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# TAXONOMY AND PHYTOGEOGRAPHY OF GENUS *CAREX* L. (CYPERACEAE) IN THE KASHMIR HIMALAYA

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## ABSTRACT

The genus *Carex* L., one of the largest genera among angiosperms in the world, is cosmopolitan in distribution, with relatively high species richness in the temperate regions of the Northern Hemisphere. In the Kashmir Himalaya, *Carex* is one of the most speciose and widely distributed genera, occurring from the sub-tropical Jammu through temperate Kashmir valley to the cold-arid Ladakh region. Owing to its rich diversity and distribution, the present paper provides a taxonomic assessment and distribution status of the *Carex* in this Himalayan region. In total, 33 species of *Carex* have been recorded, which are distributed within two sub-genera: *Carex* and *Vignea*. Out of the total species recorded, the highest with 23 species are distributed in the Kashmir valley, followed by the Ladakh with 13 species and then Jammu with 8 species.

**Key words:** Taxonomy; Phytogeography; *Carex*; *Vignea*; Glume; Perigynia.

## INTRODUCTION

The genus *Carex* L. (commonly known as sedges) belongs to Cyperaceae, a family related to Poaceae and Juncaceae in many vegetative morphological features. Worldover, the Cyperaceae is represented by 4,500-5,000 species in 100-105 genera (Goetghebeur, 1987). The genus *Carex* belonging to the tribe *Cariceceae* of the sub-family *Caricoideae* Pax. comprises of 5 genera with 2,100 species. Out of the latter, majority (ca. 2,000 species) in the sub-family are contributed by the *Carex* (Reznicek, 1990).

*Carex* is clearly distinguishable from the other genera of Cyperaceae except the genus *Kobresia* in having unisexual flowers and a perigynium. In the former the perigynium is having the false abaxial suture where as in the latter, it is completely closed (Mackenzie, 1931; Nannfeldt, 1977). Perigynium is a sac-like

structure of prophyllar origin that surrounds the naked gynoecium. The flowers are without perianth, aggregated in the staminate (male) and pistillate (female) or in mixed spikelets (compound spikelets). The staminate flowers consist of (2)3 stamens situated in the axils of the glume (staminate glume). The pistillate flowers consist of a single gynoecium in a closed sac-like organ, commonly called as perigynium or utricle, narrowed at the top into the beak, from which a part of the style and 2-3 stigmatic branches project. Both pistillate and staminate glumes are modified leaf-sheaths with completely reduced blades or remained as awns (Egorova, 1999). The floral characters in *Carex* are the most reliable for its intrageneric taxonomic delimitation. For instance, the subtle differences in shape, size, texture and nervation of the perigynium and the pistillate glumes have been used as the primary source of taxonomic characters for species delimitation in the genus.

In India, the Cyperaceae is represented by 23 genera with 400 species (Sharma, 1998), and out of which 168 species belong to the *Carex*. As the *Carex* prefers cold and moist habitats, it has reached its greatest diversity in the Kashmir Himalaya, and represents one of the largest genera in this region. Stewart (1972) recorded 50 species of *Carex* from the Kashmir Himalaya, including those areas presently under the administrative control of Pakistan and China. Kukkonen (1998) reported the occurrence of 26 species of *Carex* from the Kashmir Himalaya, India.

