

Christoph Oberprieler

Institute of Plant Sciences | Evolutionary and Systematic Botany Group
University of Regensburg
Regensburg, GERMANY

Robert Vogt

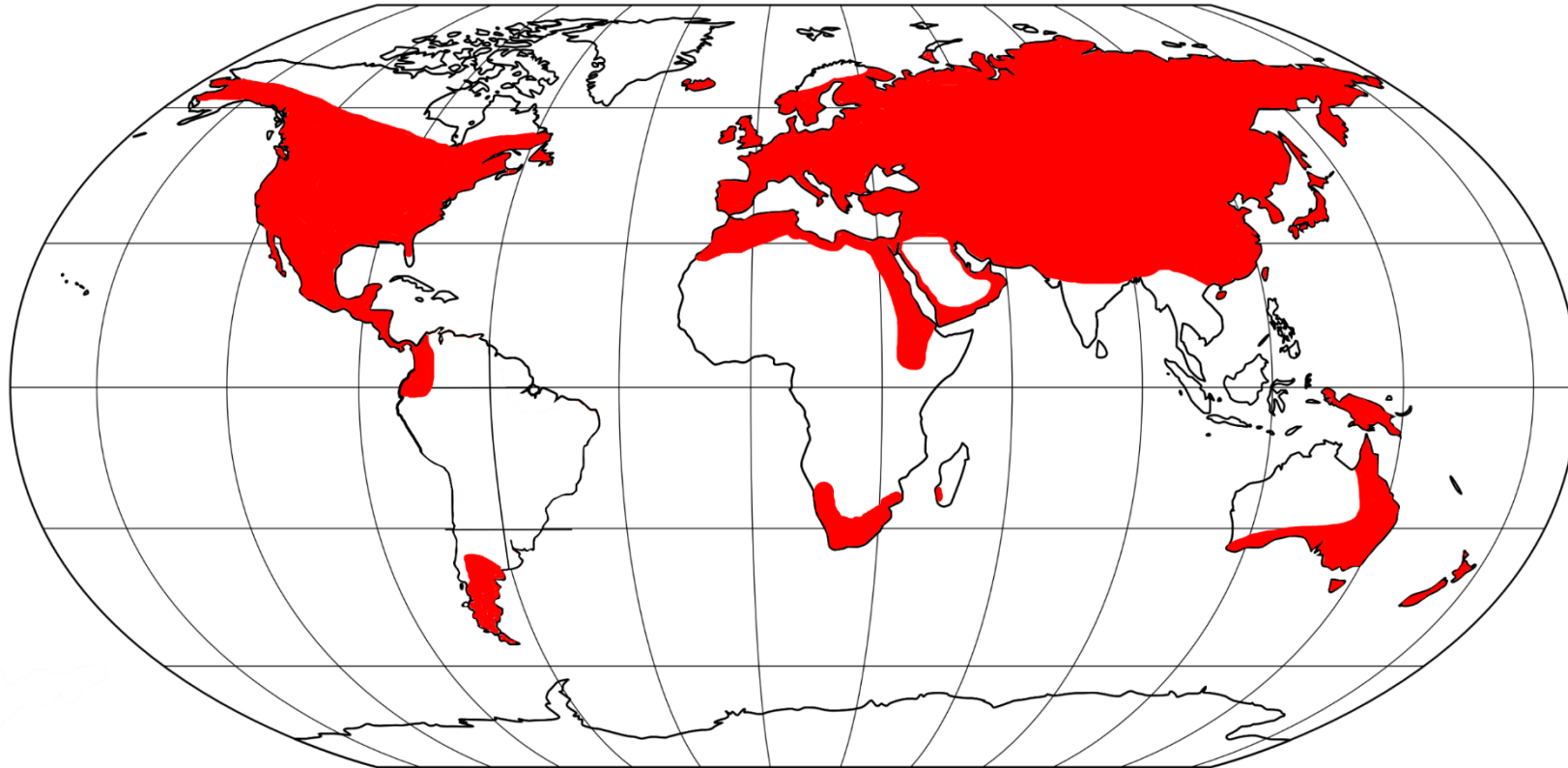
Botanic Garden & Botanical Museum Berlin
Freie Universität Berlin
Berlin, GERMANY

Introduction to the **ANTHEMIDEAE**



Anthemideae Cass.

Distribution

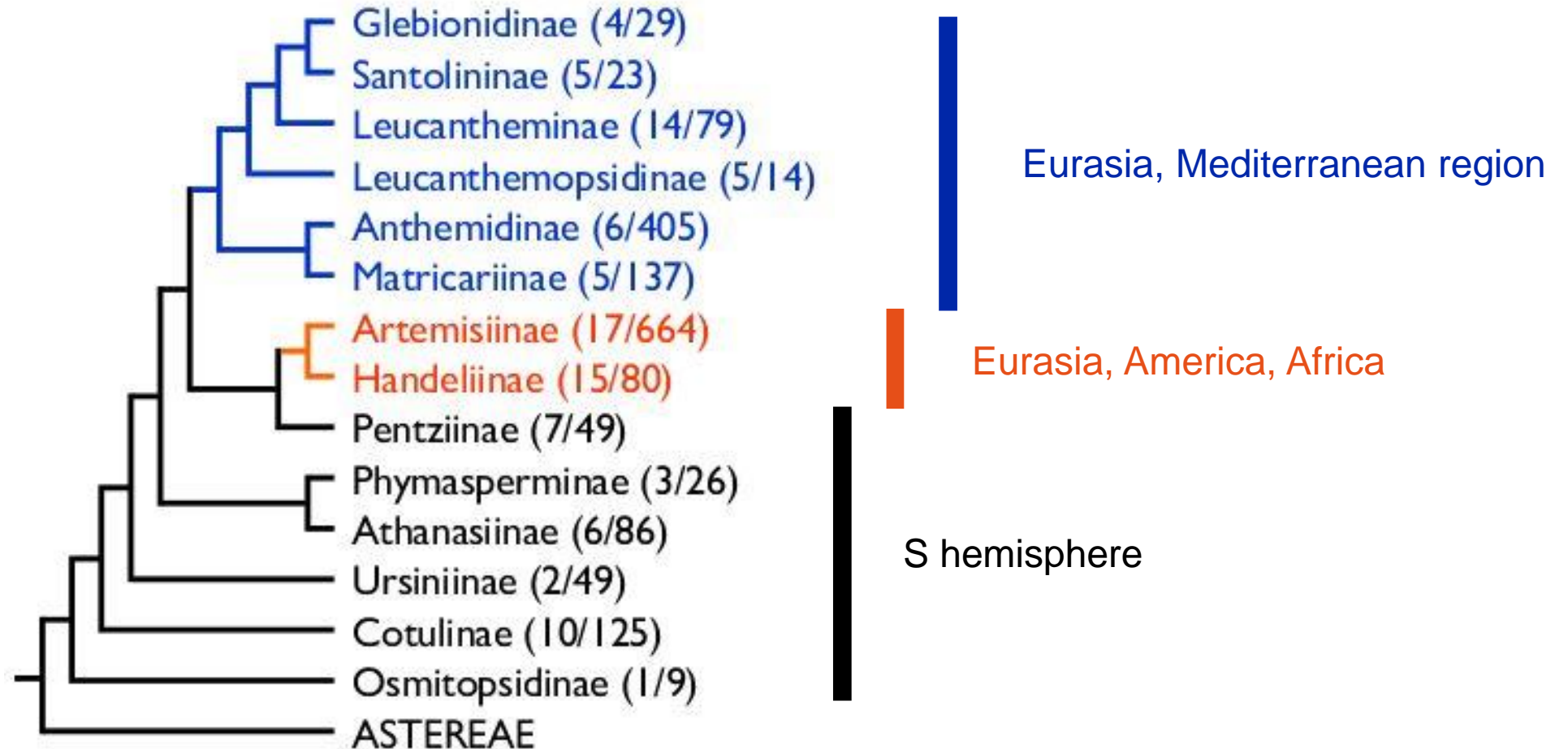


 Anthemideae

102 genera | **1775** species

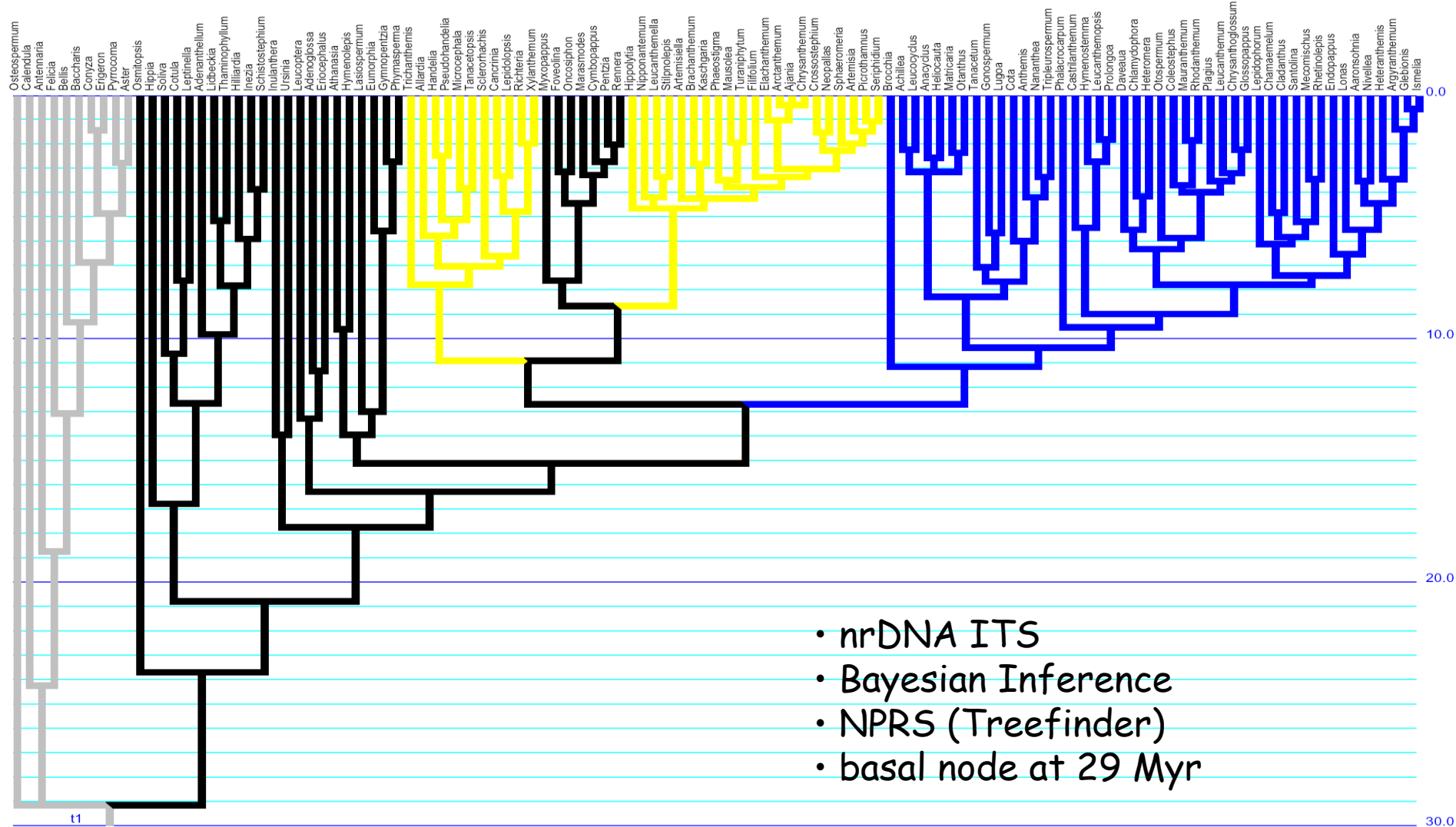
Anthemideae Cass.

