Chapter 1

World Distribution and Centres of Diversity of Cyperaceae Members

Abstract

Cyperaceae is an important group of angiosperms, and a dominant plant cover in wetlands globally.The plant group give an ideal opportunity to explore the processes of diversification in relation to clade age, diversification rate, area and niche space. Although the geographical diversification of Cyperaceae on a global scale remains unexplored, recent studies suggests that the species rich temperate clades have a tropical origin. The literature suggests the probable centre of origin of this plant group as South America and subsequently dispersed throughout the globe. The chapter gives acomprehensive account on the phylogeny and diversification pattern, characteristic features and classification of the plant group Cyperaceae.

Introduction

The family Cyperaceae, commonly known as sedge family, is the 10th most species rich family among the angiosperms and third among the monocotyledons, having 5687 species in 95 genera and 15 tribes with *Carex*(2,003 species) and *Cyperus* (964 species) as the dominant genera (Larridon, 2022). The plants in the family have cosmopolitan distribution and are an important group of angiosperms not only in terms of number of species but also in plant cover. They often form major component of many habitats ranging from marshes to deserts, and dominate many ecosystems including Tundra and Savanna. Some species are habitat-specific, narrowly distributed and of conservation concern, whereas others are ubiquitous weeds that occur in a variety of environments.

Phylogeny of Cyperaceae

Cyperaceae are graminoid herbaceous plants having solid, non-jointed and often triangular culms, linear leaves with parallel venation with inconspicuous flowers and nuts. The rather uniform morphology of the vegetative parts as well as the highly reduced microscopic flowers makes deduction of evolutionary patterns from living sedges difficult. Most

theories on the evolution of this group are derived from studies of the morphology and development of the spikelets.

Cyperaceae presents an ideal opportunity to explore the processes contributing to the diversification and maintenance of biodiversity in relation to clade age, diversification rate, area and niche space (Spalink *et al.,* 2016). The pioneer to describe this family was De Jusseu (1789) and the name was originated from the type genus *Cyperus*, from the Greek term *Kuperiros* which means sedges. The systematic position of this family and its origin and affinities are still unresolved, and several hypotheses have been proposed in this regard. Phylogenetically Cyperaceae are closely allied to Graminae. Hutchinson (1959) separated these families into two separate orders *viz*., Cyperales and Graminales. He considered the latter to be more highly advanced and treated both as having been derived from Liliaceous ancestors *via* the Juncaceae complex.

Origin and diversification of Cyperaceae

In spite of proposed tropical origin for the clade, the family shows heterogeneity in temperate regions (Givnish *et al.,* 1999; Bremer, 2002). Although the subsequent geographical diversification of Cyperaceae on a family-wide, global scale remains unexplored, recent research findings suggests that the species rich, temperate clades are derived from a tropical origin. According to the literature, the probable land of origin of the group is expected as South America (Spalink *et al.,* 2016) and subsequently dispersed throughout the globe. The time scale of the probable origin is the early coenozoic, as supported by reliable fossil record back to the Pleocene (Smith *et al.,* 2009; Spalink *et al*., 2016). As per the views of Escudero *et al.,* (2012) the origin of the genus like *Carex* has been marked between the middle and late miocene epoch.

There are two independent Cretaceous migrations to Australia from South America in Cyperaceae, first along the stem of subfamily Mapanioideae and second along the stem of subfamily Cyperoideae (**Chart 1**). Most diversification within the subfamily Mapanioideae occurred within Australia and South America, while migrations to India, Southeast Asia and Africa occurred from an Australian source in subfamily Cyperoideae. Tribes such as Trilepideae, Bisboechelereae, Sclerieae, Rhynchosporeae, and the genus *Cladium* originated within South America and migrated throughout the southern hemisphere with only occasional introductions to the northern hemisphere (Spalink *et al.,*2016).