## MATERIALS AND METHODS

The present work is based on the species of *Carex* collected from the Kashmir Himalaya, mostly the temperate Kashmir and cold-arid Ladakh regions, during 2004-2008. The study area was surveyed frequently at regular intervals from February (onset of flowering) to July (end of flowering and fruiting) each year for the collection of carices. The plant specimens were collected in the vegetative, early flowering, late flowering and fruiting stages. Standard herbarium methods were used in the collection, pressing, drying, mounting and preserving of the collected plant specimens. The processed plant specimens were identified at the Centre for Biodiversity and Taxonomy, University of Kashmir, using the relevant taxonomic literature. (Hooker,1894; Stewart,1972; Rao & Verma 1982; Dhar and Kachroo,1983; Kaul, 1986; Singh and Kachroo,1994; Kukkonen,1998; Aswal and Mahrotra, 1999; Murti, 2001) and online resources such as: Project of Royal Botanic Garden Edinburgh "Flora of Nepal"; Wu Zhengyi, Peter H. Raven and Hong Deyuan's "Flora of China",1994; Egorova's "Flora of Russia and Adjacent States",1999; Project of Japanese Society for Plant Systematists, "Flora of Japan", etc. In addition, several monographs, manuals, research papers, periodicals and relevant books were consulted for identification, description and distribution of the species. All the herbarium specimens have been deposited in the Kashmir University Herbarium (KASH).

### Study area

Kashmir Himalaya is part of the western Himalayan range and lies between $32^{o}17^{/}$-$37^{o}20^{/}$ N, and $73^{o}25^{/}$N-$80^{o}30^{/}$E (Fig. 1). Politically, it falls within the Indian State of Jammu and Kashmir. The region covers an area of about 222 235 $km^2$ (Hussain, 2002) and is divided into the three provinces: Jammu, Kashmir valley and Ladakh. The three provinces differ markedly in their climate and vegetation (Rodgers and Panwar, 1988, Singh et al. 1998). Jammu province has subtropical and temperate climates and the vegetation consists of broad-leaved deciduous forests at lower elevations and coniferous forests at higher elevations. The climate of Kashmir valley is temperate-like and the vegetation consists of coniferous forests and alpine meadows. In the cold-arid desert of Ladakh, the scarce vegetation is primarily steppe-like

grasslands with infrequent stunted scrubs. While the annual precipitation in Jammu is about 1700 mm, mainly due to the Indian summer monsoon, that of Kashmir valley is 1050 mm, mostly as winter snow. Because the high mountain ranges prevent rain clouds reaching the interior valleys, Ladakh receives just about 100 mm annual precipitation. This Himalayan region is exceptionally rich in plant biodiversity, due to the variety of climates and altitudinal ranges (Dar et al. 2002). Geologically, the region is young and has been formed by the upfolding of the Himalaya range (De Terra 1934). Kashmir used to be one of the stopping points on the erstwhile Silk Road that connected east, south and western Asia with northern Africa and Europe. During the British rule in India, Kashmir used to be summer retreat for many British officials living in the Indian Plains. The figure 1 shows the location map of the study area of Kashmir Himalaya.

