



TAXONOMY AND PRESENT DISTRIBUTION OF DIFFERENT SPECIES OF CAREXL., CYPERACEAE IN DARJEELING AND SIKKIM HIMALAYAS, INDIA

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ABSTRACT

Study of the genus *Carex* L. was performed based on 23 species, including 2 varieties, collected from North-eastern India, mostly from the Sikkim Himalaya and Darjeeling Himalaya of Darjeeling district of West Bengal, during 2006 to 2010. In all the cases life-specimens were studied in the field itself for habit and habitat nature and in this regards several populations had been regularly observed. Beside these a few previous collections were taken into consideration from the other states of North-eastern India for the study of floral biology. Most of the morphological characters of vegetative organs were studied in the field as *in-situ* condition and the morphological features of reproductive organs were studied in the laboratory. For each species a number of populations and a good number of specimens were examined. Based on the characters studied all these collected specimens were identified properly and the correct nomenclature of each species is provided. The inflorescence pattern i.e. the synflorescence, pseudoflorescence, spikes, peduncles, distribution of the sexes in a spike, ratio of the distribution of sexes was studied for each species of *Carex*. The analysis of inflorescence nature, from simple to complex synflorescence nature was thoroughly discussed. The arrangements of different types of floral glumes as male, female and sterile ones were thoroughly studied. The appendages in anthers are also important features of interest as like the stigma and the apices of glumes. Each species were arranged accordingly followed by the key to the species. As a whole this study is provided with field observations of species and population, study of different morphological macrocharacters, the study of light microscopic features of floral biology, microscopic study of utricles and nuts including the silica bodies. Besides the observations a general discussion is provided for the genus *Carex*.

Key words: Taxonomy; Floral morphology; *Carex*; Phytogeographical distribution.

1. INTRODUCTION

The sedge family (Cyperaceae) is with about 5000 species under 104 genera distributed worldwide except Antarctica, making it the 3rd largest family of monocots (Goetghebeur, 1998). The cosmopolitan genus *Carex* L. represented about 1,800 species mainly in temperate and cold regions of the world (Mabberley, 2008). The genus *Carex* of Cyperaceae is with the largest number of species, about 2000

according to Goetghebeur (1998). However, Bernard (1990) had estimated more than 2000 species distributed worldwide. Although its main centers of diversity are in North America and East Africa (Starr *et al.* 1999), and is also well represented in South East-Asia and India, especially in high lands. *Carex* is also one of the most important genera in this family Cyperaceae.

Although the species are extending throughout the world, but most of them are occurring in Northern temperate zones (Jermy and Tutin, 1968). Different species are found to occur in a wide range of habitats (Schutz, 2000). Most of the species are able to spread laterally by rhizomatous growth and as a result, large clonal patches / tufts may be formed (Bouzille, 1992). The genus *Carex* is placed under tribe *Cariceae* Pax comprises roughly 40% of the family by species making it one of the largest genera of angiosperms (Reznicek, 1990; Mabberley, 2008). *Carex* species are economically important members of flood plain forests, dry prairies, alpine meadows, peat lands, swamp forests, sedge meadows and a wide range of other communities (Reznicek, 1990). The genus is having diverse biogeographical patches as Gondwanaland, Arcto-Tertiary and Bipolar (Nelmes, 1949; Ball, 1990). It is also remarkable within Cyperaceae because it is easy to recognize as all the species of *Cariceae* Pax are distinguished by the presence of consistently unisexual flowers where a naked gynoeceum is surrounded by a flask-like prophyll known as a perigynium or utricle (Blaser, 1944; Gehrke *et al.* 2012). Although the genus is easily defined and presumably natural, the infra-generic taxonomy of the genus is complex and still unresolved. The floral structures are highly reduced (Clarke, 1893-1894; Kukenthal, 1909; Metcalfe, 1971). The anatomy is generally uniform (Metcalfe, 1969 and 1971; Reznicek, 1990) and species are often distinguished only by a single character or by many small quantitative differences (Kukenthal, 1909; Hamlin, 1959; Naczi, 1992). Due to cosmopolitan distribution and enormous diversity it is very difficult to study the entire genus. Most studies are regional and focused on a portion of sectional diversity only (Mackenzie, 1935; Nelmes, 1951; Standley, 1987; Dai Lunkai *et al.* 2010). The regional basis study provides that in the family Cyperaceae there are 865 species under 33 genera (326 species endemic and 5 species introduced) distributed only in China (Dai Lunkai *et al.* 2010). Further, it is also mentioned that out of about 2000 species of the genus *Carex* 527 species are found in China including the estimation of 260 endemic species. The species are included under 3 subgenera and 69 sections (2 endemic) in China. Thus within

South-East Asia including China *Carex* is with the highest diversity of species.

Clarke (1893-94) had reported 142 species of *Carex* from the then British India of which 69-72 are found to be restricted in North-Eastern India. Rao and Verma (1982) reported 49 species of *Carex* found in North-Eastern India and 33 species in the rest part of India. Moreover, North-Eastern India harbours the largest number of endemic species of the genus. Other species are found to be restricted to the rest part of India and then also in China, Japan and South-East Asia. Interestingly, all the species investigated here in this study are also present in China (Dai Lunkai *et al.* 2010). Accordingly Clarke's sub-area is with the total of 46 species of *Carex* found in the then Assam as a phytogeographical region of India, which is now considered as Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura. Of course, there are 7 species which are found common to the Western Himalaya, 5 to Indian desert, 12 to Peninsular India and Sri Lanka, 1 to Gangetic plain and 26 to Eastern Himalayas (Rao and Verma, 1982). Karthikeyan *et al.* (1989) had reported about 163 species of the genus in the present day India. Sikkim and from the Darjeeling hills of West Bengal are the main habitats of different species of the genus *Carex* (Rao and Verma, 1982; Karthikeyan *et al.* 1989). The study of Noltie (1994) had reported 73 species of *Carex* from Bhutan, Sikkim and the Darjeeling Himalayas along with several infra-specific taxa as subspecies and varieties. Further more, according to Noltie (1994) 55 species out of these 73 are found in Sikkim and the Darjeeling Himalayas and 26 species are found only in Darjeeling Himalayas. Hazra and Verma (1996) have reported 62 species of *Carex* along with several varieties from Sikkim and Darjeeling Himalayas. Dai Lunkai *et al.* (2010), in Flora of China had reported 530 (of which three species under taxa *incertae sedis*) species under 69 sections of which about 66 species (one species treated as taxa *incertae sedis*) found in India. The taxonomy of the genus *Carex* in general and sections of *Carex* in particular, both are a controversial issue. It has stirred emotions since the mid 18th century *i.e.* since the description of *Carex muricata* by Linnaeus (1753).

2. MATERIALS AND METHODS

Present treatise on morphological study of the genus *Carex* (Cyperaceae) is carried out for 23 species (24 taxa) based on more than 500 *in-situ* population of *Carex* collected from different localities of North-Eastern India. Out of these collected samples, morphological characters are evaluated. The plant specimens were mostly collected from Darjeeling district of West Bengal and from Sikkim Himalayas. All the specimens examined were preserved in the herbarium of the Department of Botany, University of Kalyani, Kalyani-741235, Nadia, W. B., India. The observed features of studied specimens are presented according to the treatment of Dai Lunkai *et al.* (2010). The studied specimens belonging to the same section are arranged in alphabetical sequence. The varieties of

the species are also arranged accordingly. The studied specimens belong to 3 subgenera of *Carex* as *Vigneastra*, *Carex* and *Vigneae*. The subgenus *Vigneastra* represents two sections viz. *Polystachyae* representing 4 species and *Indicae* representing 6 species (one species with two varieties). The subgenus *Carex* is represented with 9 sections. All the sections representing with one species, each except the section *Decorae* is with two species. Subgenus *Vigneae* is represented with 2 sections and these sections have studied with one species each. The details of the collection information along with the list of studied specimens and their systematic arrangements are presented in Table 1. However, the details of localities, dates of collections, collector's name and numbers are enlisted under the heading 'specimens examined' presented in the last part of materials and methods.

Table 1

List of the collected studied species and their systematic position (Arranged after Dai *et al.* 2010)

I. Name of the subgenera and sections under each subgenus	II. Sl. no.	III. Name of species studied	IV. No. of samples examined
A. <i>Carex</i> subgenus <i>Vigneastra</i> (Tuckerman) Kukenthal I. <i>Carex</i> sect. <i>Polystachyae</i> Tuckerman	1.	<i>Carex baccans</i> Nees	15
	2.	<i>Carex myosurus</i> Nees	20
	3.	<i>Carex spiculata</i> Boott	20
	4.	<i>Carex composita</i> Boott	10
II. <i>Carex</i> sect. <i>Indicae</i> Tuckerman	5a.	<i>Carex cruciata</i> Wahlenberg var. <i>argocarpus</i> C.B. Clarke	30
	5b.	<i>Carex cruciata</i> Wahlenberg var. <i>nagpurensis</i> C.B. Clarke	15
	6.	<i>Carex burtii</i> Noltie	10
	7.	<i>Carex stramentitia</i> Boott ex Boeckeler	8
	8.	<i>Carex filicina</i> Nees	12
	9.	<i>Carex continua</i> C. B. Clarke	5
B. <i>Carex</i> subgenus <i>Carex</i> III. <i>Carex</i> sect. <i>Hirtae</i> Tuckerman ex Kukenthal	10.	<i>Carex condensata</i> Nees	25
	11.	<i>Carex inanis</i> Kunth	15
	12.	<i>Carex setigera</i> D. Don	10

Continued.....