Biogeography



Anthemideae Cass.

Temporal diversification



Anthemideae Cass.

Ecological importance



A close-up photograph of several bright yellow chrysanthemum flowers. The flowers have a dense, multi-petaled structure with many long, thin, and slightly curled petals radiating from a central green core. The background is filled with dark green, serrated leaves of the plant. The lighting is soft, highlighting the texture of the petals.

Anthemideae Cass.

Economic importance

Anthemideae Cass.

Shrubs, subshrubs, annual or perennial herbs

Indumentum of basifixed or medifixed hairs

Capitula solitary or in lax to dense corymbs

Capitula radiate, disciform, or discoid

Phyllaries in 2-7 rows, with scarious margins

Receptacle epaleate or paleate

Ray florets female and fertile or sterile

Disc florets hermaphrodite or male

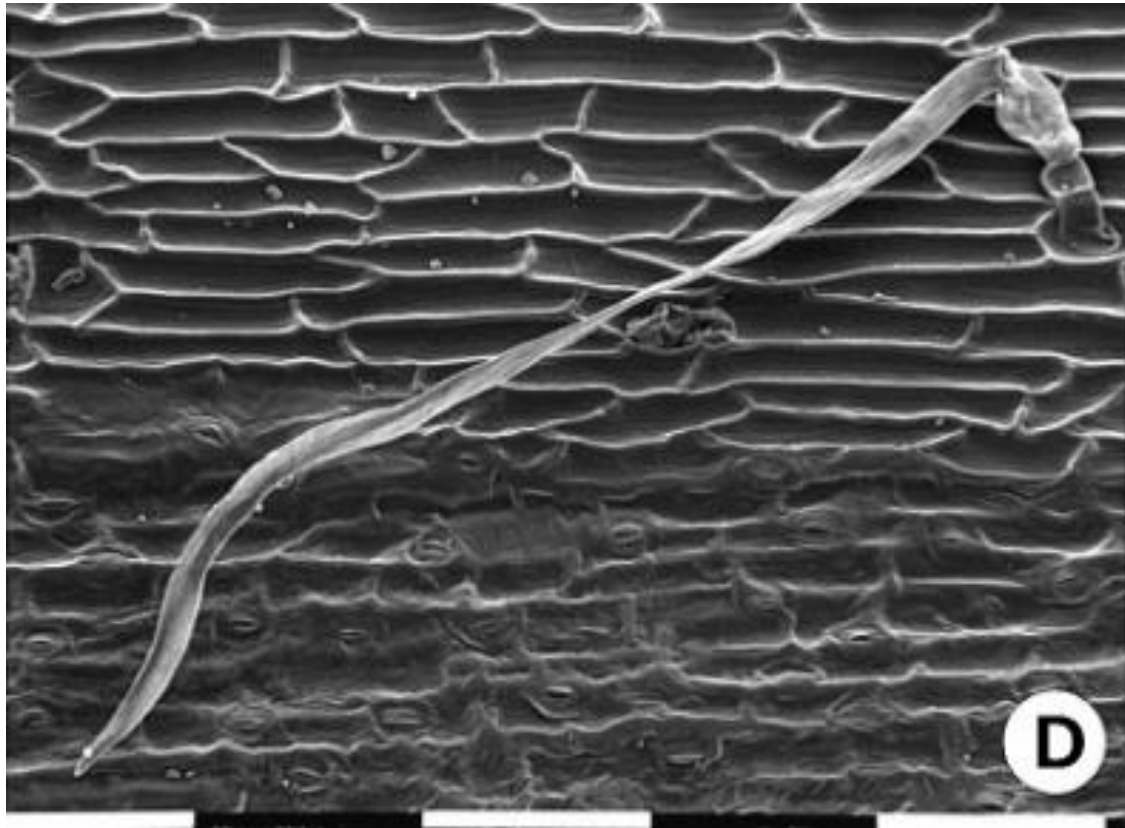
Style truncate, penicillate, with two stigmatic areas

Achenes ecoronate or with a corona or bristles or scales

Anthemideae Cass.

Morphological Main Characters | Indumentum

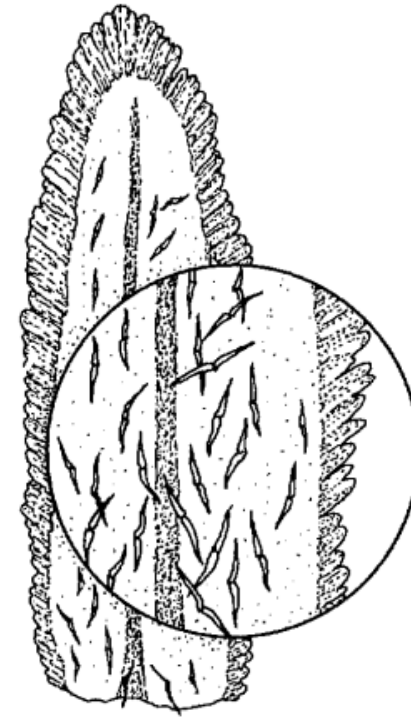
basifixed hairs



Nivellea nivellei (Braun-Blanq. & Maire) B.H.Wilcox et. al.

© Vogt & Oberprieler (1996)

medifixed hairs



Rhodanthemum laouense Vogt

© Vogt (1994)

Anthemideae Cass.

Morphological Main Characters | Capitula

heterogamous

homogamous

radiate

disciform

discoid



© Oberprieler

Rhodanthemum quezelii Dobignard & Duret



© Heenan

Leptinella filiformis (Hook.f.) D.Lloyd & C.Webb



© Oberprieler

Leucanthemum virgatum (Desr.) Clos

Anthemideae Cass.

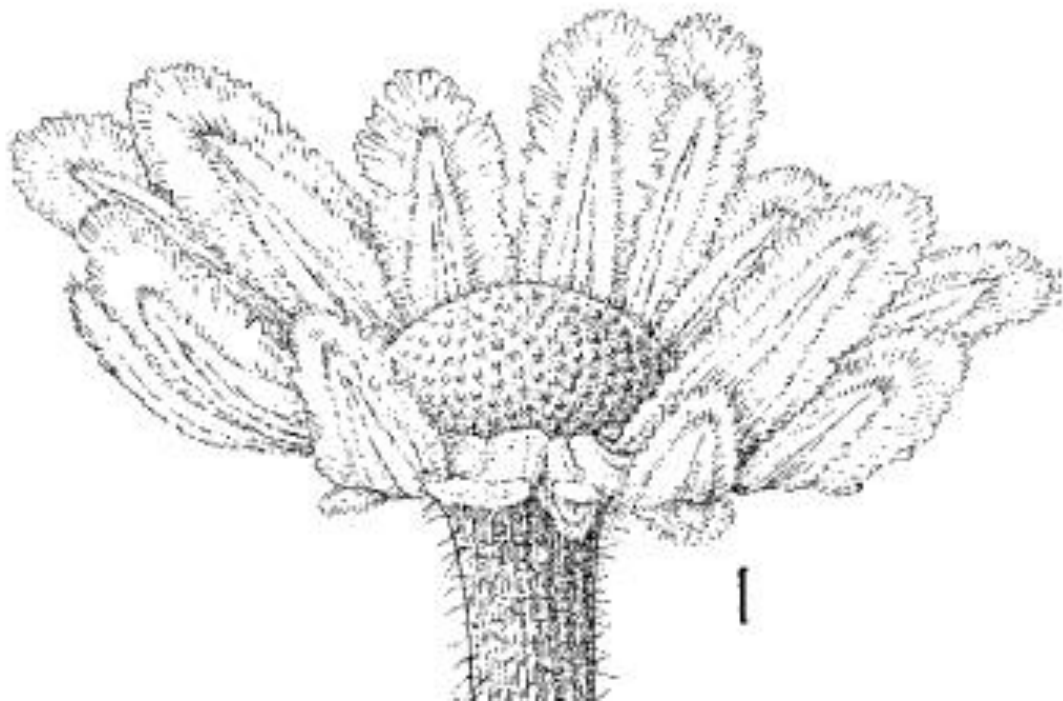
Morphological Main Characters | Capitula

Phyllaries with scarious margins



Anthemideae Cass.

Morphological Main Characters | Receptacle & Paleas



Nivellea nivellei (Braun-Blanq. & Maire) B.H.Wilcox et al.

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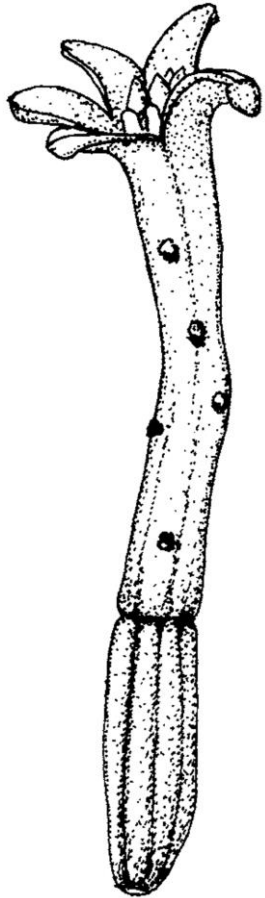


Anthemis spec.

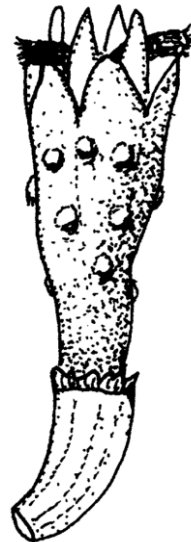
© Oberprieler

Anthemideae Cass.