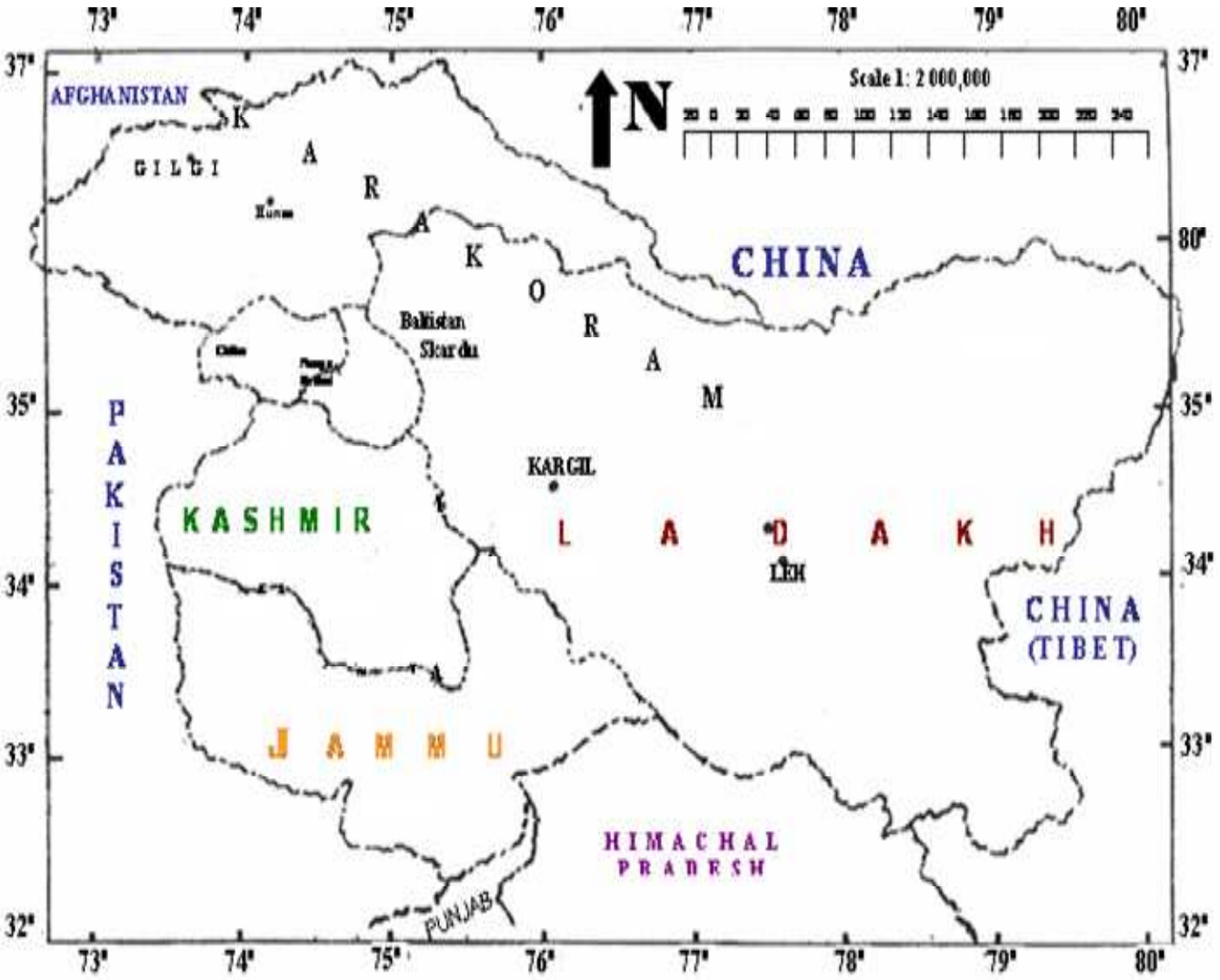


***Figure 1. Location map of the study area the Kashmir Himalaya, India.***

# CONCLUSION

**Taxonomy**

The carices recorded during the study belong to the two sub-genera *Vignea* and *Carex.* The prominent variations appear in their inflorescence features. In *Vignea* all the inflorescence units (spikes) are identical morphologically, bisexual (either androgynous or gynecandrous) and frequently overlapping on the peduncle; whereas in the sub-genus *Carex* the inflorescence units are dissimilar, unisexual, frequently staminate spikes at the top and pistillate spikes lowerdown. The spikes are frequently lax, rarely overlapping. The most frequently used diagnostic characters for the taxonomic delimitations were taken from the perigynia (a prophylar sac-like structure enclosing the pistillate flower) and the glumes (bract like structures subtending the flowers). The following illustration (Fig. 2) depicts the pistillate glumes of Kashmir Himalayan carices collected in the present work.

