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Proceedings Introduction: Phylogeny and Ecological Diversification in *Carex*

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Seven papers in this quarter's issue of *Systematic Botany* come from a symposium on phylogeny and ecological diversification in sedges (*Carex* L., Cyperaceae) convened at the Botany 2015 meetings in Edmonton. The symposium was timely, as the genus had recently been circumscribed to include the four segregate genera *Cymophyllus* Mack., *Kobresia* Willd., *Schoenoxiphium* Nees, and *Uncinia* Pers. (Global *Carex* Group 2015). Irrespective of this recircumscription, *Carex* is an impressively diverse genus. At approximately 2,000 species, *Carex* is the second largest genus of the temperate zone (after *Astragalus* L., Zarre and Azani 2013; though cf. Frodin 2004, at which time *Carex* was considered the largest). It is cosmopolitan in distribution (including the Antarctic archipelagos; Burton 2012) and ecologically important in habitats that range from tundra and dry sand prairies to open wetlands and bottomland forests (Suttie et al. 2005). *Carex* is an important food source for waterfowl (Sedinger 1984; Gadallah and Jefferies 1995) and ungulates (Uresk and Paintner 1985; Fortin et al. 2003; Evans et al. 2004; Shrestha et al. 2012), and several species have medicinal or nutritional properties for humans as well (Fiorentino et al. 2008; Li et al. 2009; Roy et al. 2012). Given its importance for ecosystems and thus also humans, *Carex* ought to be a well-understood genus from an evolutionary and ecological standpoint.

Yet due in part to the taxonomic difficulties that the genus presents, its utility as a model for understanding ecological diversification and niche evolution is not fully realized (Waterway et al. 2009). This is unfortunate, as high species number and rapid diversification of sedges make it ideal for clade-based studies of biodiversity patterns. Numerous studies have addressed phylogenetic relationships within the Cyperaceae at both broad and fine scales (reviewed in Global *Carex* Group 2016a, this issue). In recent years, several studies have used the phylogeny of *Carex* or Cyperaceae to investigate patterns and timing of lineage diversification (Gehrke and Linder 2009, 2011; Escudero et al. 2012a; Escudero and Hipp 2013; Spalink et al. 2016a, 2016b), the interaction between ecological and chromosomal evolution (Hipp 2007; Hipp et al. 2010; Chung et al. 2011, 2012; Escudero et al. 2012b, 2013a, 2013b), the understanding of biogeographic patterns (King and Roalson 2009; Escudero et al. 2010; Jiménez-Mejías et al. 2012; Villaverde et al. 2015a, 2015b), and patterns of community assembly (Slingsby and Verboom 2006; Dabros and Waterway 2008; Waterway et al. 2009; Elliott et al. 2016). Considering the diversity of the genus, its ecological importance in the temperate zone, and the promising findings of these first studies, *Carex* provides ample but largely untapped opportunity to plant evolutionary biologists and ecologists to understand fundamental processes of lineage and ecological diversification.

Our symposium investigated the ecological dimensions of *Carex* diversification in the context of a global revision of *Carex* classification by The Global *Carex* Group (<http://systematics.mortonarb.org/cariceae>). The symposium featured six talks on phylogenetic and ecological diversification of sedges. Seven papers on this theme are presented here. Two are foundational, providing a global phylogeny that serves as the underpinning of our work (Global *Carex* Group 2016a) and addressing a fundamental terminology issue in the genus (Jiménez-Mejías et al. 2016). Two are methodological, introducing approaches to linking NCBI data back to specimens for analytical purposes (Global *Carex* Group 2016b) and using *Carex* morphological diversity as a subject of collaborative research with K-12 students (Hahn et al. 2016). Three use phylogenetic data to investigate ecological diversification, focusing on trait evolution (Hoffmann and Gebauer 2016), community assembly (Waterway et al. 2016), and the effects of holocentry on lineage diversification (Escudero et al. 2016).

This set of symposium papers only scratches the surface of what is possible with a densely sampled phylogeny of a large genus such as *Carex*. Deeper sampling of the genus aimed at a more comprehensive phylogenetic hypothesis is ongoing as are additional studies relating ecological differentiation, biogeographic patterns, and chromosomal evolution to phylogenetic relationships. We expect that the phylogenetic work being conducted by the Global *Carex* Group will set the stage for expanded and more refined studies of lineage diversification and ecological adaptation in this challenging genus, building in part on the work published here.

