.* Botanical Survey of India, Culcutta. 3: 1-16.

Ved Prakash & S. K. Jain. 1984. Poaceae: Tribe Isachneae. *Fasc. Fl. India.* Botanical Survey of India, Culcutta. 14: 1-42.

Ved Prakash, U. Shukla, D. C. Pal & S. K. Jain. 1978. Addition to Indian grass flora in last two decades. *Bull. Bot. Surv. India* 20: 143-147.

Vegetti, A. C. 1998. Estudio fenetico de la inflorescencia en Andropogoneae (Poaceae). *Kurtziana* 26: 145-163.

Veldkamp, J. F. 1973. Notes on Malesian grasses VI. A revision of *Digitaria* Haller (Gramineae) in Malesia. *Blumea* 21: 1-80.

Virendra Kumar & B. Subramaniam. 1989. *Chromosome atlas of flowering plants of the Indian subcontinent*. Vol. 2. *Monocotyledons*. Botanical Survey of India, Culcutta.

Vogel de, E. F. (Ed.). 1987. *Manual of Herbarium Taxonomy.* UNESCO, Indonesia.

Wagener, A. 1924. (1966). *The origin of continents and oceans*. (Reprint ed.) Dover, New York.

Watson, L. & M. J. Dallwitz. 1980. *Australian grass genera. Anatomy, Morphology, and keys.* The Australian National University, Canberra.

Watson, L. & M. J. Dallwitz. 1992. *The Grass Genera of the World*. CAB International, Wallingford.

Willis, J. C. 1922. *Age and Area*. Cambridge University Press, London.

Zollinger, H. 1854. *Didactylon* Zoll. & Mort. *In: Systematisches Verzeichniss der Im indifchen Hrchipel aus Japan emfangenen Pflanzen.* Druck und Verlag von E. Kiesling, Zurich. p. 99.

Internet-based references

Clayton, W. D., K. T. Harman & H. Williamson (2002 onwards). World Grass Species: Descriptions, Identification, and Information Retrieval. [accessed 01 August 2005]. *http://www.kew.org/data/grasses–db.html*

FAOSTAT. 1999. Database on line. *http//:appas.fao.org/*

Holmgren, P. K. & N. H. Holmgren. 1998 – (Continuously updated): Index Herbariorum. *http://sciweb.nybg.org/science2/indexherbariorum*

IPNI, 2005. International Plant Name Index – Published on the internet. *http://www.ipni.org/index.html*

Watson, L. & M. J. Dallwitz. (1992 onwards). *Dimeria* R. Br. *In*: Grass genera of the world. Flora Online. Version. 18. *http://biodiveristy.uno.edu/delta/grass/www/dimeria.htm*

INDEX TO THE SCIENTIFIC NAMES

(Correct names in Roman and synonyms incorrect in italics)

Appendix

Copies of selected publicationss