I.	II.	III.	IV.
B. <i>Carex</i> subgenus <i>Carex</i> IV. <i>Carex</i> sect. <i>Mitratae</i> Kukenthal	13.	<i>Carex breviculmis</i> R. Brown	10
V. <i>Carex</i> sect. <i>Radicales</i> (Kukenthal) Nelmes	14.	<i>Carex speciosa</i> Kunth	10
VI. <i>Carex</i> sect. <i>Decorae</i> (Kukenthal) Ohwi	15.	<i>Carex daltonii</i> Boott	10
	16.	<i>Carex insignis</i> Boott	20
VII. <i>Carex</i> sect. <i>Hymenochlaenae</i> (Drejer) L. H. Bailey	17.	<i>Carex polycephala</i> Boott	10
VIII. <i>Carex</i> sect. <i>Debiles</i> (J. Carey) Ohwi	18.	<i>Carex finitima</i> Boott	10
IX. <i>Carex</i> sect. <i>Molliculae</i> Ohwi	19.	<i>Carex alopecuroides</i> D. Don ex Tillich & Taylor	20
X. <i>Carex</i> sect. <i>Forficulae</i> (Franchet ex Kukenthal) Raymond	20.	<i>Carex teres</i> Boott	20
XI. <i>Carex</i> sect. <i>Graciles</i> Kukenthal	21.	<i>Carex longipes</i> D. Don ex Tillich & Taylor	20
C. <i>Carex</i> subg. <i>Vignea</i> (P. Beauvois ex T. Lestiboudois) Petermann XII. <i>Carex</i> sect. <i>Phleoideae</i> Meinshausen	22.	<i>Carex nubigena</i> D. Don ex Tillich & Taylor	20
XIII. <i>Carex</i> sect. <i>Remotae</i> C. B. Clarke	23.	<i>Carex rochebrunii</i> Franchet & Savatier	25

Sampling in *Carex* included species from all the 3 subgenera, although sampling with each subgenus was limited. All total 13 sections were sampled out of 69 sections as recognized by Dai Lunkai *et al.* (2010). The habit, habitat condition and ecology of 23 species (24 taxa) of *Carex* in the field were investigated on several trips conducted during 2006-2010. The field works were included specimen collection, study of the morphological features, and field notes on ecological data at different times of collection periods as many as possible. The field trips were conducted mostly in the Darjeeling district of West Bengal and Sikkim Himalayas. The investigation is mainly based upon field studies of more than 500 samples for 23 species of *Carex*. The required morphological data as a measurement and part of the description of leaves, rhizomes, vegetative shoots, and inflorescence were mostly done in the field during collection trips.

Descriptions of the different organs of the specimens were done on the basis of Hurd *et al.* (1998), Hipp (2008), Reznicek (1990), Noltie (1994), Clarke (1893-1894), Strong (2004), and Aiken *et al.* (2003) for the typical characterization of different vegetative as well as reproductive features. Selected individual from the different populations were studied at least with 5m gap between them to avoid the same rhizomatous portion. *Carex* specimens were identified as typical samples of their species when the population was in the later stages of flowering or were fruiting and were finally collected at this time. To minimize the risk of collecting two ramets from the same genet a gap of at least 2 m was taken as standard distance as the gap had been followed by the earlier other researchers in practice of 2-5m distance (Faulkner, 1972; Standley, 1990b; Dean and Ashton, 2008). *Carex* species have different types of leafy organs

and these are (i) the leaves of vegetative shoots, (ii) the short leaves produced early in the growing seasons arising near the base of the new shoots, (iii) the leaves arising along the culm and (iv) the bracts. All these four types of leaves were considered for morphological analysis and characterization.

2.1. Collection, preservation and identification

Plant populations collected from different localities, are always in multiple numbers. The major parts of the materials were preserved as dried specimens with proper pressing, drying, labeling and poisoning. All the samples of the collected populations were studied for details of the morphology of inflorescences, flowers and fruits, sexuality of individual spikes, arrangement of sexes of the axes, for identity characters were matched with the descriptions provided in the Flora of British India, (Clarke, 1893-94), Cyperaceae of North-East India (Rao and Verma, 1982), Flora of Bhutan, 3(I) (Noltie, 1994), Flora of China, Vol. 23- Cyperaceae (Dai Lunkai *et al.* 2010); and Field guide to Wilkoncian Sedges (Hipp, 2008). Finally the identity of each and every specimens/populations were verified and established with the preserved specimens of Central National Herbarium (CAL), Botanical Survey of India, AJCB Indian Botanic Garden, Shibpur, Howrah, West Bengal, India and Llyod Botanic Garden, Darjeeling, West Bengal, India. Dried specimens with proper identification and labels kept in the herbarium of the Department of Botany, University of Kalyani, Kalyani, Nadia, West Bengal.

Morphological evidence is the basis for identification of *Carex*. Many morphological characters as possible as were described by examining the morphology, macro-morphology in the field. Macromorphological characters considered to be of observable features were done with the aid of a binocular dissecting light microscope. Micromorphologic characters those observable with a scanning electron microscope were done specially for utricle, features of nuts etc. Whole as well as a portion of inflorescence from basal portion, middle portion and upper portion of the reproductive parts were observed to study the

sexual characters of the plant. For detail study, all the flowers of the unit were studied gradually from base to apex. For this study 5-10 (sometimes more) populations were examined and dissection had been made for each species. All the ramets of all the genet have been studied, examined and dissected for those species where the reproductive characters of species are highly variable as mentioned in the earlier literatures. Even population of the same species from different localities was also studied to see the range of variation. The dissected parts of, all the floral organs were pasted with synthetic gum on a white card for further study and these cards were marked with the same collection numbers and finally kept along with respective herbarium sheets as an extra packet. The drawing of all the floral parts were done with the help of mirror type camera lucida and the magnification were provided with scales with figures. Figures as hand drawing were generally represented as inflorescence pattern, arrangement of flowering glumes, sterile glumes (if any), and sexual pattern. Among the dissected parts the glumes, carpels, utricles, nuts and stamens were provided as camera lucida drawings.

2.2. Specimens examined

1. *Carex baccans* Nees: West Bengal, Darjeeling: Leborg, 5970 ft (1820m), 04.11.2006, A. Ghosh 05; Mirik, 5740ft (1750m), 17.11.2006, A. Ghosh 13; Sikkim: Vikevanjum, 3000m, 8.6.1997, G.G.Maiti 75.

2. *Carex myosurus* Nees: West Bengal, Darjeeling: Sonada, 6552ft (1998m), 4. 09. 2006, A.Ghosh 01; Leborg Race Course, 5970ft (1820m), 04.11.2006, A. Ghosh 02; Leborg Cart Road, 6000 ft (1830m), 04.11.2006, A. Ghosh 03; North Point, 6500ft (1982m), 04.11.2006, A. Ghosh 9; Leborg Race Course, 5970ft (1820m), 04.11.2006, A. Ghosh 11; Darjeeling Govt. College campus, 6800ft (2073m), 25.11.2006, A. Ghosh, 17; kurseong, 4864ft (1483m), 26.11.2006, A. Ghosh 27; kurseong, 4864ft (1483m), 26.11.2006, A. Ghosh 30; Gayabari, 4500ft (1372m), 02.12.2006, A. Ghosh 43; Darjeeling Govt. College Campus, 6800ft (2073m), 04.11.2006, A. Ghosh 52.

3. *Carex spiculata* Boott: West Bengal, Darjeeling: Sonada, 6552ft (1998m), 4. 09. 2006, A. Ghosh 01; North Point, 6500ft(1982m), A.Ghosh 10;

Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 18; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 19; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 25; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 26; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 28; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 31; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 33; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 34; Gayabari, 4500ft(1372m), 02.12.2006, A. Ghosh 35; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh 42; Rohini, 2500ft(762m), 02.11.2008, A. Ghosh 83; Rohini, 2500ft(762m), 02.11.2008, A. Ghosh 84; Pankhabari, 3500ft(1067m), 18.30.2009, A. Ghosh 92.

4. *Carex composita* Boott: West Bengal, Darjeeling: Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 81a; 6552ft(1998m), 09.11.2008, A. Ghosh 81b; Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 81c; Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 81d; Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 82a; Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 82b; Sonada, 6552ft(1998m), 09.11.2008, A. Ghosh 82c; Meghalaya, Shillong, 2100m, 10.1.200, G.G.Maiti S1.

5a. *Carex cruciata* Wahl. var. *argocarpus* C.B. Clarke: West Bengal, Darjeeling: Darjeeling Govt. College campus 6800ft(2073m), 04.11.2006, A. Ghosh 6; Lebong, 5970ft(1820m), 04.11.2006, A. Ghosh 7; Lebong, 5970ft(1820m), 02.12.2007, A. Ghosh 60; Rohini, 2500ft(762m), 02.11.2008, A. Ghosh 80a; Rohini, 2500ft(762m), 02.11.2008, A. Ghosh 80b; Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 88a; Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 88b; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 89a; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 89b; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 89c.