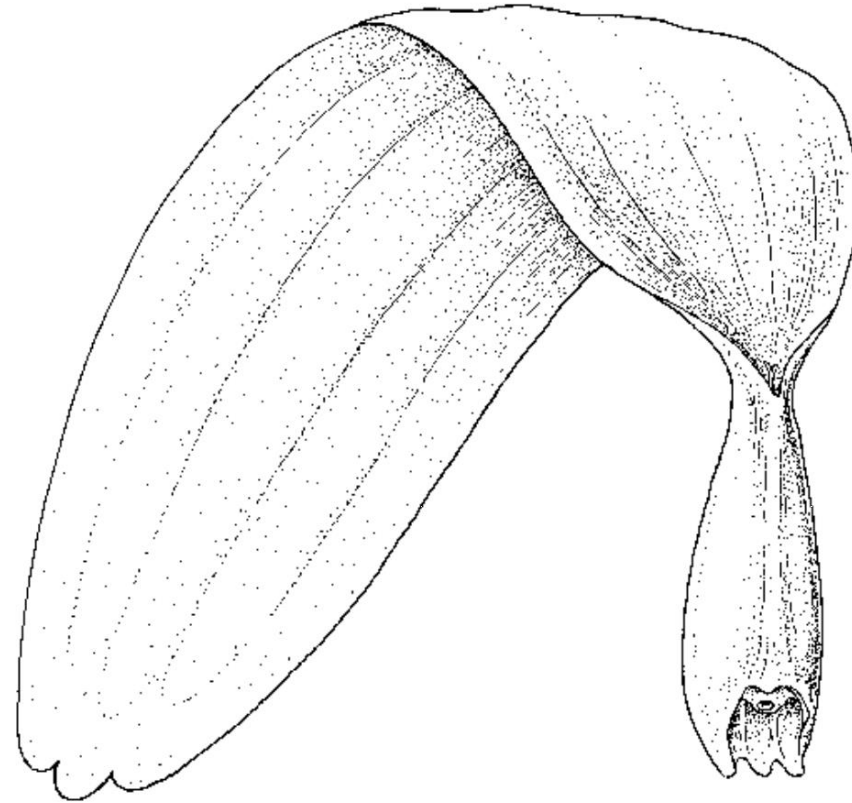
Morphological Main Characters | Corolla



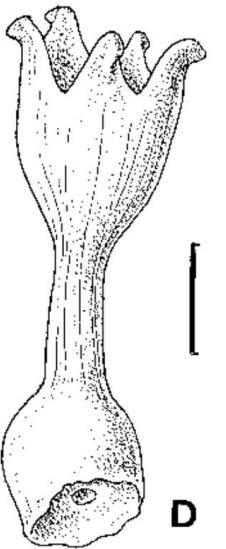
Athanasia dentata (L.) L.



Artemisia absinthium L.

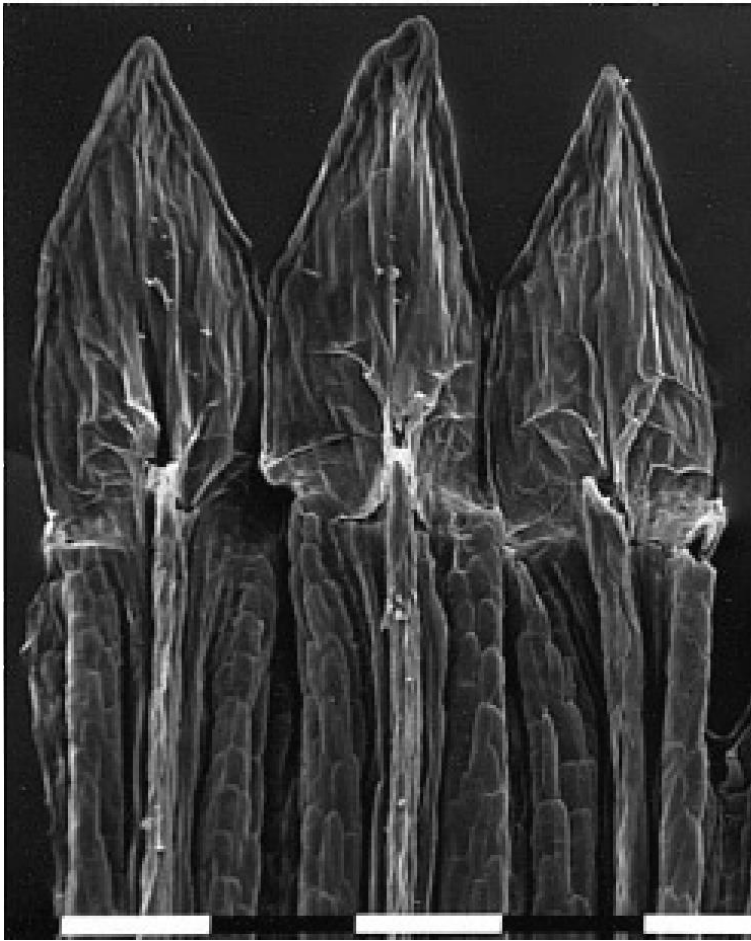


Nivellea nivellei (Braun-Blanq. & Maire) B.H.Wilcox et al.

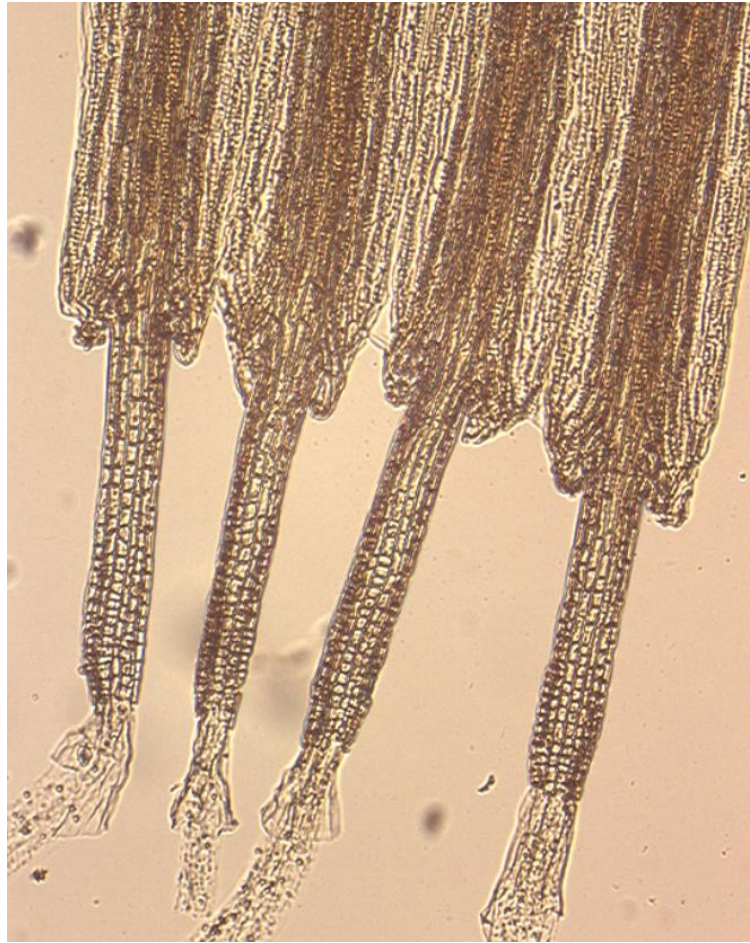


Anthemideae Cass.

Morphological Main Characters | Stamens



Nivellea nivellei (Braun-Blanq. & Maire) B.H.Wilcox et. al.



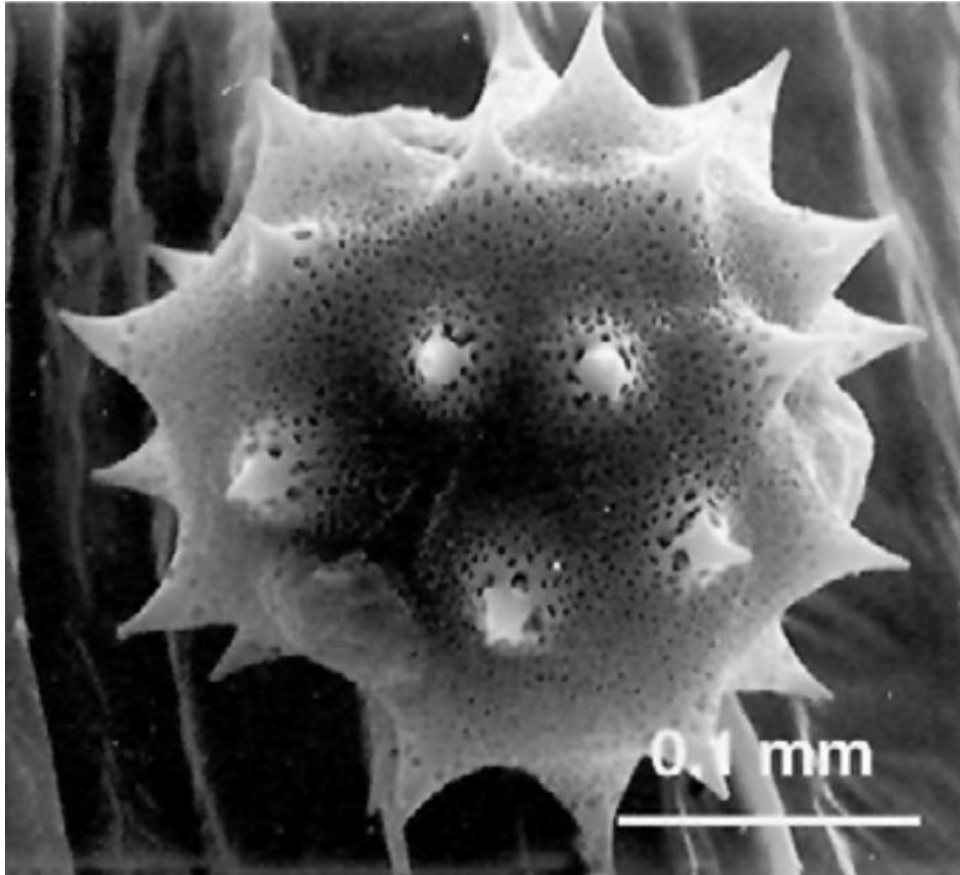
Tanacetum artemisioides Sch.Bip.