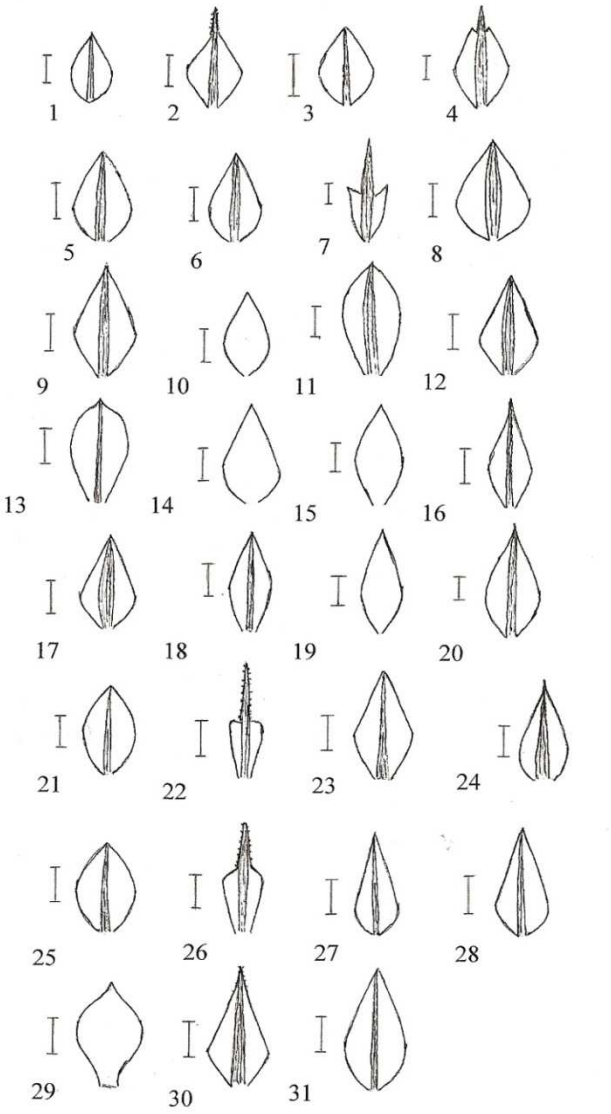


***Fig. 2. Morphological variations in the pistillate glumes of presently studied Carex species. (I 1 mm scale)***

***1. Carex acutiformis 2. C. brownii 3. C. canescens 4. C. cardiolepis 5. C. diandra 6. C. diluta 7. C. dimorpholepis 8. C. divulsa 9. C. fedia 10. C. griersonii 11. C. haematostoma 12. C. hokarsarensis 13. C. karoi 14. C. kashmirensis 15. C. melanantha 16. C. nivalis 17. C. nubigena 18. C. orbicularis 19. C. pamirica 20. C. plectobasis 21. C. pseudo-bicolor 22. C. pseudocyperus 23. C. pseudofoetida 24. C. psychrophila 25. C. remota 26. C. royleana 27. C. schlagintweitiana 28. C. serotina 29. C. setosa 30. C. songorica 31. C. stenophylla***

The most frequently used and constant characters of the glumes for the taxonomic delimations are: the shape and size of the glume, texture, shape and the nature of the midvein and nervation, nature of its apex and base, glume margins, presence or absence of pubiscence, colour, shine etc.

The characters of perigynia are very highly varied and are of much importance for the *Carex* taxonomy. The most important and constant diagnostic characters of perigynia are as follows: The shape of cross-section of perigynium, the length of the beak (sometimes it is absent) and the mode of its apex, the manner of the narrowing of the perigynium body (gradually or abruptly), features of perigynium margins, the presence or absence of pubescence, shine, papillae, tubercles, dots, etc., the presence or absence of veins and their thickness, the position of mature perigynia in relation to the axis of the spike. The ratio of perigynium and fruit dimension is also a good taxonomic character.

In subgenus *Vignea* the perigynium in cross-section are frequently bi-convex, planoconvex, concavo-convex or flattened and with winged margins; abaxial and adaxial faces of perigynia are easily distinguishable, whereas in sub-genus *Carex* the perigynia in cross-section are inflated, rounded or triangular, rarely compressed as in *C. orbicularis, C. dimorpholepis, C. plectobasis* etc. Perigynia of carices collected from the study area are illustrated (Fig. 3) as:

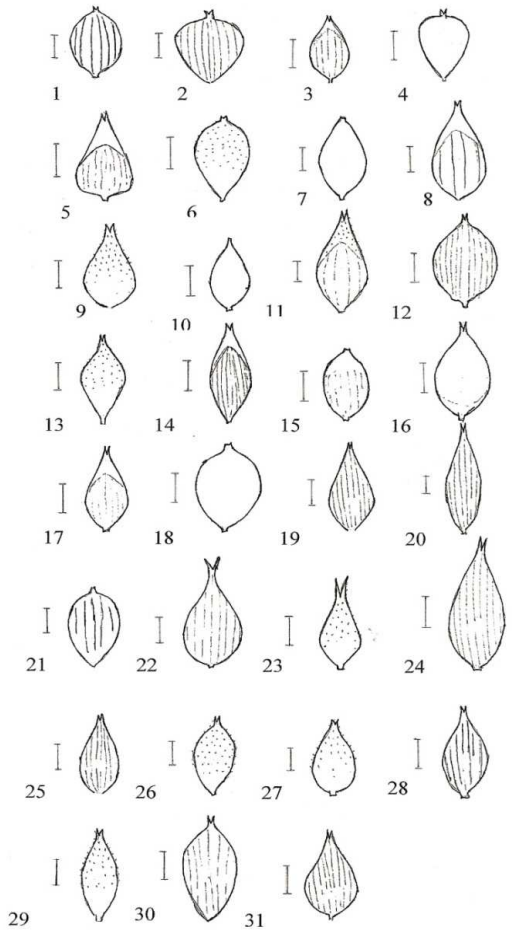


***Fig. 3. Morphological variations in the perigynia of presently studied Carex species. (I 1 mm scale )***

***1. Carex acutiformis 2. C. brownii 3. C. canescens 4. C. cardiolepis 5. C. diandra 6. C. diluta 7. C. dimorpholepis 8. C. divulsa 9. C. fedia 10. C. griersonii 11. C. haematostoma 12. C. hokarsarensis 13. C. karoi 14. C. kashmirensis 15. C. melanantha 16. C. nivalis 17. C. nubigena 18. C. orbicularis 19. C. pamirica 20. C. plectobasis 21. C. pseudo-bicolor 22. C. pseudocyperus 23. C. pseudofoetida 24. C. psychrophila 25. C. remota 26. C. royleana 27. C. schlagintweitiana 28. C. serotina 29. C. setosa 30. C. songorica 31. C. stenophylla***

## Phytogeograpy

The large number of species in the genus *Carex* together with the worldwide distribution makes it very difficult to provide a general account of the phytogeography of the genus. For a single taxon, it is necessary to examine its climatic and ecological tolerance, and evidence of its evolutionary relationships, to hypothize a period at which the taxon achieved its present distribution (Ball, 1990).

Tiffney (1985) reported that the earliest fossil record of Cyperaceae is the occurrence of fruits in the Paleocene era. However, the earliest pollen record is from the mid-Eocene. This comes as a little surprise because most of the Cyperaceae members are wind-pollinated, and pollen records predate fruit and seed records (Ball, 1990). The worldwide distribution of the family, and nearly its hundred genera, favour the view point that the family originated in the late Cretaceous or early Tertiary and the major sub-divisions of the family evolved very quickly afterwards. Consequently, the fossil evidence and distributional evidence are consistent with the view that the *Carex* originated in the early Tertiary period (Ball, 1990). The genus *Carex* has reached its greatest diversity in the northern temperate area especially in North America, both in terms of total number of species and in the number of species in each subgenera. Thus it seems that the genus most probably originated in the New World rather than in the Old World, but as yet there is little solid evidence to support such a hypothesis.

Similarly it has been observed that in the Indian subcontinent most of the species (67%) of 168 reported by Karthikiyan et al., (1989) are inhabited in the north, central and north-west Himalayas. The species proportion decreases to 40% in the eastern Himalayas. The frequency of the genus further declines from north to south to 27%, where as only 4 species of *Carex* have been reported from Andaman and Nicobar Islands. Distribution pattern of the genus again shows significant decrease in the number of species on moving from north to south or from temperate to tropical climatic zones of the Indian sub-continent

## Distribution in Kashmir Himalaya

The Kashmir Himalaya provides a variety of habitats favorable for the growth of a large number of carices. These grow from the sub-tropical Jammu region, through the predominantly temperate Kashmir, to the cold-arid Ladakh region. In the Kashmir Himalaya as a whole (including Pakistan- occupied part of Kashmir and Jammu), it is one of the larger angiospermic genera, being represented by as many as 50 species (Stewart, 1972).