5b. *Carex cruciata* Wahl. var. *nagporensis* C.B. Clarke: West Bengal, Darjeeling: Darjeeling Govt. College, 6800ft(2073m), 04.11.2006, A. Ghosh 6; Lebong, 5970ft(1820m), 04.11.2006, A. Ghosh 7; North Sikkim: Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 64; West Bengal, Darjeeling: Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 88c; Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 88d;

Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 90a; Lebong, 5970ft(1820m), 19.11.2008, A. Ghosh 90b.

6. *Carex burtii* Noltie: East Sikkim: Kobi, 5760ft(1756m), 22.03.2008, A. Ghosh 62a; Kobi, 5760ft(1756m), 22.03.2008, A. Ghosh 62b; Kobi, 5760ft(1756m), 22.03.2008, A. Ghosh 62c; Kobi, 5760ft(1756m), 22.03.2008, A. Ghosh 62d; North Sikkim: Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 65.

7. *Carex stramentitia* Boott ex Boeckeler: West Bengal, Darjeeling: Makaibari, 3000ft(915m), 04.11.2006, A. Ghosh 38; Pankhabari, 3500ft(1067m), 16.03.2009, A. Ghosh 91a; Pankhabari, 3500ft(1067m), 16.03.2009, A. Ghosh 91b; Pankhabari, 3500ft(1067m), 16.03.2009, A. Ghosh 91c.

8. *Carex filicina* Nees: West Bengal, Darjeeling: Darjeeling Govt. College campus 6800ft(2073m), 04.11.2006, A. Ghosh 04; Mirik, 5740ft(1750m), 02.10.2007, A. Ghosh 55; West Sikkim: Pelling, 7200ft(2195m); Sikkim, Gangtok, 3000m, 5.9.2000, D. Maity G-1; Meghalaya, Shillong, 2100m, 10.1.2000, G.G. Maiti S-2.

9. *Carex continua* C. B. Clarke: West Bengal, Darjeeling: Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 29; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85a; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85b; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85c; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 86a; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 86b; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 87a; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 87b; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 87c.

10. *Carex condensata* Nees: West Bengal, Darjeeling: Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 20; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 21; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 22; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 23; Kurseong, 4864ft(1483m), 26.11.2006, A. Ghosh 24; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85d; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85e; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh

- 85f; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 85g; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 86; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 87d; Mahanadi, 4600ft (1402m), 13.11.2008, A. Ghosh 87e; Mahanadi, 4600ft(1402m), 13.11.2008, A. Ghosh 87f.
11. *Carex inanis* Kunth: West Bengal, Darjeeling: Back Mall Road, 7100ft(2165m), 31.05.2008, A. Ghosh 68; Lebong, 5970ft(1820m), 01.06.2008; A. Ghosh 70.
12. *Carex setigera* D. Don: West Bengal, Darjeeling: Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 78a; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 78b; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 78c; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 78d.
13. *Carex breviculmis* R. Brown: West Bengal, Darjeeling: Ghum, 7900ft(2409m), 14.07.2007, A. Ghosh 54; Tigerhill, 8515ft(2596m), 18.11.2007, A. Ghosh 58.
14. *Carex speciosa* Kunth: West Bengal, Darjeeling: Kalingpong, 3937ft (1200m), 10.06.2007, A. Ghosh 53.
15. *Carex daltonii* Boott: Sikkim: Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 61; Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63a(i, ii, iii); Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63b; Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63c; Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63d; Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63e; Lachung, 8610ft(2625m), 22.03.2008, A. Ghosh 63f; West Bengal, Pkallut, 3200m, 10.6.1997, G.G.Maiti 78.
16. *Carex insignis* Boott: West Bengal, Darjeeling: Lebong, 5970ft (1820m), 04.11.2006; A. Ghosh 39; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh 40; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh 41; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh L1; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh Lii; Lebong, 5970ft(1820m), 04.11.2006; A. Ghosh Liii.
17. *Carex polycephala* Boott: West Bengal, Darjeeling: Senchel, 8163ft (2488m), 08.04.2007, D. Palit Ai; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 74.
18. *Carex finitima* Boott: West Bengal, Darjeeling: Ghum, 7900ft (2409m), 29.06.2008, A. Ghosh 77a; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 77b; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 77c; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 77d.
19. *Carex alopecuroides* D. Don ex Tillich & Taylor: West Bengal, Darjeeling: D. M. Office, 6500ft (1982m), 08.05.2008, A. Ghosh 66 (ten gatherings).
20. *Carex teres* Boott: West Bengal, Darjeeling: Tigerhill, 8515ft (2596m), 07.06.2008, A. Ghosh 73 (more than 15 gatherings).
21. *Carex longipes* D. Don ex Tillich & Taylor: West Bengal, Darjeeling: Lebong, 5970ft(1820m), 15.04.2007, A. Ghosh 44; Gymkhana, 7100ft(2165m), 13.05.2008, A. Ghosh 67; Lebong, 5970ft(1820m), 01.06.2008, A. Ghosh 69; Lebong, 5970ft(1820m), 05.06.2008, A. Ghosh 72.
22. *Carex nubigena* D. Don ex Tillich & Taylor: West Bengal, Darjeeling: Third Mile, 6000ft(1829m), 03.12.2006, A. Ghosh 36; Mirik, 5740ft(1750m), 02. 10. 2007, A. Ghosh 57; Tigerhill, 8515ft(2596m), 08.11.2007, A. Ghosh 59; Lebong, 5970ft(1820m), 05.06.2008; A. Ghosh 71; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 75; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 76a; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 76b; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 76c; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 76d; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 79a; Ghum, 7900ft(2409m), 29.06.2008, A. Ghosh 79b; Nepal, boarder of Darjeeling district of West Bengal, Kalipokhari, 2500m, 6.6.1997, G.G.Maiti 73.
23. *Carex rochebrunii* Franchet & Savatier: West Bengal, Darjeeling: D. M. office, 6500ft (1982m), 09.05.2008, A. Ghosh 45; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 75a; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 75b; Tigerhill, 8515ft(2596m), 07.06.2008, A. Ghosh 75c; Darjeeling, 7100ft(2165m), 07.06.2008, A. Ghosh 76.

3. OBSERVATION

The present study of the genus *Carex* is done for 23 species (24 taxa) collected from North-eastern India, especially from the Sikkim Himalaya and from the Darjeeling district of West Bengal. The field studies of the specimen, observation of the population, finally a description of morphological features including scanning electron microscopic study of utricles and nuts have provided. It is worthy to mention here again that both field characters of habit and habitat and the floral biology including the anatomical features all are important characters for the study of the genus *Carex*. All these characters are used to place the genus *Carex* in Cyperaceae under a separate subfamily *Cyperoideae* or under a separate tribe *Cariceae* including some other genera. Moreover, these characters are useful for the classification of the genus *Carex* into the infrageneric rank to subgenera and sections as well. Furthermore, the evolutionary aspects and the phylogeny of this genus *Carex* and its subgenera as well as sections can be of better understanding. These general accounts of the characteristic features of the studied species of *Carex* with examples are provided below: The plants are either stoloniferous or rhizomatous and most of the studied species are rhizomatous. Plants may be phyllopodic with leafy nature or aphylllopodic with bladeless sheathing leaves. The presence of the number of modules in a tuft of a plant is also an important feature as *C. burtii* has 50-70 modules; *C. inanis* and *C. breviculmis* have upto 100 as maximum count while least number is present in *C. baccans*, *C. alopecuroides* as 2-5. The roots are always fibrous, of different colouration, grow as profuse aggregation. The leaves in the rhizomatous plant or in stems of ground level and above ground level may be of bladeless with sheathing bases or with leaf blades. The leaf-sheaths bear some important features including the ligular nature and the existence of different fibrous natures of the remnants of older leaves. The lamina or leaf blades, however, provide more important features in folding nature and too much in the anatomical structures. The culms have the inflorescence, leafy bracts, flowering peduncles, spikes and the arrangements of different sexes in a spike and all

these features are forming a unique nature of synflorescence in *Carex* (Fig. 1). The details of each feature for each species was thoroughly described (Table 2). Basically spikelet is an inflorescence of *Carex* as like other genera of Cyperaceae. However, as a general account, it can be summarized that the pseudoflorescence is the basic unit of synflorescence in *Carex* (Fig. 1). Further details are also found as simple truncated-pseudoflorescence in *C. nubigena*, spikoloidium-pseudoflorescence in *C. rochebrunii*, antheloidium-pseudoflorescence in *C. teres*, fasciculoidium-pseudoflorescence in *C. insignis* and paniculoidium-pseudoflorescence in *C. stramentitia* (Fig. 1). The number of flowering nodes per module and the number of the peduncle and spike per node are also the important account for the identity of the species (Table 2). The arrangements of male, female as well as sterile flowers in a spike are the important criteria of identity of species or a group of species under a section. Thus the study of the pistillate portion, staminate portion and the position of sterile flowers are too much important for the identity of the species which is quite different as well as characteristic for species (Fig. 2). The synflorescence and the distribution of the sexes were thoroughly studied and here represented for studied species (Figs. 2-8). The simplest form is noted in the case of *C. baccans* (Fig. 2) and gradually complex nature is observed in *C. teres* (Fig. 7) and also in *C. rochebrunii* (Fig. 8). The arrangements of sexes are mostly androgynous in many of the studied species. However, some species are gynaeandrous as in *C. rochebrunii*. *C. teres* shows variations as gynaeandrous and mesogynous.