Vogtia microphylla (DC.) Oberpr. & Sonboli

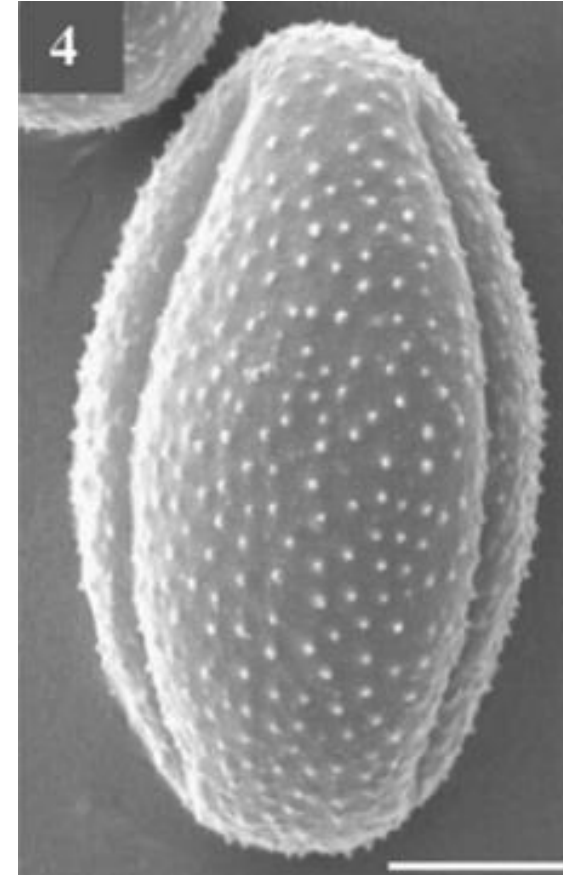
Anthemideae Cass.

Morphological Main Characters | Pollen



Castrilanthemum debeauxii (Degen & al.) Vogt & Oberpr.

© Vogt & Oberprieler (1996)

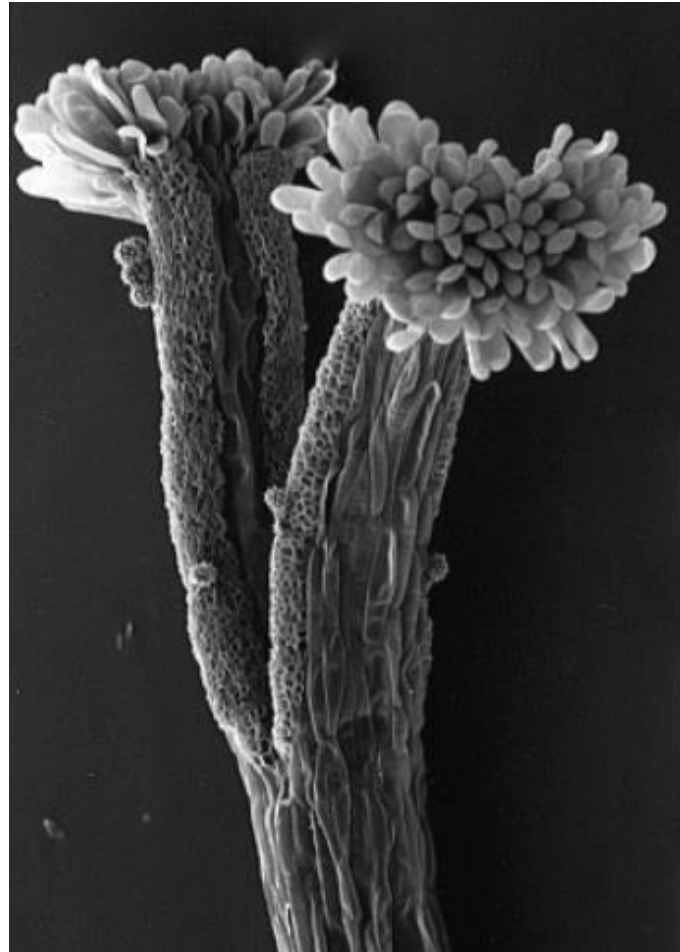


Artemisia paraxodum (Bornm.) Sonboli

© Sonboli et al. (2011)

Anthemideae Cass.

Morphological Main Characters | Style

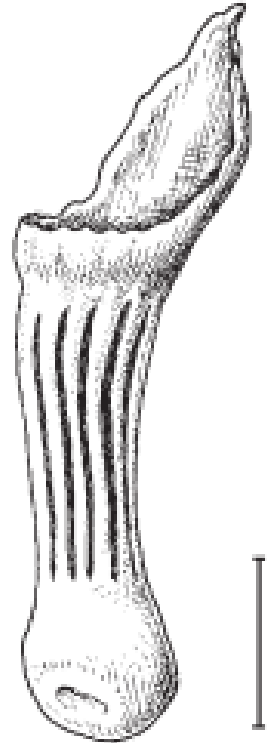
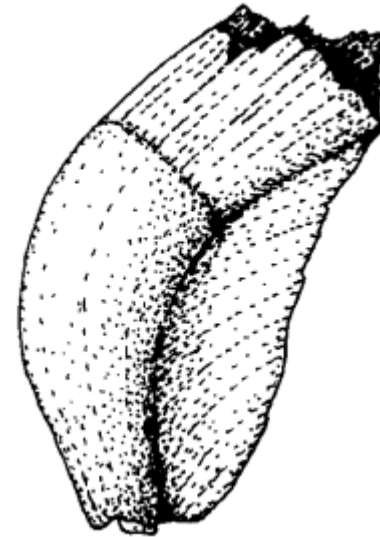
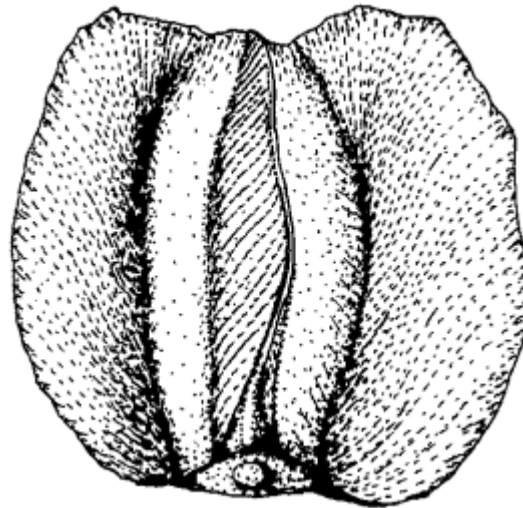
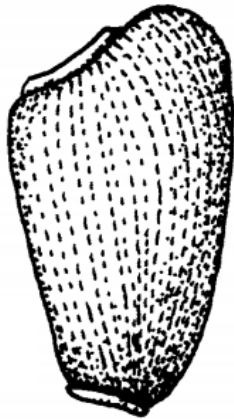
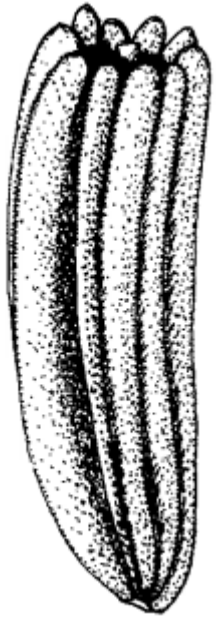


Nivellea nivellei (Braun-Blanq. & Maire) B.H.Wilcox et. al.

© Vogt & Oberprieler (1996)

Anthemideae Cass.

Morphological Main Characters | Achenes



Athanasia dentata (L.) L.

Artemisia absinthium L.

Argyranthemum foeniculaceum (Willd.) Webb ex Sch.Bip.

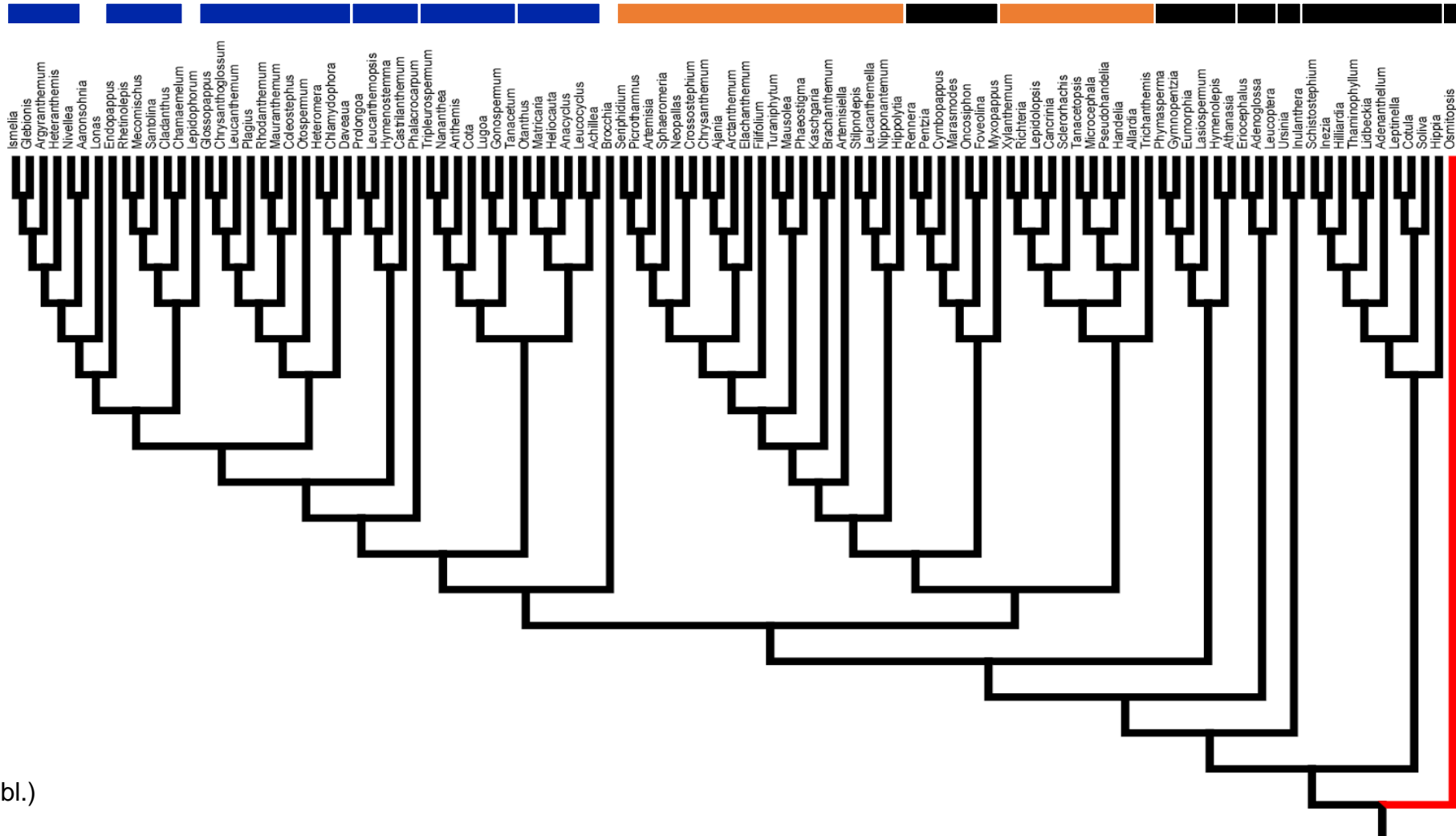
Plagius grandis (L.) Alavi & Heyw.

© Oberprieler et al. (2007)

© Vogt & Oberprieler (2006)

Anthemideae Cass.