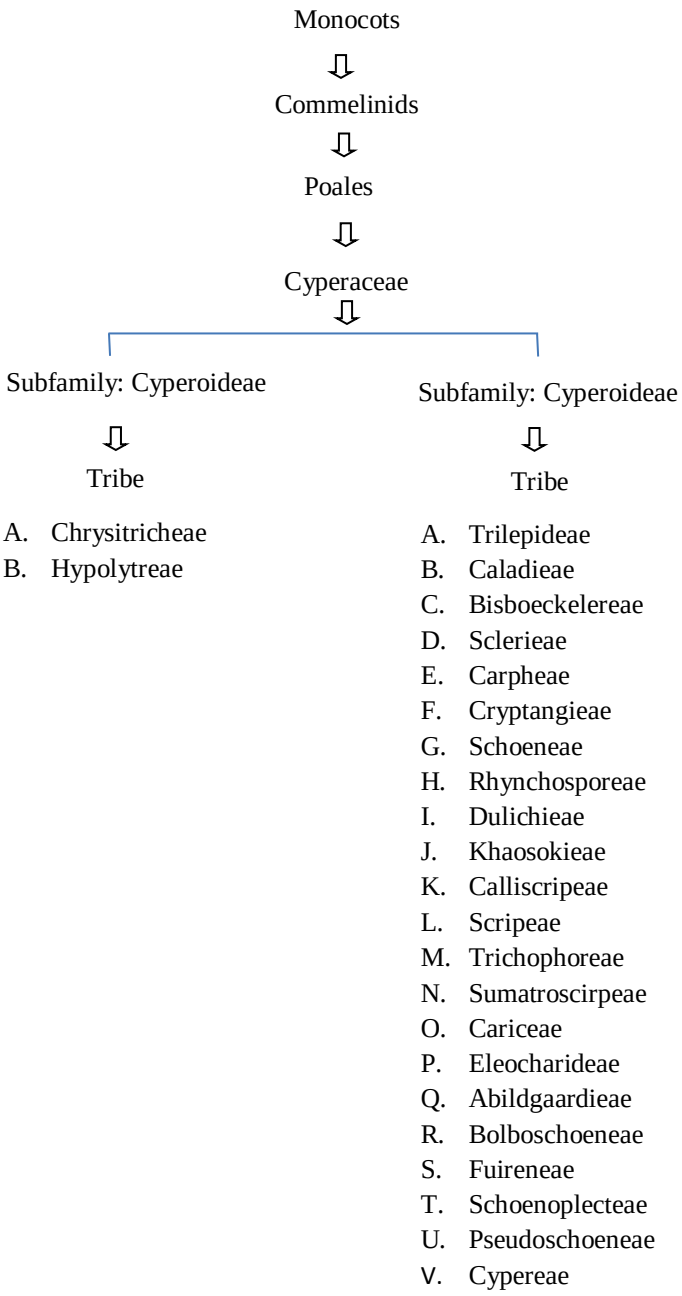

Chart 1. Diversification of Cyperaceae

Sedge genera vary considerably in richness and geographical extent, ranging from monotypic to containing over 2000 species, and from narrowly restricted to essentially cosmopolitan. Some genera are adapted to long-distance wind dispersal, but the majority lack obvious dispersal adaptations and are carried short distances by gravity, wind, water or animals (Kern, 1974). Members show a wide range of growth forms, the phenotypic diversity ranges from tiny ephemerals (*Isolepis inconspicua* (Levyns) J. Raynal,), climbing herbs (*Scleria boivinii* Steud.) and to the dwarf tree like *Microdracoides squamosa* Hua. (Larridon *et al.*, 2018). Sedges are diverse in their habitats, mostly growing on waterlogged areas, however, the ecological diversity ranges from truly aquatics to fire prone grasslands and forest. Some species like *Carex moorcroftii* found only in high elevation vegetation up to 5700 m (Dai *et al*., 2010). *Coleochloa domensis* is aspecies with a tendency for epiphytism (Larridon *et al.*, 2021).