The nature of bract, leafy in nature, prophyll, etc. are also important features which provide some characters for grouping of species as these are shorter than the inflorescence structure, or equal to the inflorescence, or exceeding the top of inflorescence structure. The count of the flowering glumes (Table 2) provides some important information for the identity of species specially whenever there are the presence of sterile glumes and their position of the arrangement. *C. insignis* thus can be identified by the presence of more number of sterile glumes and their arrangements as

basal, middle as well as upper position. In *C. cruciata* var. *nagporensis* although their position is basal but variable in count which can be of useful study to separate *C. cruciata* var. *argocarpous* where there are 1-2 basal sterile glumes. Of course, many of the studied species do not have sterile glumes. Morphological characters of glumes as shape, size, apex, vein, colour, etc. provide most important features for the study of individual species of *Carex*. The apices of glumes as cuspidate, awned and their surface features as muricate, mucronate, scabrid, hispid etc. provide many important information (Figs. 9-11). In the male flower the stamens are mostly 3 in number. Stamens are mostly isomorphic (Fig. 12). However, the length of filaments may be very shorter in some species or may be equal in size. In *C. composita* and *C. daltonii* the length of filaments are very short. The equal size of filament with that of the anther length is found in *C. setigera*. The panthers have mostly apiculate appendage above and that appendage structure is different in many species.

Moreover, the surface of appendages often has a unique feature as hispid, hispidulous, or often spinous nature. The hispidulous nature is found in *C. composita*, *C. daltonii* and *C. rochebrunii*, *C. stramentitia*, etc. (Fig. 12). The gynoecium or pistil of *Carex* is although not unique for the identity but often provided the features of ovary and stigma as unique for identity. The stigmatic surface is also different in few cases. The utricles or perigynia are the important structural features and that are mostly used for identification. The shape, size, surface, veins and beak of utricle of *Carex* should be studied in details for the identity (Fig. 13, 14) of species. Nuts of *Carex* provide more information about shape, size, and surfaces as well as many additional taxonomic characters. Besides shape and size, basal carpodium structure and even the apex of nut are different in different species (Fig. 15). The stipitate nuts of *C. teres*, *C. polycephala*, *C. nubigena* and *C. setigera* are no doubt different from other species of *Carex*.

Table 2

Comparison of some vegetative and reproductive morphological features of the studied taxa of Carex

I. Sl.no.	II. Names of studied taxa	III. Characters of bract	IV. No. of Module/ tuft	V. No. of flowering node/module	VI. No. of peduncles /node	VII. No. of spike s/ node	VIII. Total flower -ing glume s/ spike	IX. No. of sterile glumes and arrangement	X. Ratio of male and female portions of the spikes		XI. Arrangement of sexes
									Xa In length female:male	Xb In no. of flowers female:male	
1.	<i>Carex baccans</i> Nees	Exceeding inflorescence	2-5	5-6	1(2)	7-18	50-65	Absent	1.5:1	1.5:1	All androgynous
2.	<i>Carex myosurus</i> Nees	Greatly exceeding inflorescence	5-7	8-9	1-3	3-9	50-60	Absent	1:2-1:1	1:1- 2:1-3:1	All androgynous
3.	<i>Carex spiculata</i> Boott	Slightly to greatly exceeding inflorescence	5-10	5-7	1	3-12	40-60	Basal 1-2	3:1-4:1	3:1-4:1	All androgynous
4.	<i>Carex composita</i> Boott	Exceeding inflorescence top	12-15	5-7	1	9-17	30-100	Absent	3:1-1:1	3:1-1:1	All androgynous

Continued.....

I	II	III	IV	V	VI	VII	VIII	IX	Xa	Xb	XI
5a.	<i>Carex cruciata</i> Wahl. var. <i>argocarpus</i> C.B. Clarke	Greatly exceeding inflorescence	3-5	8- 9	1-2	7-10	10- 15	Basal 1-2	3:1- 4:1	2:1	All androgynous
5b.	<i>Carex cruciata</i> Wahl. var. <i>nagpurensis</i> C.B. Clarke	Greatly exceeding inflorescence	5-7	5- 7	2-3	7-25	100- 150	a) 3-4 basal; b) 25 basal; c) 20-25 basal	3:1- 4:1	2:1	All androgynous
6.	<i>Carex burtii</i> Noltie	Slightly exceeding inflorescence top	50- 70	7- 9	1-2	Nume- rous	15- 35	Generally 1 rarely 2	1:2- 1:3	1:4- 1:5	All androgynous
7.	<i>Carex stramentitia</i> Boott ex Boeckeler	Slightly exceeding inflorescence top	5-7	3- 5	1-2	Numer- ous	12- 20	1-2, basal	1:2	1:3- 1:4	All androgynous
8.	<i>Carex filicina</i> Nees	Just exceeding inflorescence	5-7	4- 6	Generally 2(one longer and other one shorter)	11-15	10- 12	Absent	2:1- 3:1	1.5:1	All androgynous

Continued.....

I	II	III	IV	V	VI	VII	VIII	IX	Xa	Xb	XI
9.	<i>Carex continua</i> C.B. Clarke	Just equaling inflorescence top	Up to 50	4-6	1-2	15-24	14-20	Absent	4:1-5:1	2:1- 5:1	All androgynous
10.	<i>Carex condensata</i> Nees	Slightly to greatly exceeding inflorescence top	30- 70	8-9	Mainly 2, rarely 1	Numerous	19-25	1-3, basal	1:2	1:3- 1:4	All androgynous
11.	<i>Carex inanis</i> Kunth	Hardy equaling to inflorescence	Up to 100	4-5	More or less absent	1 to each node	Up to 75	2,basal; 4-5, upper	4:1-5:1 upper totally male	5:1- 6:1	Basal 4-5 androgynous; upper one totally male
12.	<i>Carex setigera</i> D. Don	Greatly exceeding inflorescence top	30- 35	7-10	One to each node	3-11	60- 100	Absent	1:2	1:2- 1:3	a) androgynous; b) totally male; c) totally female
13.	<i>Carex breviculmis</i> R. Br.	Greatly exceeding inflorescence	Up to 100	4-5	Almost absent	1 to each node	6-60	Absent	4:1-11:1; upper totally male	4:1- 10:1	Basal 4-5 androgynous; upper one totally male
14.	<i>Carex speciosa</i> Kunth	Equaling to or slightly exceeding inflorescence	2-20	1-2 rarely 3	1-2	Generally 1, rarely 2	More than 40	1-2, basal	1:1-1.5:1	1:1- 1:3	All androgynous

Continued.....

I	II	III	IV	V	VI	VII	VIII	IX	Xa	Xb	XI
15.	<i>Carex daltonii</i> Boott	Greatly exceeding inflorescence top(twice of	3-5	5- 7	2-28	2-35	15-40	2-3, basal	variable	variable	Basal totally female; middle androgynous;

		the length)									upper totally male
16.	<i>Carex insignis</i> Boott	Shorter or just equaling inflorescence top	10-20	7-10	1-5	5-10	Up to-90	Up to 25, basal, middle, upper	10:1-3:10	1:10-1:30	Mostly androgynous; sometimes totally male
17.	<i>Carex polycephala</i> Boott	Equaling inflorescence	2-4	3-5	2-7	2-7	40-70	Absent.	2:1-3:1	3:1-6:1	All androgynous
18.	<i>Carex finitima</i> Boott	Exceeding inflorescence top	3-5, up to 20	3-5	1 to each node	1	Female 85-90; male 55-60	Absent	4:1	5.5:1	Basal 3-4 spikes female; topmost one totally male
19.	<i>Carex alopecuroides</i> D. Don ex Tilloch & Taylor	Lower exceeding but upper equaling inflorescence top	2-5	4-6	One to each each	generally 1, rarely 2	134-224	Terminal one with several sterile glumes, position not fixed	5:1-6:1	3:1	Basal 4-5 female; terminal one variously arranged

Continued.....

I	II	III	IV	V	VI	VII	VIII	IX	Xa	Xb	XI
20.	<i>Carex teres</i> Boott	Exceeding inflorescence top	2-5	4-6	1	1, rarely 2 (terminal)	210-400	20-25, basal	5:1-6:1	5:1-6:1	Basal 2-3 female; topmost various (gynaecandrous, mesogynous)
21.	<i>Carex longipes</i> D. Don ex Tilloch & Taylor	Slightly exceeding inflorescence top	5-10	5-12	1	1-3	22-30	1-3, basal	2:1, 3:1-5:1	1.5:1-2:1	Mostly androgynous; basal totally female
22.	<i>Carex nubigena</i> D. Don ex Tilloch & Taylor	Half of the length to equaling to inflorescence top	50-100	1-2	1	5-10	15-30	1-2, basal	5:1	5:1	All androgynous
23.	<i>Carex rochebrunii</i> Franchet & Savatier	Equaling to or slightly exceeding inflorescence top	20-50	8-9	Absent	1	25-35	8-10 (rarely), top	10:1	6:2-25:2	Gynaecandrous (basal male, upper female)

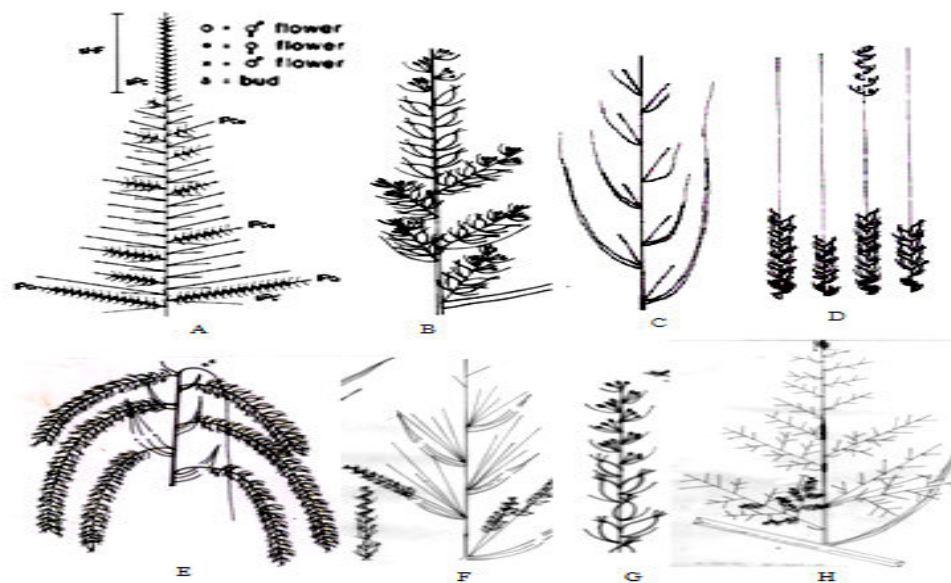


Figure 1
Synflorescence types in *Carex* L.