Phylogeny

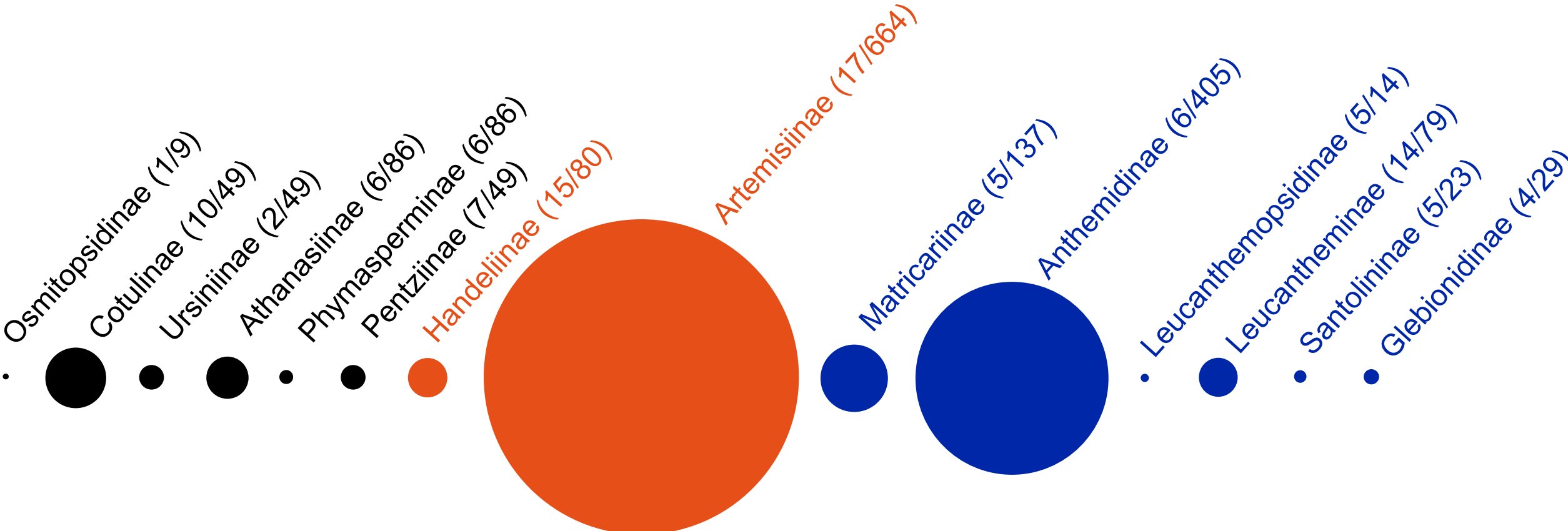


©Töpfer et al. (unpubl.)

Cladogram from a NJ tree based on multi-copy (nrDNA ITS and ETS) and three single-copy nuclear markers (DSP, P-3, PDOT)

Anthemideae Cass.

Subtribal diversity



102 genera | 1775 species

Anthemideae Cass.

subtribe Osmitopsidinae Oberpr. & Himmelreich

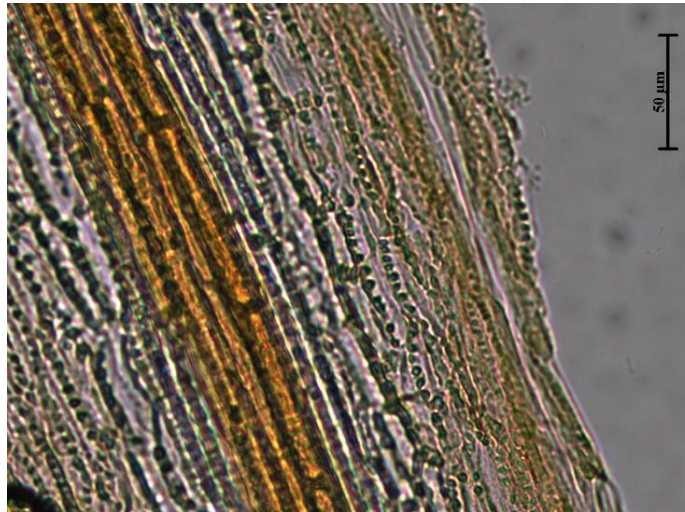
1 genus | 9 species | S Africa

Osmitopsis (9)



© Oberprieler

- pales present
- unpolarised endothelial tissue
- basifixed hairs
- $x = 10$
- filament collar slender
- tailed anthers



***Osmitopsis asteriscoides* (P.Bergius) Less.**

Anthemideae Cass.

subtribe Cotulinae Kitt.

10 genera | 125 species | S hemisphere

Adenanthellum (1)
Cotula (55)
Hilliardia (1)
Hippia (8)
Inezia (2)
Leptinella (33)
Lidbeckia (2)
Schistostephium (12)
Soliva (8)
Thaminophyllum (3)

- pales absent
- unpolarised endothecial tissue
- basifixed hairs
- $x = 10$
($\rightarrow 9, 8$ *Cotula*; $\rightarrow 13, 15, 17$ *Leptinella*)



© Himmelreich

Leptinella dendyi (Cockayne) D.Lloyd & C.Webb



Hilliardia zuurbergensis

Anthemideae Cass.

subtribe Cotulinae Kitt.

Polyploidy, biogeography, and evolution of sex expression in *Leptinella* Cass.



24x *L. rotundata*, *L. traillii*

20x *L. dioica*,
L. squalida ssp. *squalida*,
L. squalida ssp. *mediana*

16x *L. squalida* ssp. *mediana*

12x *L. squalida* ssp. *mediana*,
L. intermedia,
L. pyrethrifolia

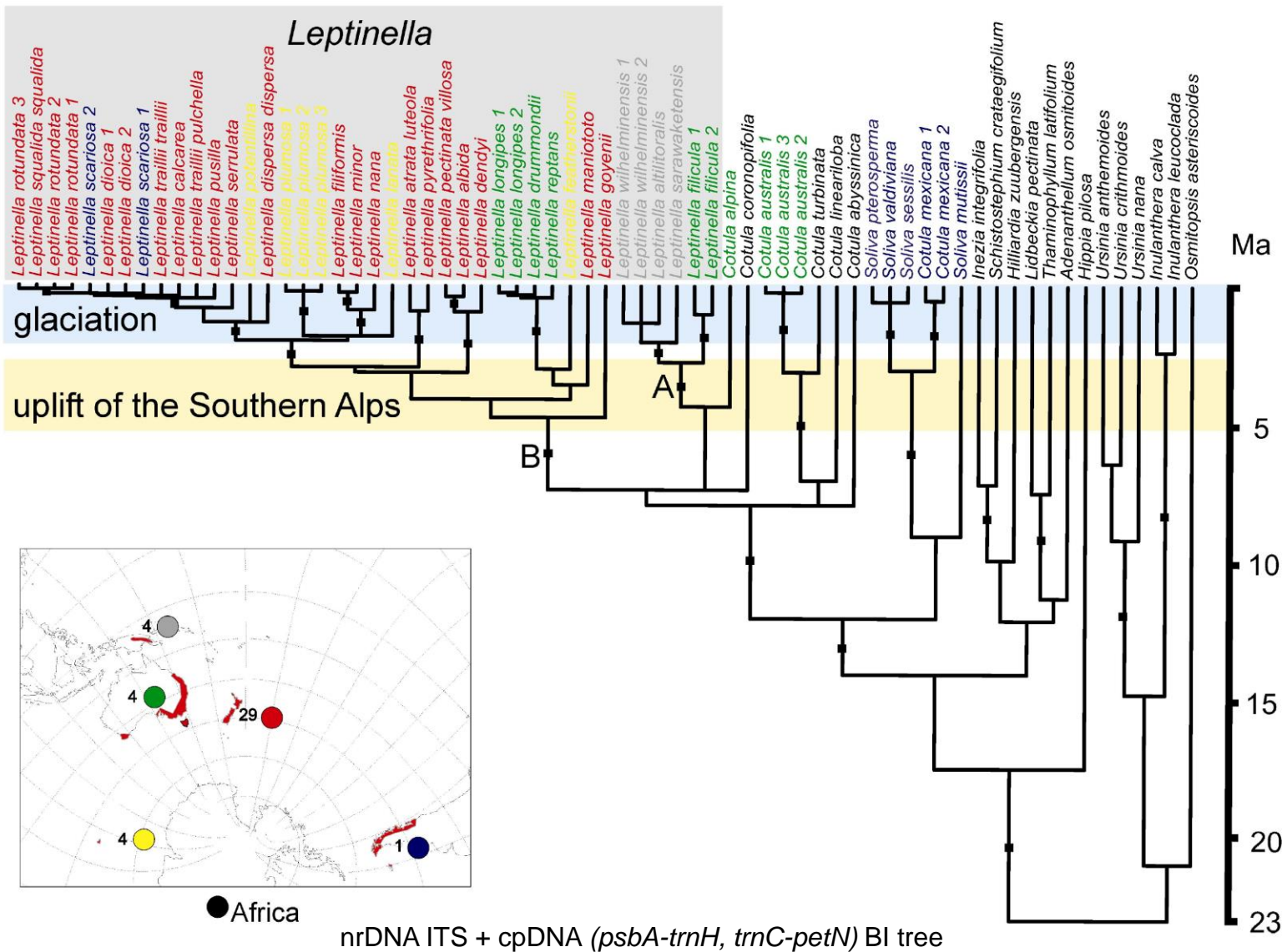
8x *L. pusilla*, *L. calcarea*,
L. pectinata

4x *L. potentillina*, *L. tenella*,
L. dispersa, *L. serrulata*,
L. maniototo, *L. nana*,
L. filiformis, *L. minor*,
L. atrata, *L. albida*,
L. pectinata, *L. plumosa*,
L. featherstonii

Anthemideae Cass.

subtribe Cotulinae Kitt.