Habitat specificity of Cyperaceae

The highest diversity of the family is marked in humid and semi humid tropics along with temperate and cold temperate regions of the world, and flourish well in a wide range of habitat especially in wetlands. Some species are highly adapted to a particular habitat such as rocks, high altitudes and large swamps. On the other hand, many species are competitively inferior, restricted to vulnerable habitats, and thus rare, endangered, and important from the point of conservation aspects. Simpson *et al.* (2003) suggests that for ecologically oriented research, sedges are very often useful as phyto-indicators of site properties because many species of the family possess relatively narrow ecological amplitudes in respect to environmental factors such as soil acidity or water chemistry.

Classification of Cyperaceae

The classification and analysis of sedges are somewhat complicated, many reductions and convergence in the inflorescence architecture have obstructed evolutionary remaking and classification. Largest subfamily under the Cyperaceae family is Cyperoideae, which consists of two extreme species diverse clades, Cariceae and Cypereae including two large genera, *Carex* and *Cyperus* respectively. The tribe Cariceae includes predominantly temperate genus *Carex*, widely distributed and diversified throughout the Northern Hemisphere, ranging from the Arctic to temperate and even high mountains at tropical latitudes where it is restricted to montane habitats (Benitez *et al.*, 2018). The tribe

Cypereae corresponds mainly to the tropical genus, with *Cyperu*s as the most diverse genus.

Cyperaceae is taxonomically difficult one and this leads to the lumping of many synonyms and changes of names due to different concepts of generic delimitation. There are many interpretations for different genera and it is sometimes difficult to decide what characters constitute the generic status. Thus, the treatment of genera in different floras is based on different opinions according to the author's concept (**Table 1**). According to the latest enumeration of Cyperaceae, the present estimate of the members of Cyperaceae is 5687 species under 95 genera (Larridon, 2022). Mabberley in 'The plant-book: a portable dictionary of the vascular plants' reported that the family contains 4350 species belonging to 98 genera. Takhtajan (1997) has estimated that there are about 5300 species under 125 genera, but according to Thorne (1992) the count is more, as many as 5315 species distributed within 146 genera. The estimate by Judd *et al.* (1999) reports 4500 species under 122 genera.

Table1. List of publications on sedge diversity

Sl. No.	Publication	Author, Year	No. of genera	No. of species
1.	An integrated system of classification of flowering plants	Cronquist, 1981	70	4000
2.	Classification and geography of the flowering plants	Thorne, 1992	146	5315
3.	The plant-book: a portable dictionary of the vascular plants	Mabberley, 1997	98	4350
4.	Diversity and classification of flowering plants	Takhtajan, 1997	125	5300
5.	Cyperaceae: The families and genera of vascular plants. Vol.4	Goetghebeur, 1998	104	5000
6.	Plant Systematics: a phylogenetic approach	Judd *et al.*, 1999	122	4500
7.	Cyperaceae: sedge family	Ball *et al.*, 2002	100	5000
8.	World checklist of Cyperaceae (Sedges)	Govaerts *et al.*, 2007	109	5500
9.	World checklist of selected plant families: Cyperaceae	Govaerts *et al.*, 2020	94	5600
10.	A linear classification of Cyperaceae. Kew Bulletin	Larridon, 2022	95	5687

Conclusions

Physical environment and climate patterns play an important role in the distribution of sedge species. Both biotic and abiotic factors, such as soil topography, geology, climate, species evolution and migration will affect their spatial distribution. Most of the species are neither evenly nor randomly distributed, and the physical environment and climate governs their distribution in definite geographical units. Sedges shows remarkable range of adaptability to various ecological conditions, some species were highly specific in their habitat, which finally leads to rarity and local endemism. Knowledge of how ecologically important morphological characters vary within the distributional range of these species, as well as the underlying control mechanisms for such variation, is essential to understand how the plants may respond to environmental changes.

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