A. Pseudoflorescence-the basic unit of synflorescence of *Carex* L (after Vegette, 2003).; B. Simple truncated pseudoflorescence of *C. nubigena*; C. Spikolidium-pseudoflorescence of *C. rochebrunii*; D. Arrangement of flowers of different sexes on single spike of *C. rochebrunii*; E. Antheloidium-pseudoflorescence of *C. teres*; F. Fasciculoidium – pseudoflorescence of *C. insignis*; G. Arrangement of flowers of different sexes on single spike of *C. insignis*; H. Paniculoidium-pseudoflorescence of *C. stramentitia*. (All diagrammatic- not after scale)

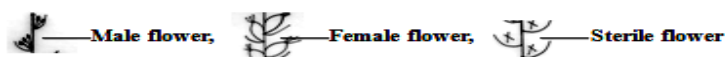
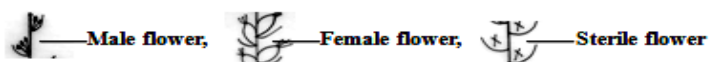


Figure 2
Synflorescence in different species of *Carex* L. (showing distribution of sexes):
A. and B. *C. baccans*; C. and D. *C. myosurus*; E. and F. *C. spiculata*.
B. (All diagrammatic- not after scale)



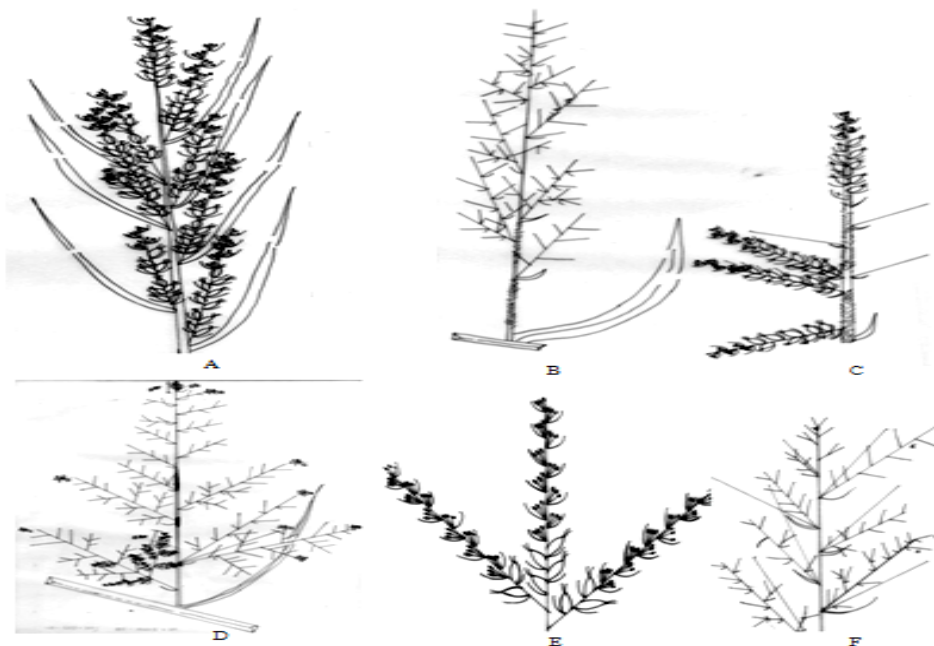


Figure 3

Synflorescence in different species of *Carex* L. (showing distribution of sexes)

A. *C. composita*; B. and C. *C. cruciata* var. *argocarpus*; D. *C. cruciata* var. *nagporensis*; E. and F. *C. burtii* (All diagrammatic- not in scale)

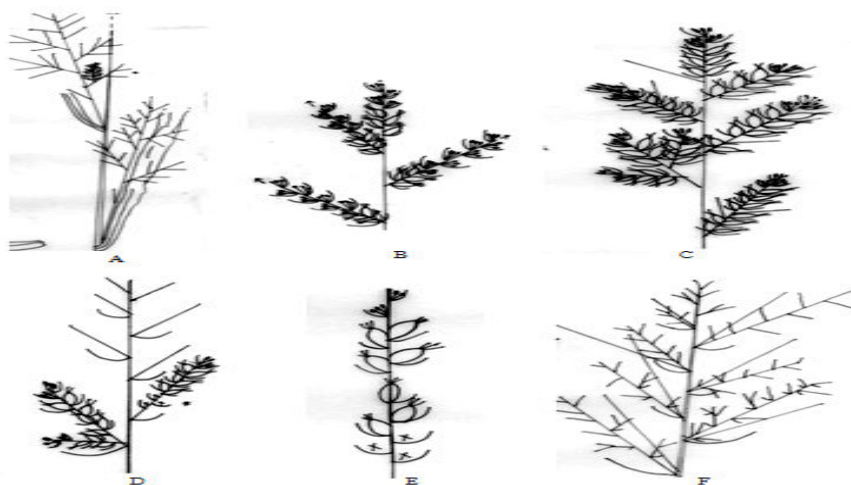
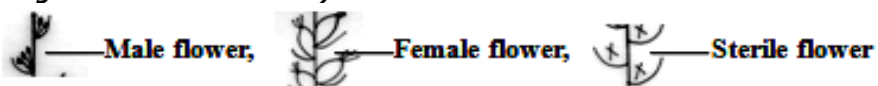
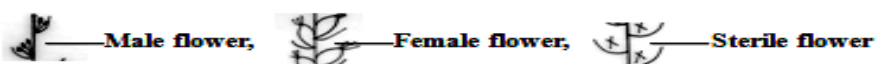


Figure 4

Synflorescence in different species of *Carex* L. (showing distribution of sexes):

A. and B. *C. stramentitia*; C. *C. filicina*; D. and E. *C. continua*; F. *C. condensata* (All diagrammatic- not in scale)



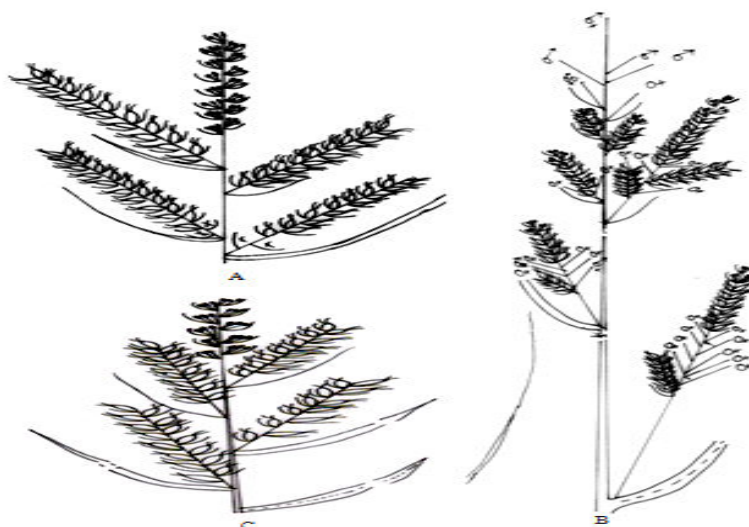


Figure 5
Synflorescence in different species of *Carex*-L.(showing distribution of sexes)

A. *C. inanis*; B. *C. setigera*; C. *C. breviculmis*.
(All diagrammatic- not in scale)

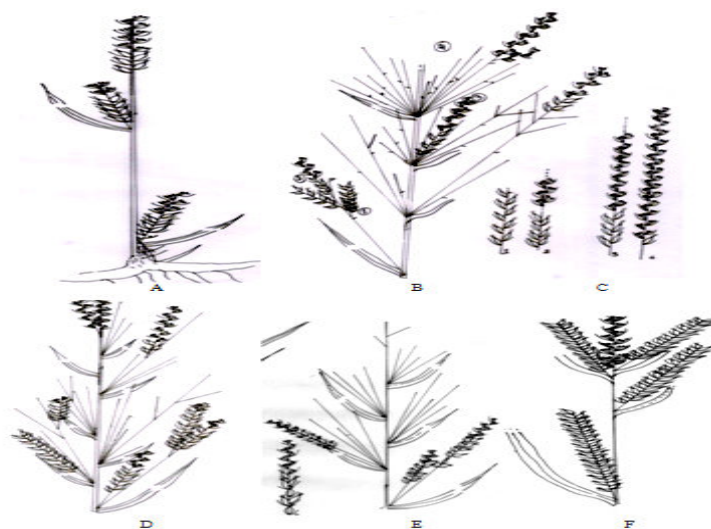
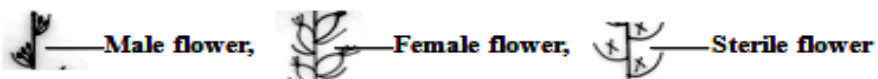