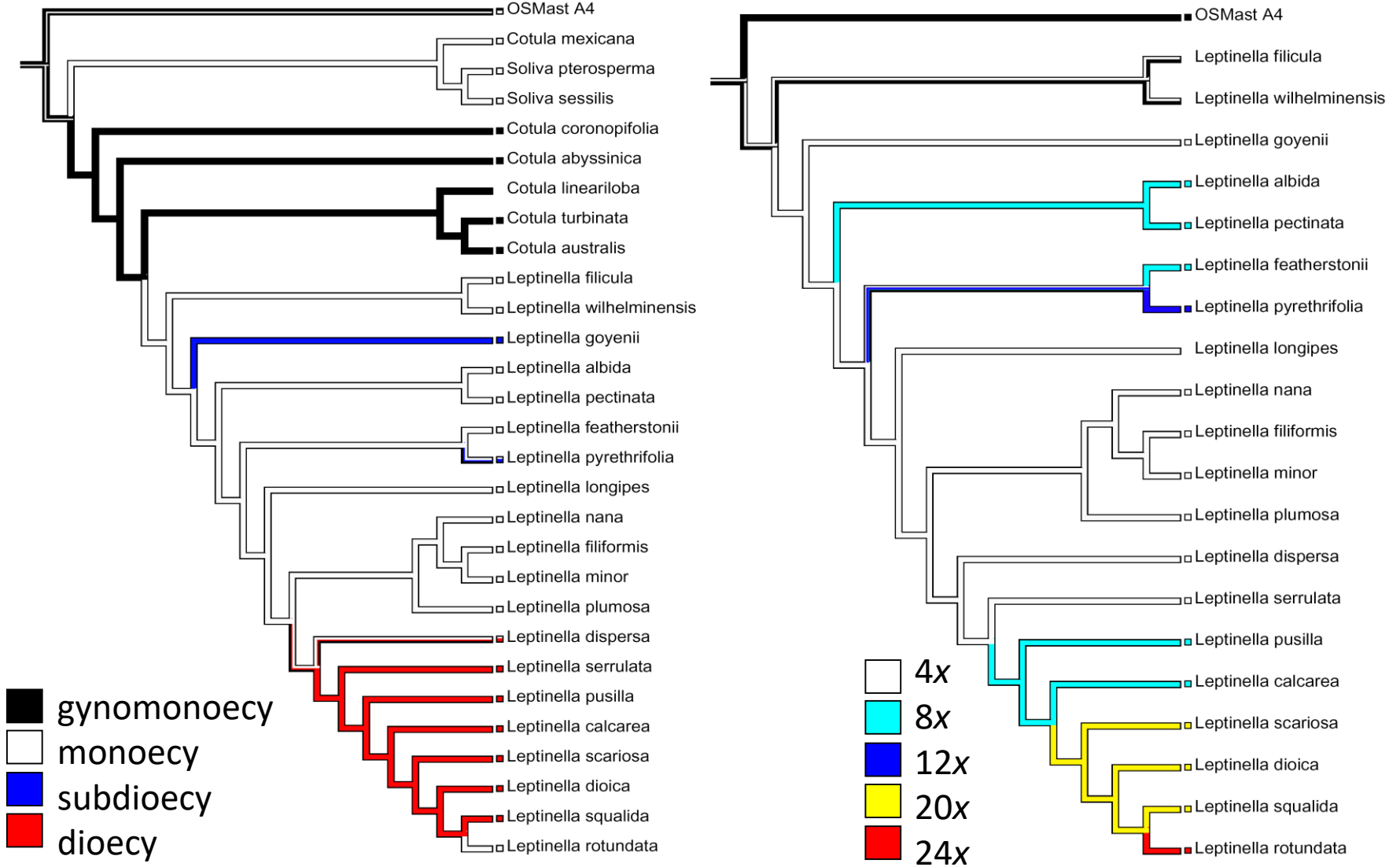
Polyploidy, biogeography, and evolution of sex expression in *Leptinella* Cass.



Anthemideae Cass.

subtribe Cotulinae Kitt.

Polyploidy, biogeography, and evolution of sex expression in *Leptinella* Cass.



gynomonoecy
 monoecy
 subdioecy
 dioecy

4x
 8x
 12x
 20x
 24x

nrDNA ITS + cpDNA (*psbA-trnH*, *trnC-petN*) BI tree

Anthemideae Cass.

subtribe Ursiniinae Bremer & Humphries

2 genera | 49 species | S Africa, Ethiopia

Inulanthera (10)
Ursinia (39)

- pales present
- polarised endothecial tissue
- basifixed hairs
- $x = 5, 7, 8$
- filament collar balusterform



© Wikimedia Commons

***Ursinia calenduliflora* (DC.) N.E.Br.**



Anthemideae Cass.

subtribe Athanasiinae (Less.) Lindl. ex Pfeiff.

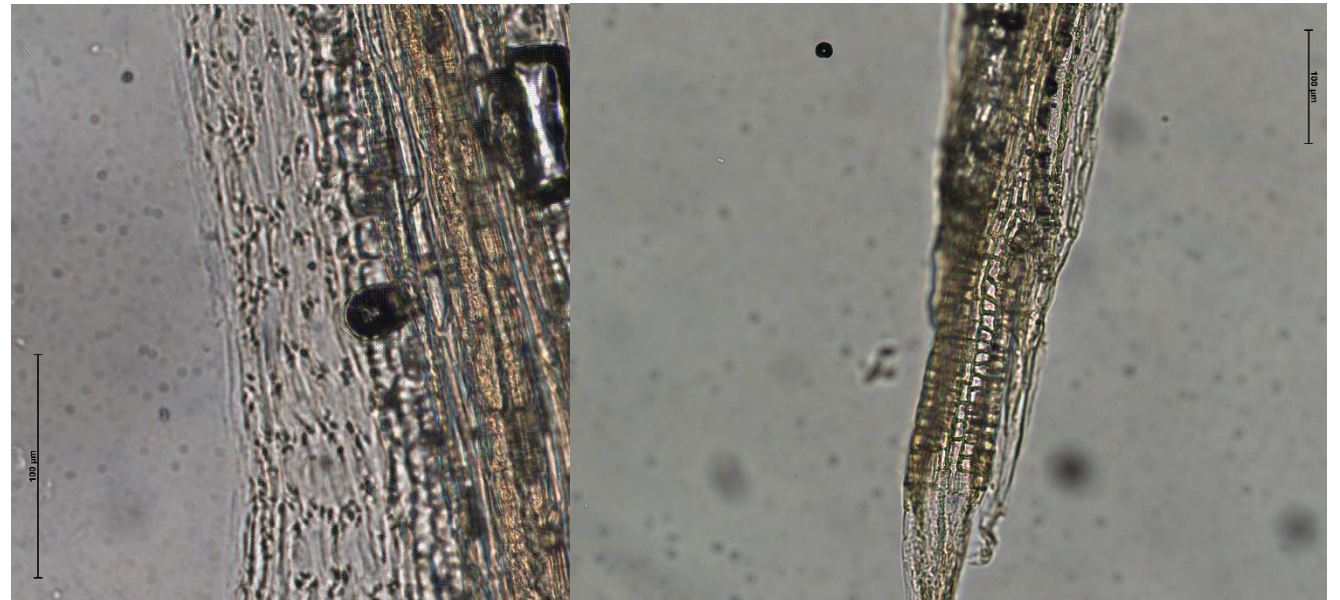
6 genera | 86 species | S Africa, Sinai

Adenoglossa (1)
Athanasia (39)
Eriocephalus (32)
Hymenolepis (7)
Lasiospermum (4)
Leucoptera (3)

- pales present / absent
- polarised endothelial tissue
- basifixed / medifixed hairs
- $x = 8$
- filament collar slender



Athanasia dentata (L.) L.



Anthemideae Cass.

subtribe Phymasperminae Oberpr. & Himmelreich

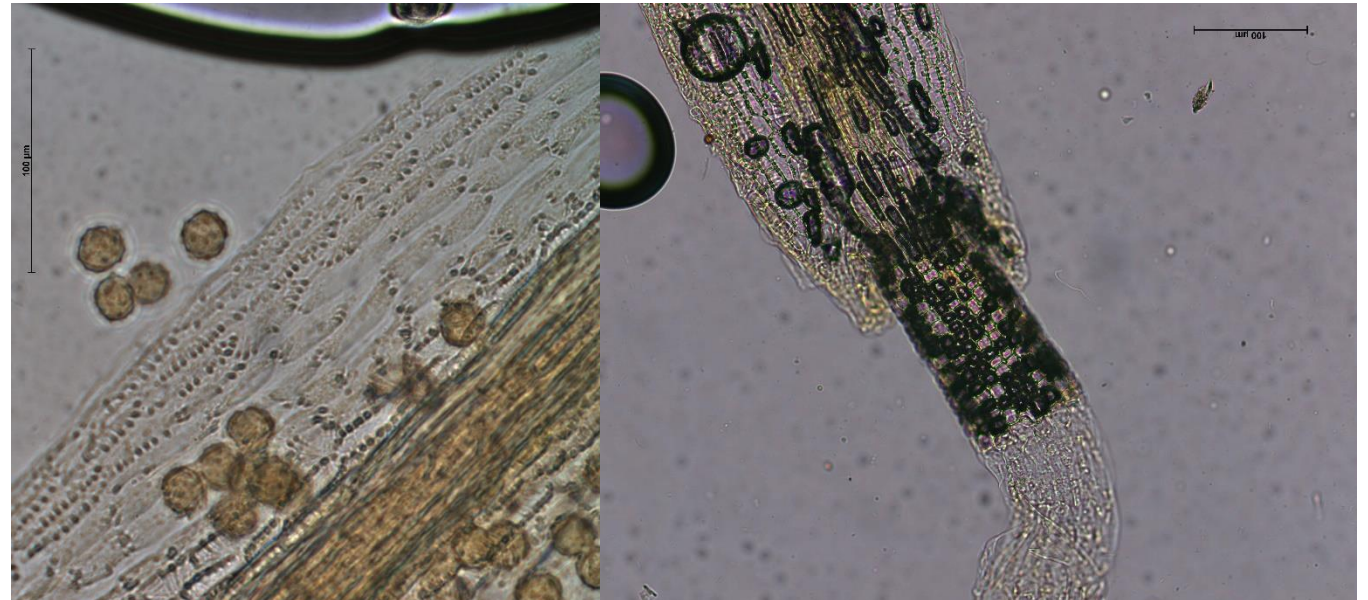
3 genera | 26 species | S Africa

Eumorphia (6)
Gymnopentzia (1)
Phymaspermum (19)

© Oberprieler



- pales present / absent
- polarised endothecial tissue
- basifixed hairs
- $x = 9$
- filament collar slender



Phymaspermum leptophyllum (DC.) Benth. & Hook.f.