LITERATURE CITED

- Burton, R. 2012. *A field guide to the wildlife of South Georgia*. Princeton: Princeton University Press.
- Chung, K.-S., A. L. Hipp, and E. H. Roalson. 2012. Chromosome number evolves independently of genome size in a clade with non-localized centromeres (*Carex*: Cyperaceae). *Evolution* 66: 2708–2722.
- Chung, K.-S., J. A. Weber, and A. L. Hipp. 2011. Dynamics of chromosome number and genome size variation in a cytogenetically variable sedge (*Carex scoparia* var. *scoparia*, Cyperaceae). *American Journal of Botany* 98: 122–129.
- Dabros, A. and M. J. Waterway. 2008. Segregation of sedge species (Cyperaceae) along environmental gradients in fens of the Schefferville region, northern Quebec. Pp. 145–161 in *Sedges: uses, diversity, and systematics of the Cyperaceae*, eds. R. F. C. Naczi and B. A. Ford. St. Louis: Missouri Botanical Garden Press.
- Elliott, T. L., M. J. Waterway, and T. J. Davies. 2016. Contrasting lineage-specific patterns conceal community phylogenetic structure in larger clades. *Journal of Vegetation Science* 27: 69–79.
- Escudero, M., P. Vargas, P. Arens, N. J. Ouborg, and M. Luceño. 2010. The east-west-north colonization history of the Mediterranean and