Figure 6
Synflorescence in different species of *Carex* L.(showing distribution of sexes)

A. *C. speciosa*; B. and C. *C. daltonii*; D. *C. insignis*; E. *C. polycephala*. F. *C. finitima*. (All diagrammatic- not in scale)

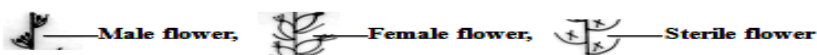




Figure 7
Synflorescence in different species of *Carex* L.(showing distribution of sexes)

A. and B. *C. alopecuroides*; C. *C. longipes*; D and E. *C. teres*
(All diagrammatic- not in scale)

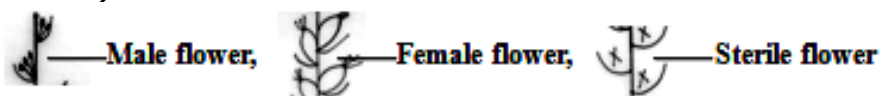
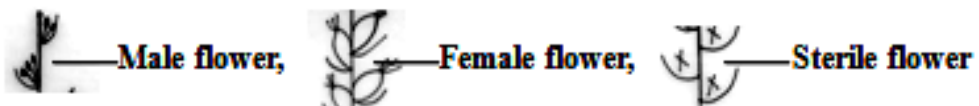


Figure 8
Synflorescence in different species of *Carex* L.(showing distribution of sexes)

A. *C. nubigena*; B. and C. *C. rochebrunii*.
(All diagrammatic- not in scale)



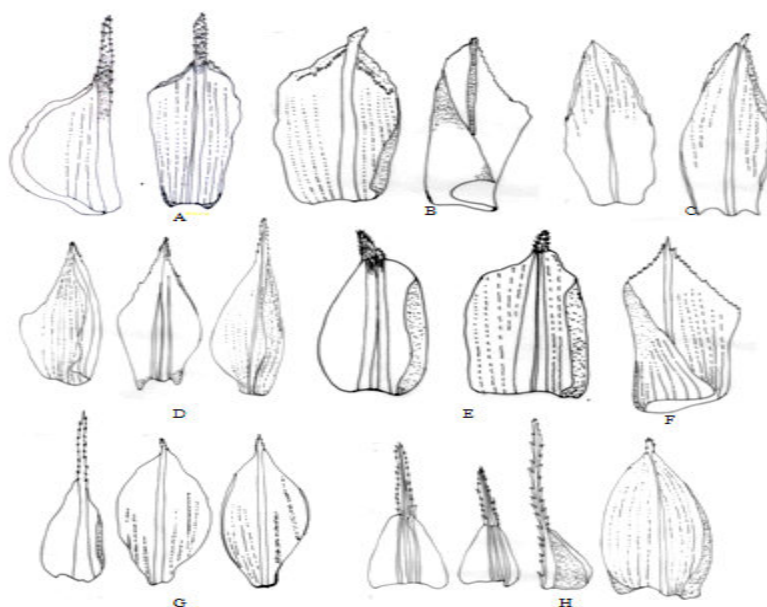


Figure 9
Morphology of glumes of female flowers of *Carex* L.

A. *C. baccans*; B. *C. myosurus*; C. *C. spiculata*; D. *C. composita*; E. *C. cruciata* var. *argocarpus*; F. *C. cruciata* var. *nagpurensis*; G. *C. burttii*; H. *C. stramentitia*
(All diagrammatic- not in scale)

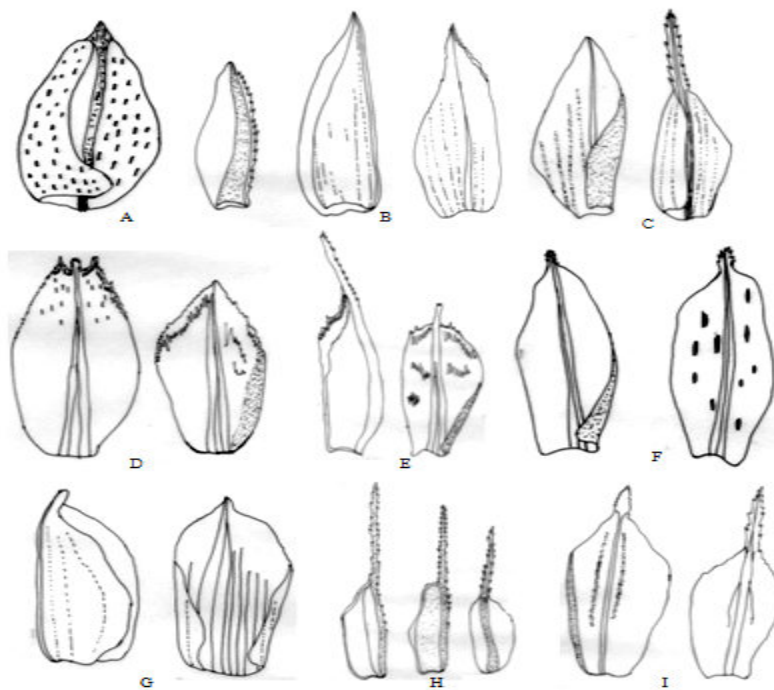


Figure 10
Morphology of the glumes of female flowers of *Carex* L.

A. *C. filicina*; B. *C. continua*; C. *C. condensata*; D. *C. inanis*; E. *C. setigera*; F. *C. breviculmis*; G. *C. speciosa*; H. *C. daltonii*; I. *C. insignis* (All diagrammatic- not in scale)

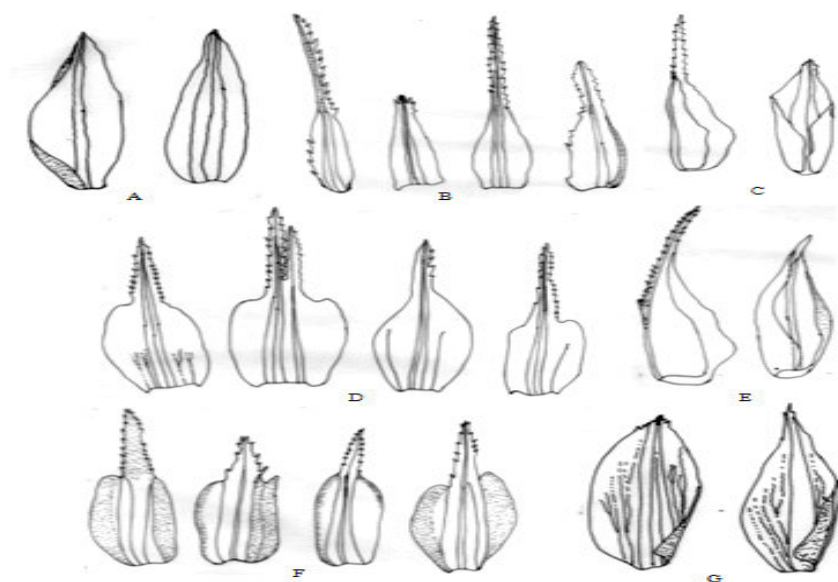


Figure 11
Morphology of the glumes of female flowers of *Carex L.*

**A. *C. polycephala*; B. *C. finitima*; C. *C. longipes*; D. *C. alopecuroides*; E. *C. nubigena*;
F. *C. teres*; G. *C. rochebrunii* (All diagrammatic- not after the scale)**

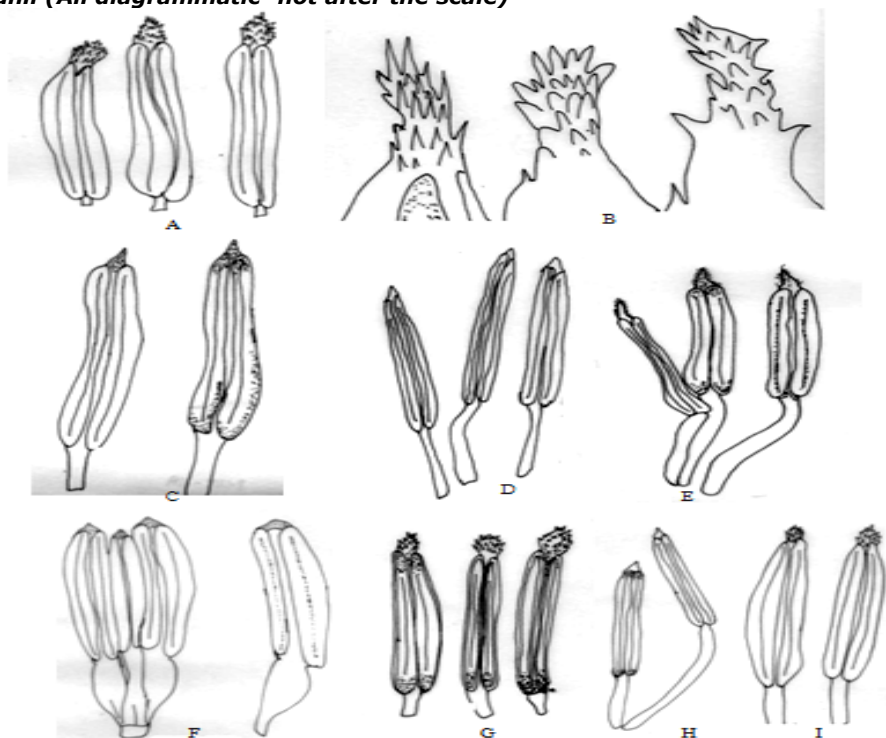


Figure 12
Morphology of the stamens of *Carex L.*

**A. and B. *C. composita*; C. *C. stramentitia*; D. *C. filicina*; E. *C. setigera*; F. *C. speciosa*; G. *C. daltonii*; H. *C. nubigena*; I.
C. rochebrunii (All diagrammatic- not in scale)**

