ASTERALES composition and COMPOSITAE diversification

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ASTERACEAE
or
COMPOSITAE

c. 1.700 genera

c. 24.000 spp.

- the largest families of flowering plants.

- strongly supported as a monophyletic group by morphological, chemical, and molecular characters.

- strong evidence for its nesting in the clade ASTERALES s.l., together with some ten other families according to APG-III (2009).

- surpassed all other families in the order, and lead to the conquest of a cosmopolitan distribution with a wide range of life forms in practically almost all biomes on Earth.
COMPOSITAE in ASTERALES s.l.

- a general panel of the Asterales

- synapomorphies of the clade Compositae-Calyceraceae as sister-group to the Goodeniaceae.

- the evolutive success of the Compositae.
18S rDNA, $rbcL$, $atpB$, $atp1$, $matR$ (+ 61 molecular markers of 45 taxa)

**ASTERALES**
in the
**ASTERIDS CAMPANULULIDS**
e.g. acetylenes, lactones; inferior ovary, early sympetalal
Late Sympetaly
Asterids LAMIIDS

Anchusa officinalis
Boraginaceae

Leins 2000
EARLY SYMPETALY
ASTERIDS
CAMPANULIDS

*Calendula officinalis*, Compositae

Leins 2000
APIALES

DIPSACALES

ASTERIDS

CAMPANULULIDS

pseudanthia

Plant systematics

Eryngium

Trachymene

Dipsacus

Cynara

Dasyphyllum

Calea

Leonardo Ré Jorge

Fernando Costa
Monophyly of the order strongly supported by \textit{rbcL}, \textit{ndhF}, and \textit{atpB} sequences + mitochondrial \textit{rpl2} gene lost.

\textbf{route I secoiridoids, oligo- or polyfructosans, including \textit{inulin}, with isokestose linkages [starch generally wanting]}
Fructans may stabilize cell membranes under drought and/or freezing conditions (Livingston III et al. 2009)

\textbf{petals valvate}

\textbf{pollen grains tricellular}

\textbf{11 families 1,649 genera 25,790 species (10\% of the angiospermas)}
Each of the 12 major families of Asterales is labeled.

Maximum-likelihood phylogeny for 4954 species
MEGA-PHYLOGENY method

(Tank & Donoghue 2010)

DNA sequences of 5 genes: rbcL, matK, trnL-F, ndhF, ITS
ASTERALES phylogeny

Rousseaceae - 6
Campanulaceae – 2,400 spp
Pentaphragmataceae - 30
Alseuosmiaceae - 10
Phellinaceae - 11
Argophyllaceae - 20
Stylidiaceae - 245
Menyanthaceae - 60
Goodeniaceae - 440
Calyceraceae - 60

COMPOSITAE (ASTERACEAE)

All branches have Bayesian position probabilities $\geq 0.95$ and ML bootstrap $\geq 75%$

10 chloroplast gene analysis - Tank & Donoghue 2010

In South America

CORE ASTERALES
ASTERALES
CAMPANULACEAE

Hippobroma

Centropogon

I. Cordeiro

secondary pollen presentation

Centropogon

Plant systematics

pump mechanism in Lobelioideae

Leins & Erbar 2010

J.R. Pirani

I. Cordeiro

I. Cordeiro

Lobelia
ASTERALES

- secondary pollen presentation

  [protandry, anthers connivent at dehiscence, the style elongates after pollen deposition]

- stigma dry, ± papillate

- calyx persistent in fruit

- ovule 1
ASTERALES

GOODENIACEAE  440 spp.

Scaevola plumieri
INKBERRY

São Paulo, Brazil

Florida - USA
GOODENIACEAE

Stylar cup mechanism

ASTERALES

Selliera radicans

style curved, with apical hairy pollen-collecting indusium and stylar cup

Leins & Erbar 1989

Leins & Erbar 2010
CALYCERACEAE  60 spp.

Apical ovule, filaments connate, anthers free

involucrate CAPITULUM made of cymose units

A-D. Acicarpha tribuloides
H-I. Boopsis itatiaiae

E-G. Acicarpha spathulata
J-L. Boopsis bupleuroides

Acicarpha spathulata
Brazil

Magenta & Pirani  2002
Secondary pollen presentation
Deposition mechanism

Stigma minutely capitate, pollen deposited on its top

deposition mechanism in Calyceraceae

Leins & Erbar 2010
ASTERALES

ASTERACEAE ou COMPOSITAE

- ovule 1, basal

- involucrate CAPITULA

- synanthery

- sesquiterpene lactones
COMPOSITAE

Cichorium

Liatris

Plant systematics
COMPOSITAE - Secondary pollen presentation

Brushing mechanism       Pump mechanism

a

brushing mechanism in Asteraceae

b

pump mechanism in Asteraceae

Senecio   Achillea   Grindellia

Leins & Erbar 2010
COMPOSITAE - Capitulum development

Mutisia

Xerxes

Calea

Fernando Costa

Eduardo L.H. Giehl

Gustavo Shimizu
CAPITULUM (head): centripetal development

Hess 1983
Asterales  COMPOSITAE -  CAPITULUM

Pollination: generalists

Helianthus

Aspilia sp.

plantsystematics.org

adoroplantas.com
COMPOSITAE

generalists

*Cirsium helenioides* with various visitors on the heads:

- *Zygaena* - moth
- *Melanargia* - butterfly
- *Bombus* - bumblebee

Leins & Erbar 2010
CAPITULUM: high genetic diversity among seeds

(adapted from Hess 1983)
COMPOSITAE

dispersion
Fawcett et al. (2009) and Soltis et al. (2009): genome doubling helped numerous plant lineages survive mass extinctions.

The modern polyploidy paradigm attributes enormous genomic versatility and concomitant evolutionary success to polyploid lineages.

- hexaploid event
- duplication events previously reported (e.g. Cui et al. 2006)
- 2 ancient groups of WGDs (whole-genome duplications): 319 m.a. and 192 m.a. (Jiao et al. 2011)
All branches have Bayesian position probabilities $\geq 0.95$ and ML bootstrap $\geq 75%$
Thanks!

To USP, CNPq and FAPESP. 
To my students and collaborators.

Let’s have a good Compositae Meeting!