- Europe by the coastal plant *Carex extensa* (Cyperaceae). *Molecular Ecology* 19: 352–370.
- Escudero, M., A. L. Hipp, M. J. Waterway, and L. M. Valente. 2012a. Diversification rates and chromosome evolution in the most diverse angiosperm genus of the temperate zone (*Carex*, Cyperaceae). *Molecular Phylogenetics and Evolution* 63: 650–655.
- Escudero, M., A. L. Hipp, T. F. Hansen, K. L. Voje, and M. Luceño. 2012b. Selection and inertia in the evolution of holocentric chromosomes in sedges (*Carex*, Cyperaceae). *The New Phytologist* 195: 237–247.
- Escudero, M. and A. L. Hipp. 2013. Shifts in diversification rates and clade ages explain species richness in higher-level sedge taxa (Cyperaceae). *American Journal of Botany* 100: 2403–2411.
- Escudero, M., E. Maguilla, and M. Luceño. 2013a. Selection by climatic regime and neutral evolutionary processes in holocentric chromosomes (*Carex* gr. *laevigata*: Cyperaceae): a microevolutionary approach. *Perspectives in Plant Ecology, Evolution and Systematics* 15: 118–129.
- Escudero, M., J. A. Weber, and A. L. Hipp. 2013b. Species coherence in the face of karyotype diversification in holocentric organisms: the case of a cytogenetically variable sedge (*Carex scoparia*, Cyperaceae). *Annals of Botany* 112: 515–526.
- Escudero, M., J. I. Márquez-Corro, and A. L. Hipp. 2016. The phylogenetic origins and evolutionary history of holocentric chromosomes. *Systematic Botany* 41: 580–585.
- Evans, S. G., A. J. Pelster, W. C. Leininger, and M. J. Trlica. 2004. Seasonal diet selection of cattle grazing a montane riparian community. *Journal of Range Management* 57: 539–545.
- Fiorentino, A., A. Ricci, B D'Abrosca, S. Pacifico, A. Golino, M. Letizia, S. Piccolella, and P. Monaco. 2008. Potential food additives from *Carex distachya* roots: identification and in vitro antioxidant properties. *Journal of Agricultural and Food Chemistry* 56: 8218–8225.
- Fortin, D., J. M. Fryxell, L O'Brodovich, and D. Frandsen. 2003. Foraging ecology of bison at the landscape and plant community levels: the applicability of energy maximization principles. *Oecologia* 134: 219–227.
- Frodin, D. G. 2004. History and concepts of big plant genera. *Taxon* 53: 753–776.
- Gadallah, F. L. and R. L. Jefferies. 1995. Comparison of the nutrient contents of the principal forage plants utilized by lesser snow geese on summer breeding grounds. *Journal of Applied Ecology* 32: 263–275.
- Gehrke, B. and H. P. Linder. 2009. The scramble for Africa: pan-temperate elements on the African high mountains. *Proceedings. Biological Sciences* 276: 2657–2665.
- Gehrke, B. and H. P. Linder. 2011. Time, space and ecology: why some clades have more species than others. *Journal of Biogeography* 38: 1948–1962.
- Global *Carex* Group. 2015. Making *Carex* monophyletic (Cyperaceae, tribe Cariceae): a new broader circumscription. *Botanical Journal of the Linnean Society* 179: 1–42.
- Global *Carex* Group. 2016a. Megaphylogenetic specimen-level approaches to the *Carex* (Cyperaceae) phylogeny using ITS, ETS, and *matK* sequences: implications for classification. *Systematic Botany* 41: 500–518.
- Global *Carex* Group. 2016b. Specimens at the center: an informatics workflow and toolkit for specimen-level analysis of public DNA database data. *Systematic Botany* 41: 529–539.
- Hahn, M., B. Budaitis, J. Grant, D. Wetta, P. Murphy, A. Cotton, K. Pham, and A. L. Hipp. 2016. Training the next generation of sedge taxonomists: School kids tackle sedge morphological diversity. *Systematic Botany* 41: 540–551.
- Hipp, A. L. 2007. Non-uniform processes of chromosome evolution in sedges (*Carex*: Cyperaceae). *Evolution* 61: 2175–2194.
- Hipp, A. L., P. E. Rothrock, R. Whitkus, and J. A. Weber. 2010. Chromosomes tell half of the story: the correlation between karyotype rearrangements and genetic diversity in sedges, a group with holocentric chromosomes. *Molecular Ecology* 19: 3124–3138.
- Hoffmann, M. H. and S. Gebauer. 2016. Quantitative morphological and molecular divergence in replicated and parallel radiations in *Carex* (Cyperaceae) using symbolic data analysis. *Systematic Botany* 41: 552–557.
- Jiménez-Mejías, P., M. Luceño, K. A. Lye, C. Brochmann, and G. Gussarova. 2012. Genetically diverse but with surprisingly little geographical structure: the complex history of the widespread herb *Carex nigra* (Cyperaceae). *Journal of Biogeography* 39: 2279–2291.
- Jiménez-Mejías, P., M. Luceño, K. L. Wilson, M. J. Waterway, and E. H. Roalson. 2016. Clarification of the use of the terms perigynium and utricle in *Carex* L. (Cyperaceae). *Systematic Botany* 41: 519–528.
- King, M. G. and E. H. Roalson. 2009. Discordance between phylogenetics and coalescent-based divergence modelling: exploring phylogeographic patterns of speciation in the *Carex macrocephala* species complex. *Molecular Ecology* 18: 468–482.
- Li, L., G. E. Henry, and N. P. Seeram. 2009. Identification and bioactivities of resveratrol oligomers and flavonoids from *Carex folliculata* seeds. *Journal of Agricultural and Food Chemistry* 57: 7282–7287.
- Roy, B., B. R. Giri, C. Mitali, and A. Swargiary. 2012. Ultrastructural and biochemical alterations in rats exposed to crude extract of *Carex baccans* and *Potentilla fulgens*. *Microscopy and Microanalysis* 18: 1067–1076.
- Sedinger, S. S. 1984. Protein and amino acid composition of tundra vegetation in relation to nutritional requirements of geese. *The Journal of Wildlife Management* 48: 1128–1136.
- Shrestha, B., P. Kindlmann, and S. R. Jnawali. 2012. Interactions between the Himalayan Tahr, livestock and snow leopards in the Sagarmatha National Park. Pp. 157–176 in *Himalayan biodiversity in the changing world*, ed. P. Kindlmann. Dordrecht: Springer.
- Slingsby, J. A. and G. A. Verboom. 2006. Phylogenetic relatedness limits co-occurrence at fine spatial scales: Evidence from the schoenoid sedges (Cyperaceae: Schoeneae) of the Cape Floristic Region, South Africa. *American Naturalist* 168: 14–27.
- Spalink, D., B. T. Drew, M. C. Pace, J. G. Zaborsky, P. Li, K. M. Cameron, T. J. Givnish, and K. J. Sytsma. 2016a. Evolution of geographical place and niche space: Patterns of diversification in the North American sedge (Cyperaceae) flora. *Molecular Phylogenetics and Evolution* 95: 183–195.
- Spalink, D., B. T. Drew, M. C. Pace, J. G. Zaborsky, J. R. Starr, K. M. Cameron, T. J. Givnish, and K. J. Sytsma. 2016b. Biogeography of the cosmopolitan sedges (Cyperaceae) and the area-richness correlation in plants. *Journal of Biogeography*, doi: 10.1111/jbi.12802.
- Suttie, J. M., S. G. Reynolds, and C. Batello. 2005. *Grasslands of the World*. FAO, Rome.
- Uresk, D. W. and W. W. Paintner. 1985. Cattle diets in a ponderosa pine forest in the northern Black Hills. *Journal of Range Management* 38: 440–442.
- Villaverde, T., M. Escudero, M. Luceño, and S. Martín-Bravo. 2015a. Long-distance dispersal during the middle–late Pleistocene explains the bipolar disjunction of *Carex maritima* (Cyperaceae). *Journal of Biogeography* 42: 1820–1831.
- Villaverde, T., M. Escudero, S. Martín-Bravo, L. P. Bruederle, M. Luceño, and J. R. Starr. 2015b. Direct long-distance dispersal best explains the bipolar distribution of *Carex arctogena* (*Carex* sect. *Capituligerata*, Cyperaceae). *Journal of Biogeography* 42: 1514–1525.
- Waterway, M. J., T. Hoshino, and T. Masaki. 2009. Phylogeny, species richness, and ecological specialization in Cyperaceae tribe Cariceae. *Botanical Review* 75: 138–159.
- Waterway, M. J., K. T. Martins, A. Dabros, A. Prado, and M. J. Lechowicz. 2016. Ecological and evolutionary diversification within the genus *Carex* (Cyperaceae): Consequences for community assembly in subarctic fens. *Systematic Botany* 41: 558–579.
- Zarre, S. and N. Azani. 2013. Perspectives in taxonomy and phylogeny of the genus *Astragalus*: a review. *Proceedings. Biological Sciences* 3: 1–6.