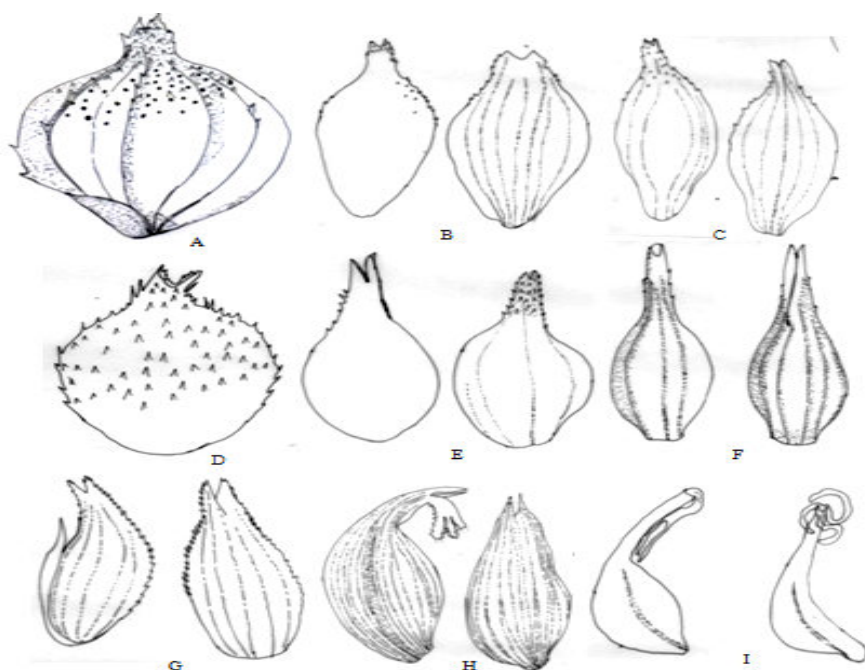


Figure 13
Morphology of utricles of *Carex* L.

A. *C. baccans*; B. *C. myosurus*; C. *C. spiculata*; D. *C. composita*; E. *C. cruciata* var. *argocarpus*; F. *C. cruciata* var. *nagporensis*; G. *C. burtii*; H. *C. stramentitia*; I. *C. filicina* (immature) (All diagrammatic- not in scale)

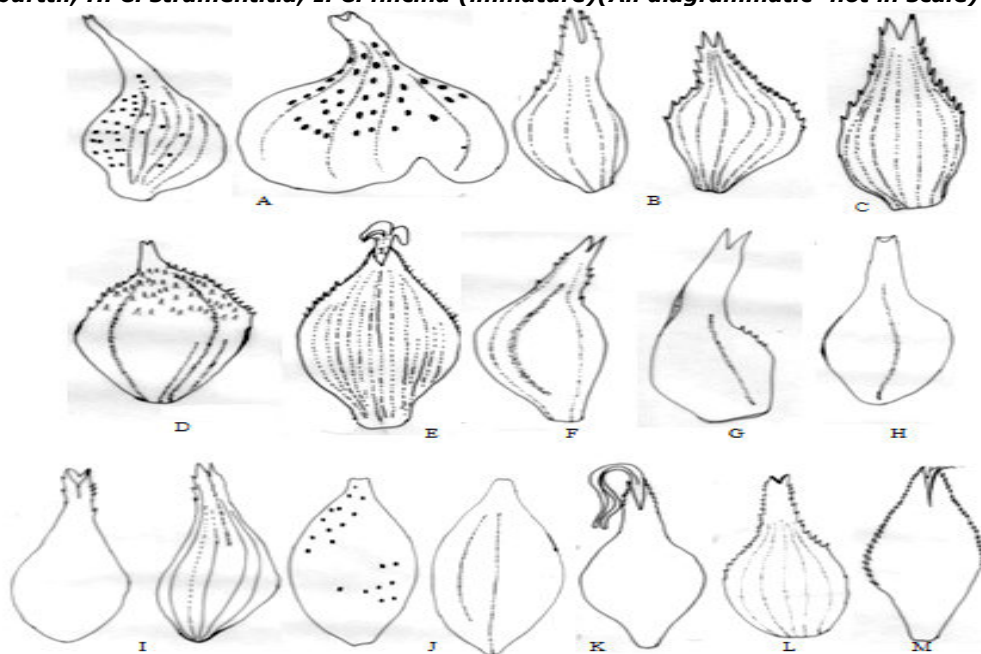


Figure 14
Morphology of utricles of *Carex* L.

A. *C. filicina*; B. *C. continua*; C. *C. condensata*; D. *C. inanis*; E. *C. speciosa*; F. *C. insignis*; G. *C. polycephala*; H. *C. finitima*; I. *C. alopecuroides*; J. *C. teres*; K. *C. longipes*; L. *C. nubigena*; M. *C. rochebrunii* (All diagrammatic- not in scale).

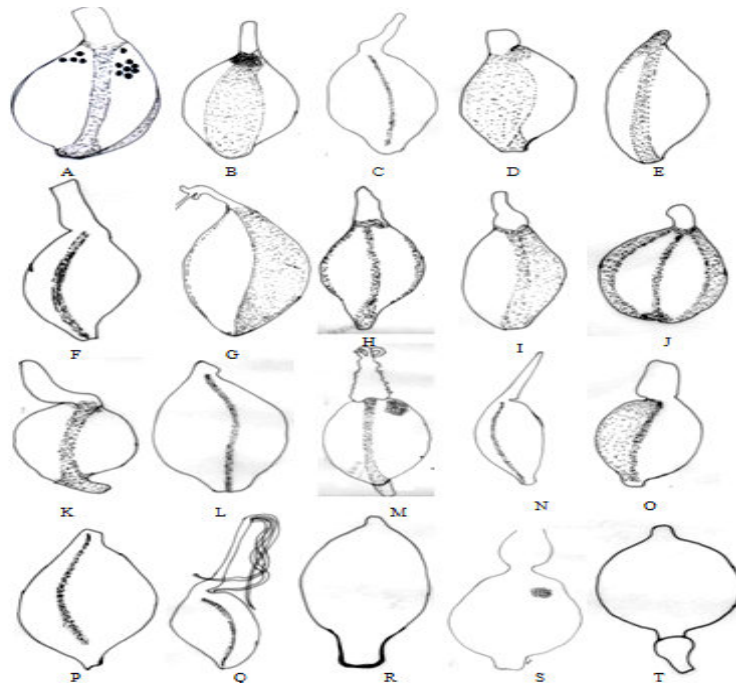


Figure 15
Morphology nuts of *Carex* L.

A. *C. baccans*; B. *C. myosurus*; C. *C. spiculata*; D. *C. cruciata* var. *argocarpus*; E. *C. cruciata* var. *nagporensis*; F. *C. burtii*; G. *C. stramentitia*; H. *C. filicina*; I. *C. continua*; J. *C. inanis*; K. *C. setigera*; L. *C. breviculmis*; M. *C. speciosa*; N. *C. insignis*; O. *C. polycephala*; P. *C. finitima*; Q. *C. alopecuroides*; R. *C. teres*; S. *C. longipes*; T. *C. nubigena* (All diagrammatic- not in scale)

4. DISCUSSION AND CONCLUSION

The genus *Carex* consists of more than 2000 species distributed throughout the World. In India it has a good representative of about 142 species as stated by Clarke (1893-1894). Rao and Verma (1982) reported 49 species of *Carex* found in North-eastern India and 33 species in the rest part of India. Karthikeyan *et al.* (1989) had reported about 163 species of the genus in the present day India. The study of Noltie (1994) had reported 73 species of *Carex* from Bhutan, Sikkim and from the Darjeeling Himalayas along with several infra-specific taxa as subspecies and varieties. Furthermore, according to Noltie (1994) 55 species are found in Sikkim and the Darjeeling Himalayas and 26 species are found only in the Darjeeling Himalayas out of 73 species found in Bhutan. Hazra and Verma (1996) have reported 62 species of *Carex* along with several varieties from Sikkim and Darjeeling Himalayas and out of them North-eastern region has the maximum concentration. *Carex* is a difficult as well

as important genus of the family Cyperaceae placed under subfamily *Caricoideae* or under tribe *Cariceae* along with other 3 or 4 genera. The phylogeny and the evolution of *Carex* were studied in regards to the placement of the genus within Cyperaceae. The classification of the genus *Carex* was also done with the recognition of 3 subgenera and 71 sections. The evolutionary aspects were based on both morphological and floral biological characters and finally the molecular data. In India the works on *Carex* was least done. The first taxonomic account was presented by C. B. Clarke in 1893-1894 and afterwards the estimation and count were provided in many floristic accounts only. The taxonomy of *Carex* and their anatomical features were almost untouched and thus here attempted. On the basis of the present study on 23 species (24 taxa) of *Carex* it is seen that the habit and habitat features of *Carex* are important and that should be taken into account to know the actual status of

different species of India. Moreover, it is required for the proper identity of species. The rhizomes, stems, culms, leaves, leafy bracts, sheaths of both leaves and bracts provide many characters for the study of different species and for identity of species of *Carex*. The inflorescence and floral biology of *Carex* is interesting aspect of study. There is an evolutionary line in the floral biology as well as in the structural pattern of inflorescence.