Anthemideae Cass.

subtribe Pentziinae Oberpr. & Himmelreich

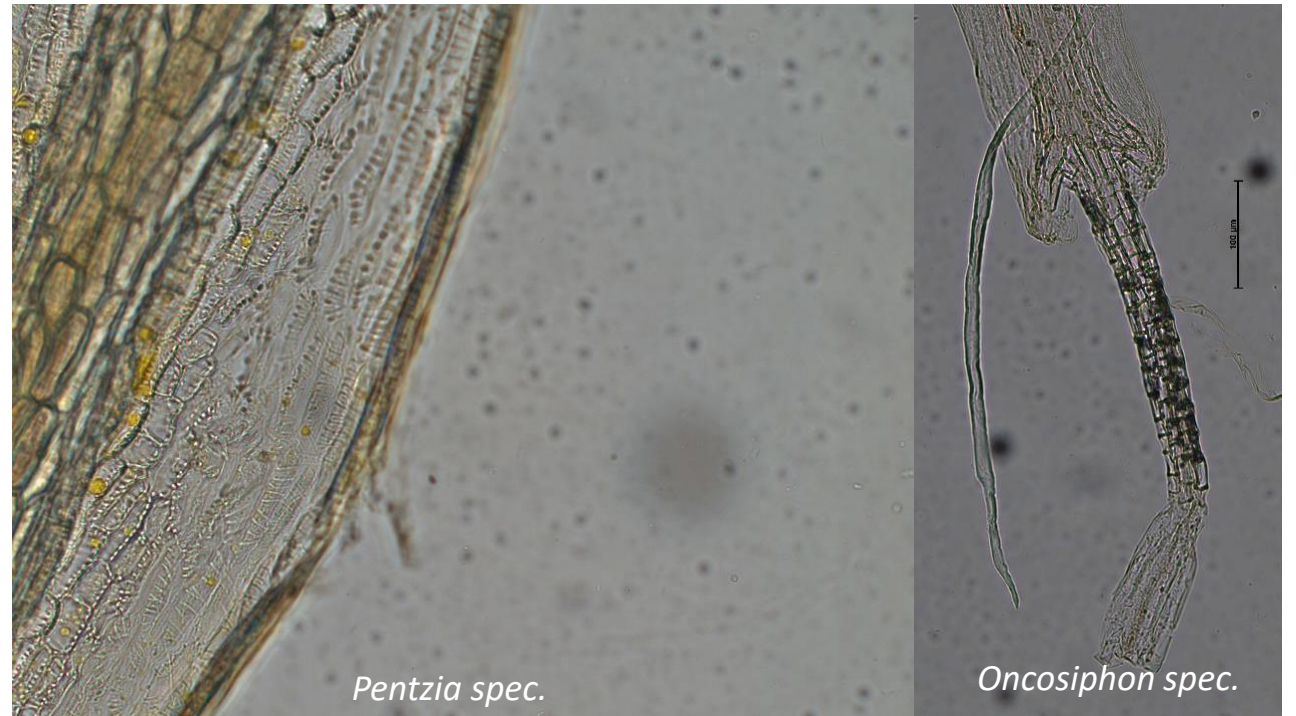
7 genera | 49 species | S Africa, N Africa, S Arabia

Cymbopappus (3)
Foveolina (5)
Marasmodes (4)
Myxopappus (2)
Oncosiphon (8)
Pentzia (23)
Rennera (4)

- pales absent
- unpolarised endothelial tissue
- basifixed hairs (→ medifixed)
- $x = 9, 8, 7, 6$
- filament collar slender



Pentzia incana (Thunb.) Kuntze



Pentzia spec.

Oncosiphon spec.

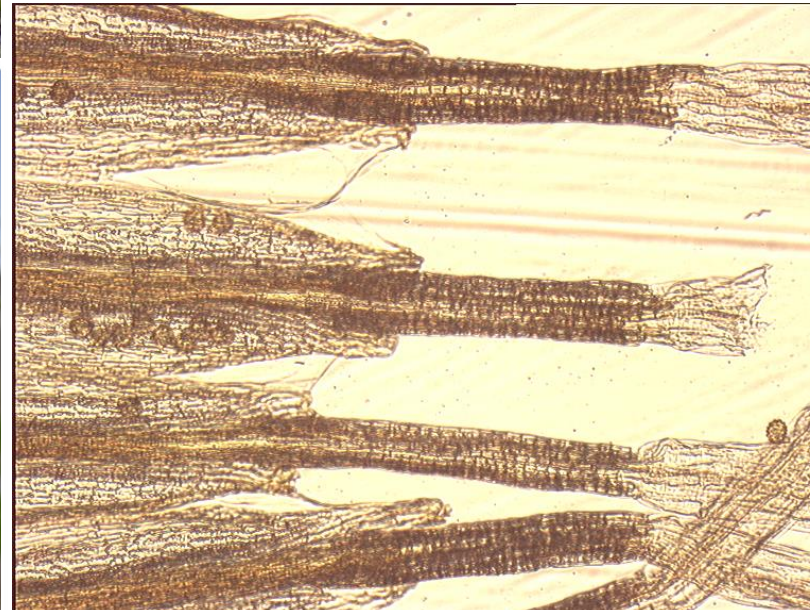
Anthemideae Cass.

subtribe Handeliinae Bremer & Humphries

15 genera | 80 species | C Asia, Iran, Afghanistan, Pakistan, Mongolia, China

- Allarida* (4)
- Cancrinia* (4)
- Cancriniella* (1)
- Handelia* (1)
- Lepidolopha* (9)
- Lepidolopsis* (1)
- Microcephala* (5)
- Polychrysum* (1)
- Pseudohandelia* (1)
- Richteria* (6)
- Sclerorhachis* (4)
- Tanacetopsis* (21)
- Trichanthemis* (9)
- Ugamia* (1)
- Waldheimia* (4)

- pales absent (→ present)
- unpolarised endothecial tissue
- basifixed hairs
- $x = 9$ (→ 7 *Microcephala*)
- filament collar broad / slender



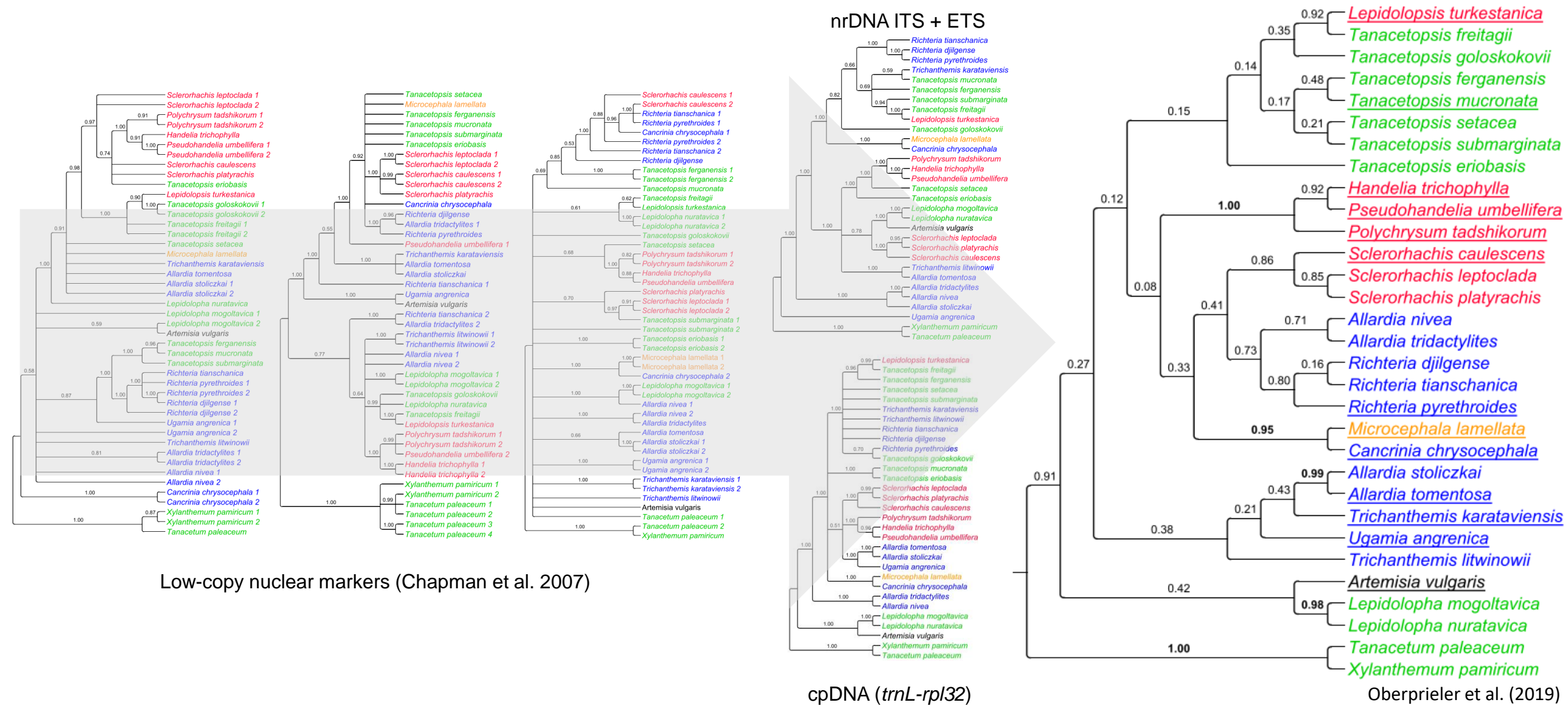
Sclerorhachis platyrhachis (Boiss.) Podl. ex Rech.f.

Waldheimia nivea

Anthemideae Cass.

subtribe Handeliinae Bremer & Humphries

Generic relationships in Handeliinae and species delimitation in *Sclerorhachis* (Rech.f.) Rech.f.



Low-copy nuclear markers (Chapman et al. 2007)