During the course of the present study, 33 species were collected, from the Kashmir Himalaya (Kashmir, Ladakh and Jammu), the praportion of species is again quite different in three climatic zones (Fig. 4), 32 in the temperate Kashmir region, 13 in the cold-arid Ladakh, and 8 in the sub-tropical Jammu region.

In the Kashmir Himalaya the highest number of *Carex* species (32) are recorded from Kashmir region fallowed by ladakh 13 species and 8 species of *Carex* are recorded from Jammu region. The proportion of species in the two subgenera, *Carex* and *Vignea* is quite different in three climatic zones (Fig. 4), with 31% of *Vignea* species in the temperate Kashmir region, 16% in the cold-arid Ladakh, and 13% in the sub-tropical Jammu region. This decrease in the number of species of sub-genus *Vignea* from the Kashmir valley towards the other two regions (more to the sub-tropical Jammu) is interesting and amply demonstrates that the temperate Kashmir region provides the most favorable conditions and variety of habitats for congenial growth of both the

subgenera. Figure 4 shows the number of species of *Carex* in three regions of the Kashmir Himalaya.

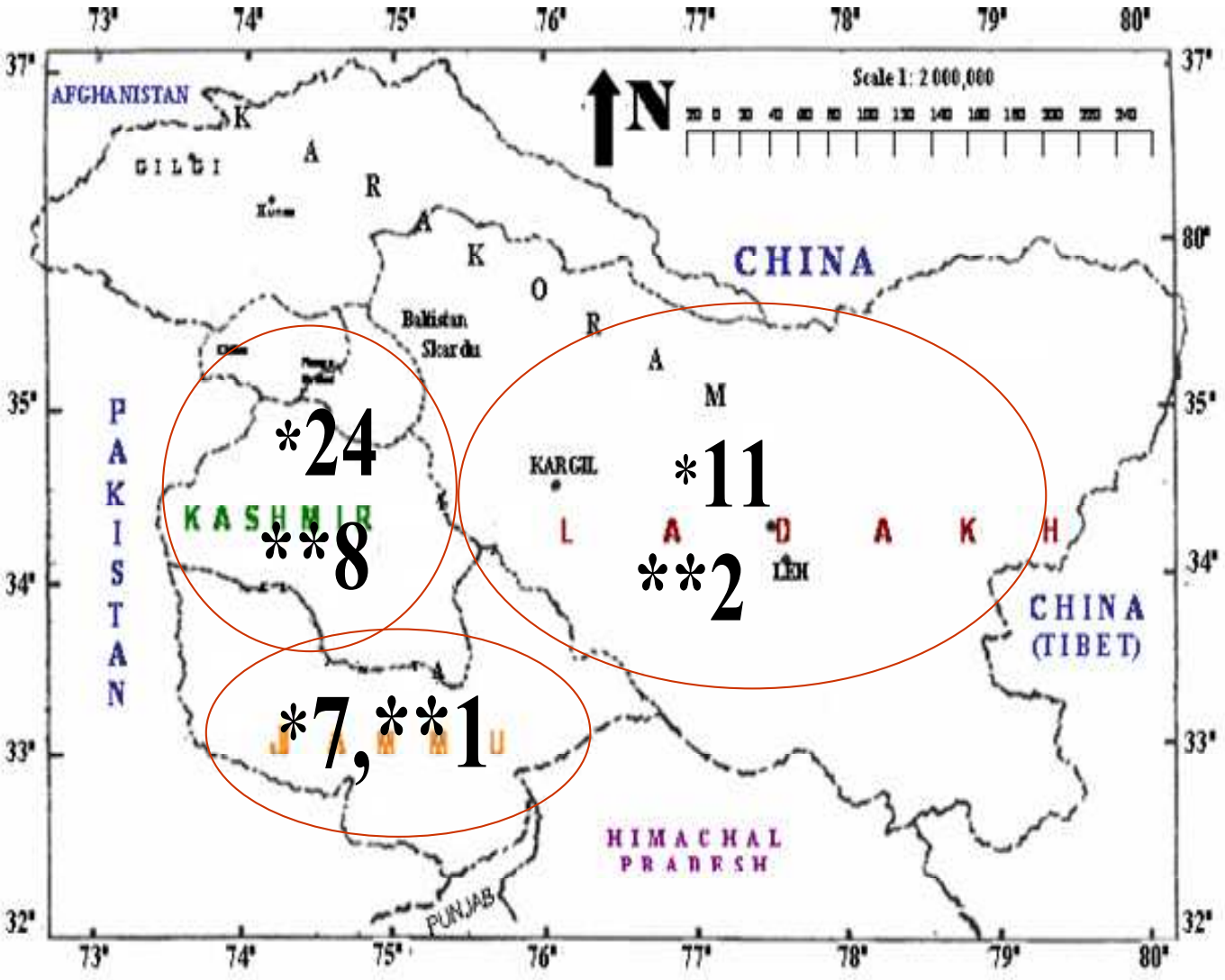


***Fig. 4. Number of species of Carex in three regions of the Kashmir Himalaya: * number of species in subgenus Carex; ** number of species in sub-genus Vignea.***

***Table 1. Distribution, elevational range and habitat of the Carex species recorded in the Kashmir Himalaya.***

| Subgenera | Species | Elevational range (m) | Habitat | Collection sites |
|---|---|---|---|---|
| *Vignea* | *C. canescens* Linn. | 3000- 3600 | Habitat: marshy to wet alpine meadows | Gulmarg, Sonamarg, Tangmarg, Kargil |