Carex has complex structural patterns for inflorescence nature as a whole. It is quite necessary to study this pattern of complexity as found in different species for the phylogeny and evolution within the genus *Carex*. Thus for each of the species the pattern of floral arrangement, furthermore, arrangement of flowers in spike, arrangement of the spikes and peduncles and finally the total structures was thoroughly described. The distribution or arrangement of pistillate portion, staminate portion as well as the sterile portion within a spike is also most important feature for the identification of species. The morphology of glumes, for different flowers as male, female or even sterile ones, is in most cases providing many characteristic features to identify the species. The characters of glume as shape, size, apices, venation, colour, etc. are important features of interest. The apices of glumes are different as cuspidate, awned, etc. and again the length, surface of the awns are providing sometimes the specific characters of identity. The utricles are the important structures in *Carex*. The shape, size, apex, base, the surface having costate nature and finally cellular features all are important characters for the identity of the species of *Carex*. The apex of utricle is mostly bidentate but again the surface

features of beak portion as scabrid, hispid, scaberulous, etc. are providing characteristic features of the identity of the species. Thus the scanning electron microscopic study is necessary to ascertain these features of interest. Nuts of the member of Cyperaceae are providing important characters and so also for the genus *Carex*. The light microscopic studies (LMS) as well as scanning electron microscopic study (SEM) both are providing many important features. The shape, size, nut stipitate or not, apex of nut, surface of nut, etc. under light microscopic study are very much important features to identify the species and the group of species. Whenever, studied under SEM there are again many of the information about the cellular features, presence of silica bodies, etc. The study of silica bodies in *Carex* is here first worked out for the genus *Carex* of India. The nature and types of silica bodies in the nuts of *Carex* are providing important features. As a whole under concluding remarks of this study based on 24 taxa it can be stated that the most important features of morphological data are available from the characters of the followings: number of module per plant, character of bracts in culm, number of flowering nodes in the culm, number of peduncles in the culm and nodes, number of spikes in a node, number of flowering glumes in a spike, number and arrangement of sterile glumes, male flowers and female flowers and finally the arrangement of sexes in the spike. The other study is required for glumes, utricle, nuts, etc. For the study of nuts SEM microscopic study is required for the detailed study of silica bodies.

Key to the studied species of *Carex* L. (artificial key to the studied species based on morphological characters):

- 1a. Inflorescence simple to compound, spicate to paniculate; spikes few to many, bisexual, all androgynous; stigmas generally 3, rarely 2.....2
- 1b. Inflorescence spicate, spikes few to many, unisexual or both unisexual and bisexual (sometimes variable in sexuality); stigmas 3, rarely 2..... 3
- 2a. Length of spikes generally more than 2 cm; with 2-3 orders of lateral paracladia; spikes evenly distributed..... 15
- 2b. Length of spikes generally less than 2cm; with secondary paracladia of 3-4 order present; spikes compactly arranged 18
- 3a. Spikes sessile, comparatively shorter..... 4
- 3b. Spikes stalked (atleast lower few), comparatively longer.....5

- 4a. Sexuality gynaecandrous; stigmas 2; epidermal cells of nut with distinct single silica body *C. rochebrunnii*
- 4b. Sexuality androgynous; stigmas 3; silica body absent in the epidermal cell of nut *C. nubigena*
- 5a. Peduncles 1-3(4) per flowering node, gradually decreasing in length towards apex.....6
- 5b. Number of peduncles more than 5 per flowering node, sometimes upto 28, all peduncles of different length.....7
- 6a. Terminal spike totally male, or variable in sexuality.....9
- 6b. Terminal spike androgynous, or totally male.....11
- 7a. Spikes stout, comparatively shorter; length of spike not related with sexuality of spike, even male spike with shortest length; nuts distinctly stipitate *C. polycephala*
- 7b. Spikes lax, weaker, longer; maleness increases with the increase of length of spike (longest spike totally male); nuts not stipitate..... 8
- 8a. Glumes loosely arranged; female glumes not awned or aristate; base of stem deep red (glistening red); leaves shorter, throughout the stem and culm, bladeless leaf-sheath present even after maturity..... *C. insignis*
- 8b. Glumes compactly arranged (except basal 2-3); both male and female glumes distinctly aristate or awned; base of the stem pale brown; leaves longer, much overtopping; bladeless sheath absent..... *C. daltonii*
- 9a. Lower peduncle distantly placed, longer; all the male glumes and basal few female glumes long aristate *C. finitima*
- 9b. Lower peduncle not so distantly placed, shorter; both male and female glumes not aristate10
- 10a. Bracts not sheathing; spikes shorter; plant shorter; utricles distinctly veined; stigmas 3 *C. alopecuroides*
- 10b. Bracts sheathing; spikes longer; plant longer; veins of utricles not distinct; stigmas-2 *C. teres*
- 11a. Spikes developed just from few cm above the ground; multiple modules within a common cluster of leaves; stigma very short, recurved *C. speciosa*
- 11b. Spikes not from the ground level; single module in a leaf cluster; stigma long, not recurved12
- 12a. Leaf-blade wider, to 7 mm; spikes elongated; utricles hispidulous (except beak), biconcave-flattened; stigmas 2 *C. longipes*
- 12b. Leaf blade narrower, to 2.5 mm; spikes comparatively shorter; utricles not hispidulous (except beak), trigonous; stigmas 313
- 13a. Plant short, to 30 cm long, erect-semierect, sometimes decumbant; breaking leaf-sheath of previous year not distinct *C. inanis*
- 13b. Plant long, to 60 cm, erect; leaf-sheath of previous year distinct, or sometimes breaking down into elongated fibres..... 14
- 14a. Lowest flowering node often more distant; spikes 30-35 per module; wings of female glumes subequal..... *C. setigera*
- 14b. Lowest flowering node not so distant, spikes 5-7(9) per module; wings of female glume equal *C. breviculmis*
- 15a. Utricles comparatively shorter, less than 3 mm; upper half of utricles hispidulous; beak of the utricles short; anther crests distinct..... *C. composita*
- 15b. Utricles comparatively longer, more than 3 mm; surface of utricle glabrous (not hairy); beak long, distinctly bidentate; anther crests not distinct16

- 16a. Female glumes awned or cuspidate, broad, longer; mature utricles/fruits bright red, with indistinct veins.....*C. baccans*
- 16b. Female glumes apiculate or acuminate, comparatively shorter; mature utricle brown, distinctly veined.....17
- 17a. Silica body of the epidermal cell of nut conical; outline of epidermal cells not clear; mature inflorescence stout, pale brown; male portion of the spike often spreading and blunt ended*C. spiculata*
- 17b. Silica body of the epidermal cell of nut slightly raised; outline of epidermal cells distinct; mature spike/ inflorescence slightly drooping(much drooping at maturity), deep brown; male portion of spike conical, or pointed.....*C. myosurus*
- 18a. Panicle pyramidal19
- 18b. Panicle linear oblong-elongated (not pyradimal).....22
- 19a. Beak of utricle deflexed/reflexed, comparatively longer, and not bidentate (with oblique aperture); female glumes and utricles with blackish brown unique glandular spots *C. filicina*
- 19b. Beak of utricle straight, comparatively shorter, bidentate; female glumes and utricles devoid of glands20
- 20a. Leaf-sheaths and both the male and female glumes with pale brown streaks; leaf-blades much wider; immature inflorescence typical cream-coloured; tip of female glume muticous; anther crests distinct.....*C. stramentitia*
- 20b. Leaf-sheath and both the male and female glumes without streaks; leaf-blades less wide; immature inflorescence green; female glumes not muticous; anther crests not distinct 21
- 21a. Mature utricles glistering white, often infected by smut fungi; vegetative phase comparatively shorter*C. cruciata* var. *argocarpus*
- 21b. Mature utricles greenish-pale brown, never infected by smut; vegetative phase robust *C. cruciata* var. *nagporensis*
- 22a. Female flowers more in comparison to count of of male flowers; terminal portion of spike represented by very few male flowers; spikes very distantly placed, never in groups*C. continua*
- 22b. Female flowers less in comparison to count of male flowers; terminal portion with more male flowers; spikes are in group of 5-9(12)..... 23
- 23a. Spike(s) long, to 12 mm; linear, shining brown to reddish brown.....*C. condensata*
- 23b. Spike(s) short, generally to 7 mm; ovate-elliptical, pale brown.....*C. burtii*

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