| | *C. diandra* Schrank | 1600-1700 | along stream sides, and wetlands | Ganderbal, Hokarsar wetland |
| | *C. nivalis* Boott | 2700-5000 | meadows and rocky areas above the tree line | Gulmarg, Pahalgam, Chattergul, Sonamarg, Kargil, |
| | *C. nubigena* D. Don | 1600-3500 | Common along the drainage and water channels. Grassy glades along forested slopes | Gulmarg; Pahalgam,(Ladder Valley); Chattergul |
| | *C. ovalis* Goodenough | 1800-2700 | mesic to moist grasslands and forest slopes | Gulmarg; Srinagar, (Dachigam) |
| | *C. pseudofoetida* Kuk. | 2700-4700 | moist alpine meadows, along rivulets. | Sonamarg, (Thajwas); Tangmarg; Kargil, (Zanskar, Rangdum) |
| | *C. remota* Linn. | 1500-3000 | mesophytic meadows to wet alpine habitats | Gulmarg; Chattergul; Bandipora, (Papchan); Uri, (Behama) |
| | *C. stenophylla* Wahlenb. | 1700- 4000 | common on moist sandy soils. | Kashmir,(Sonamarg Budgam, Branwar); Kargil (Drass, Thrungs, Zanskar, Padam); Ladakh,( Nubra) |
| | *C. hokarsarensis* E. U. Haq et Dar | 1600 | marshy to sub-aquatic | Kashmir, (Srinagar, Zainakoot |
| *Carex* | *C. acutiformis* Ehrh. | 1600-2200 | On moist ground along wetlands and around ponds. | Srinagar, (Nigeen Lake, Dal Lake, University Campus, Narbal); Ganderbal, (Darend); Hokarsar |
| | *C. brownii* Tuckermen | 1600-1700 | along water channels, under-forests, moist meadow | Bandipora; Srinagar, (Dachigam) |
| | *C. diluta* M. Bieb. | 1500-3500 | moist meadows, along streams and irrigation channels; on mountain slopes | Uri (Chanderwari, Noorkhah, Qazinag); Tangdar; Ladakh, (Drass) |
| | *C. dimorpholepis* Steud | 1500-2400 | on marshy grounds, along rice fields and | Bandipora; Srinagar, (Dachigam); Ganderbal, |

| | | | |
|---|---|---|---|
| | | ponds. | (Chattergul) |
| *C. fedia* Nees | 1550- 2400 | on wet to moist places, along rice fields. | Srinagar, (Bamina, Dachigam, Batpora, Nigeen, Zainakot, Hokarsar); Bandipora,(Wular lake); Ganderbal, (Darend); Ananthnag, (Khudwani) |
| *C. griersonii* Noltie | 3000-3350 | frequenlty occur in dampy and silty soils, rarely in mesic habitat | Gulmarg |
| *C. haematostoma* Nees | 2100- 3500 | alpine meadows | Prang; Kangan; Budmarg |
| *C. infuscata* Nees | 1700-4000 | common on moist grassy slopes, mostly along alpine water channels and streams. | Gulmarg; , Sonamarg; Pulwama; Kongwatan; Gurez, (Bagtor, Checkwali); Kargil, (Drass, Thrungs, Zanskar, Parkachik) |
| *C. karoi (*Freyn*)* Freyn | 2800-3500 | moist slopes, along brooks | Sonamarg, (Thajwas) |
| *C. kashmirensis* C. B. Clarke | 2800-4500 | on moist places in alpine meadows | Gulmarg; Sonamarg, (Thajwas) |
| *C. melanantha* C. A. Mey. | 3000-4700 | moist alpine meadows, along streams. | Ladakh (Rangdum, Parkachy, Zanskar, Kargee, Changla Pass, Thusgam, Nubra) |
| *C. orbicularis* Boott | 2400-4300 | on moist to sub-marshy places in alpine and sub-alpine grasslands | Kashmir (Gulmarg, Sonamarg, Thajwas); Kargil (Zanskar, Parkachy, Rangdum, Drass) |
| *C. pamirica* (O. Fedtsch.) O. & B. Fedtsch. | 2600-4000 | wet mountain meadows, marshs, sometimes in water | Kashmir, (Gulmarg); Kargil, (Parkachy, Zanskar, Padam) |
| *C. plectobasis* V. Krecz. | 2600-4500 | Mountain meadows | Sonamarg, (Baltal, Prang) |
| *C. plectobasis* V. Krecz. | 2600-4500 | Mountain meadows | Sonamarg, (Baltal, Prang) |
| *C. pseudo-bicolor* Boeck. | 2700-5000 | along streams, meadows above the tree line. | Sonamarg, (Thajwas, Bugmarg); Kargil, (Rangdum, Parkachy) |
| *C. pseudocyperus* Linn. | 1500-2200 | wet wooded areas | Uri, (Limber); Srinagar, (Hokarsar, Dal lake) |
| *C. psychrophila* | 1600-3300 | marshy ground on | Gulmarg; Srinagar, |

| | | | |
|---|---|---|---|
| Nees | | shady mountain slopes. | (Dachigam); Tangdar |
| *C. royleana* Nees | 1500- 3000 | Damp soil on rocky slops | Uri (Noorkhah, Chandenwari); Pahalgam, (Aru) |
| *C. schlagintweitiana* Boeck. | 1500-3000 | mountain slopes. | Gulmarg; Sonamarg; Usemargm; Tangdar |
| *C. serotina* Merat | 1450- 2750 | wet or marshy meadows, along streams and rivers on mountains | Gulmarg; Sonamarg; Kargil, (Drass); Uri, (Noorkhah; Prang, Kujar) |
| *C. setosa* Boott | 2500- 4800 | marshes. | Kashmir, (Sonamarg, Thajwas) |
| *C. songorica* Kar. et Kir. | 1600-3600 | moist meadows, lake shores, along rivers, irrigation channels and ditches | Srinagar, (Dachigam) |

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