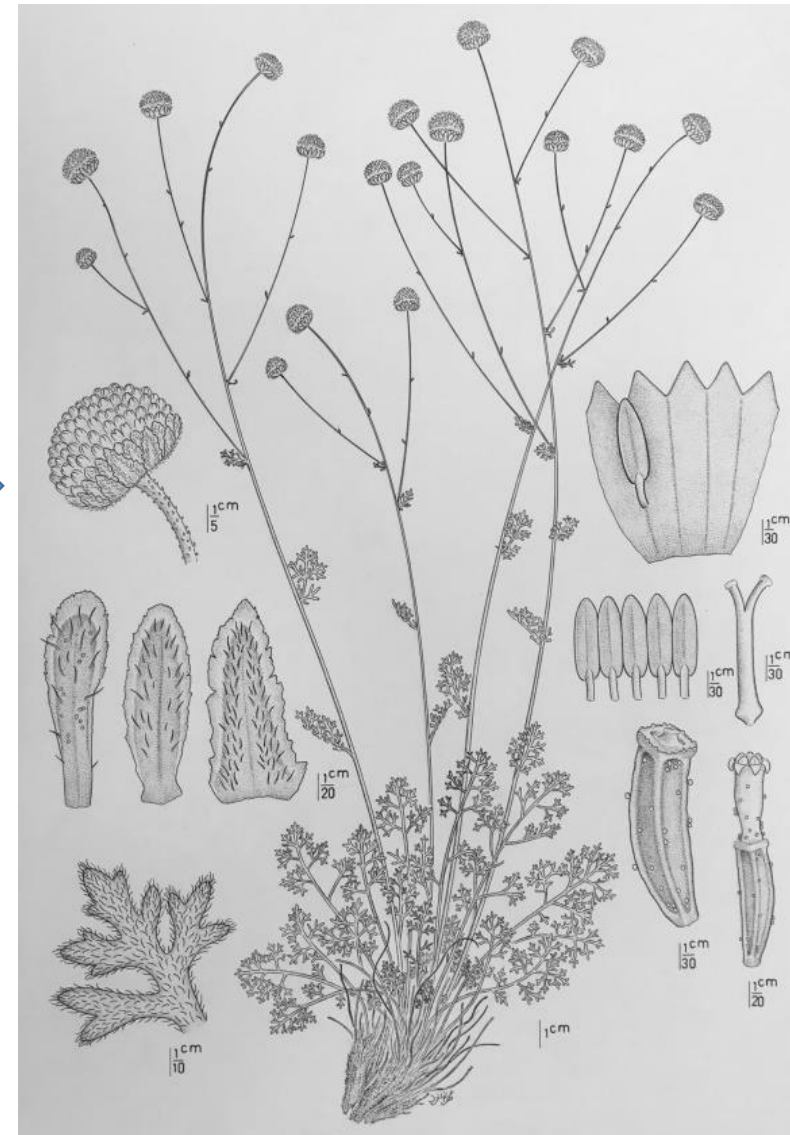
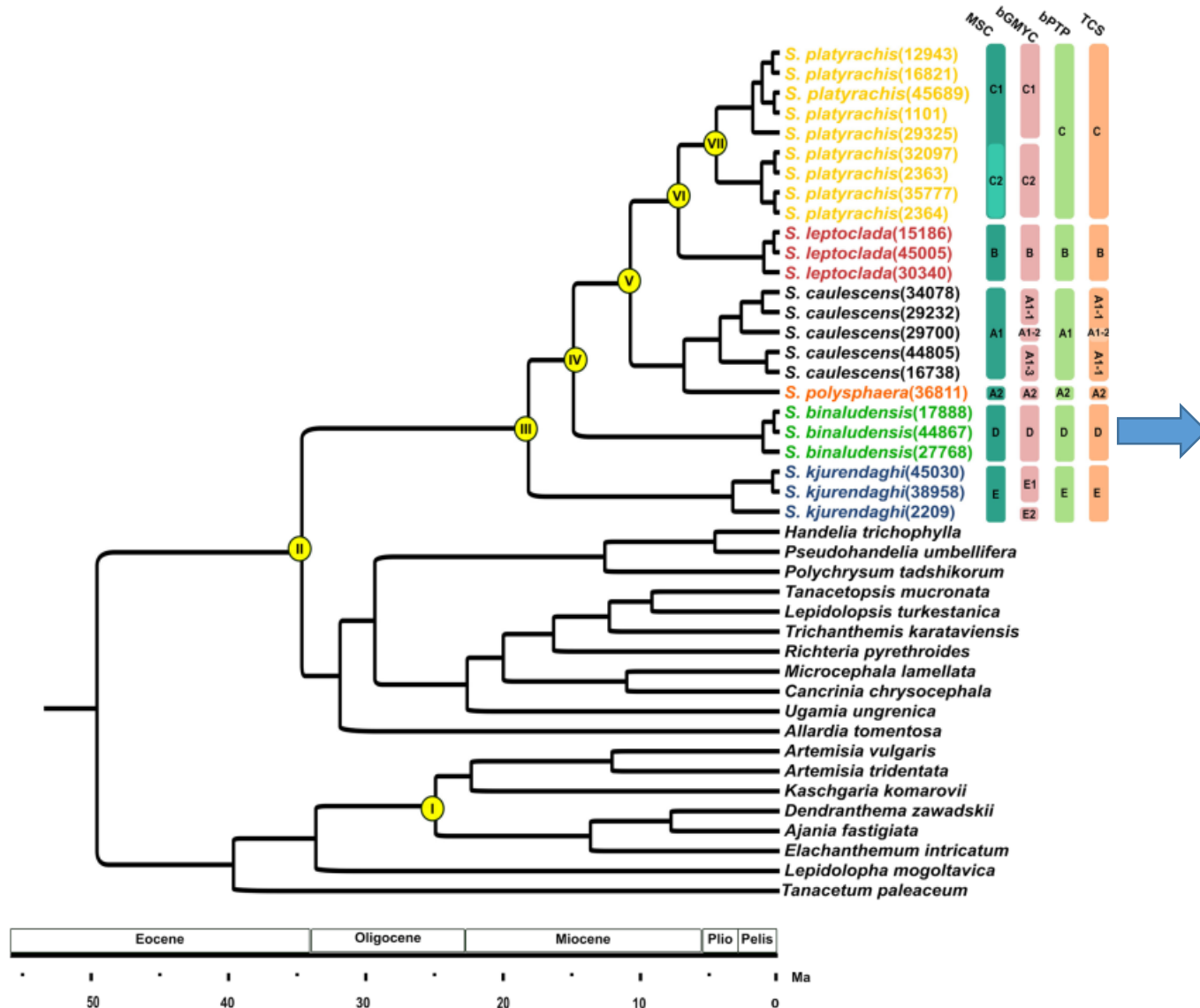
cpDNA (*trnL-rpl32*)

Oberprieler et al. (2019)

Anthemideae Cass.

subtribe Handeliinae Bremer & Humphries

Generic relationships in Handeliinae and species delimitation in *Sclerorhachis* (Rech.f.) Rech.f.



Anthemideae Cass.

subtribe Artemisiinae Less.

18 genera | 664 species | N hemisphere, S America, S Africa, Pacific Islands

Ajania (39)
Ajaniopsis (1)
Arctanthemum (3)
Artemisia (540)
Artemisiella (1)
Brachanthemum (10)
Chrysanthemum (37)
Elachanthemum (1)
Hippolytia (19)
Hulteniella (1)
Kaschgaria (2)
Lepidolopha (9)
Leucanthemella (2)
Nipponanthemum (1)
Opisthopappus (2)
Phaeostigma (3)
Stilpnolepis (1)
Tridactylina (1)

- pales absent (→ present)
- unpolarised endothelial tissue
- medifixed / stellate hairs
- $x = 9$ (→ 7, 8, 10, 11, 17 *Artemisia*)
- pollen spines → spineless



Hippolytia delavayi



Artemisia arborescens (Vaill.) L.

© Schönfelder

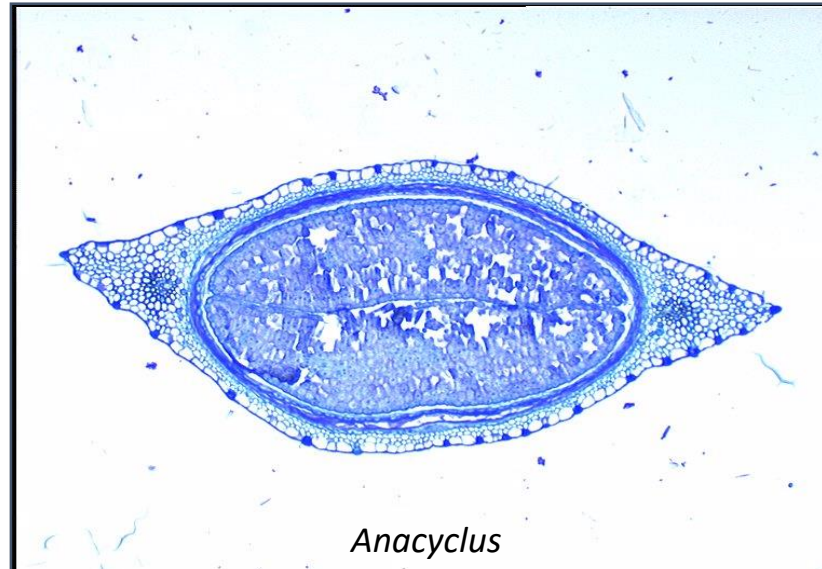
Anthemideae Cass.

subtribe Matricariinae Willk.

5 genera | 137 species | N hemisphere

Achillea (117)
Anacyclus (12)
Brocchia (1)
Heliocauta (1)
Matricaria (6)

- pales present (→ absent)
- unpolarised endothelial tissue
- $x = 9$
- basifixed hairs
- monosporic embryo sac development
- achenes with thin pericarp



Achillea cretica L.

Anthemideae Cass.

subtribe Anthemidinae (Cass.) Dumort.

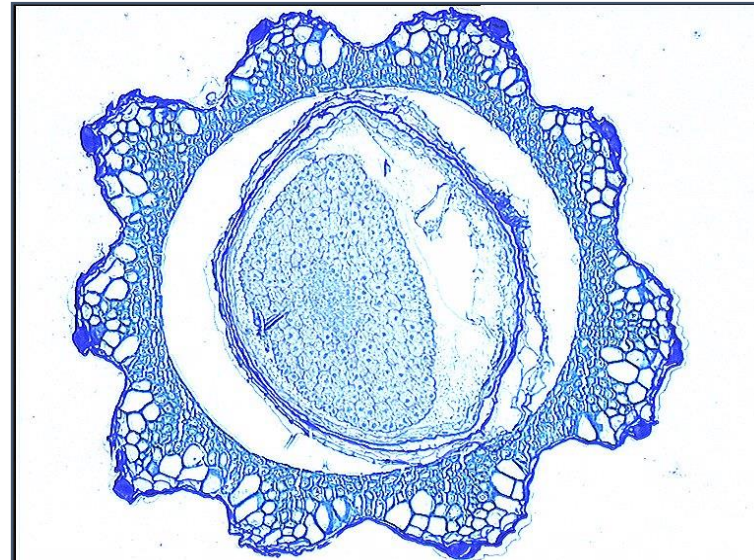
8 genera | 405 species | N hemisphere

Anthemis (175)
Archanthemis (4)
Cota (40)
Nananthea (1)
Tanacetum (159)
Tripleurospermum (40)
Xylanthemum (8)
Vogtia (2)

- pales present (→ absent)
- unpolarised endothelial tissue
- $x = 9$
- medifixed hairs
- tetrasporic embryo sac development
- achenes with thick pericarp



Anthemis rigida Hledr.



Anthemis spec.

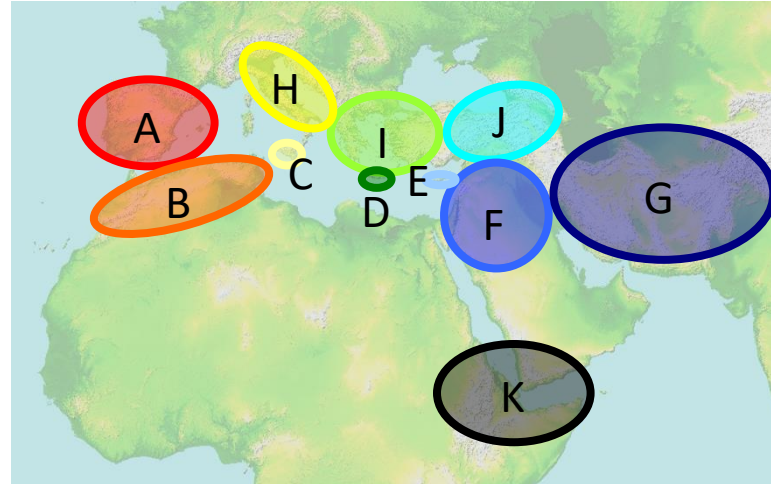
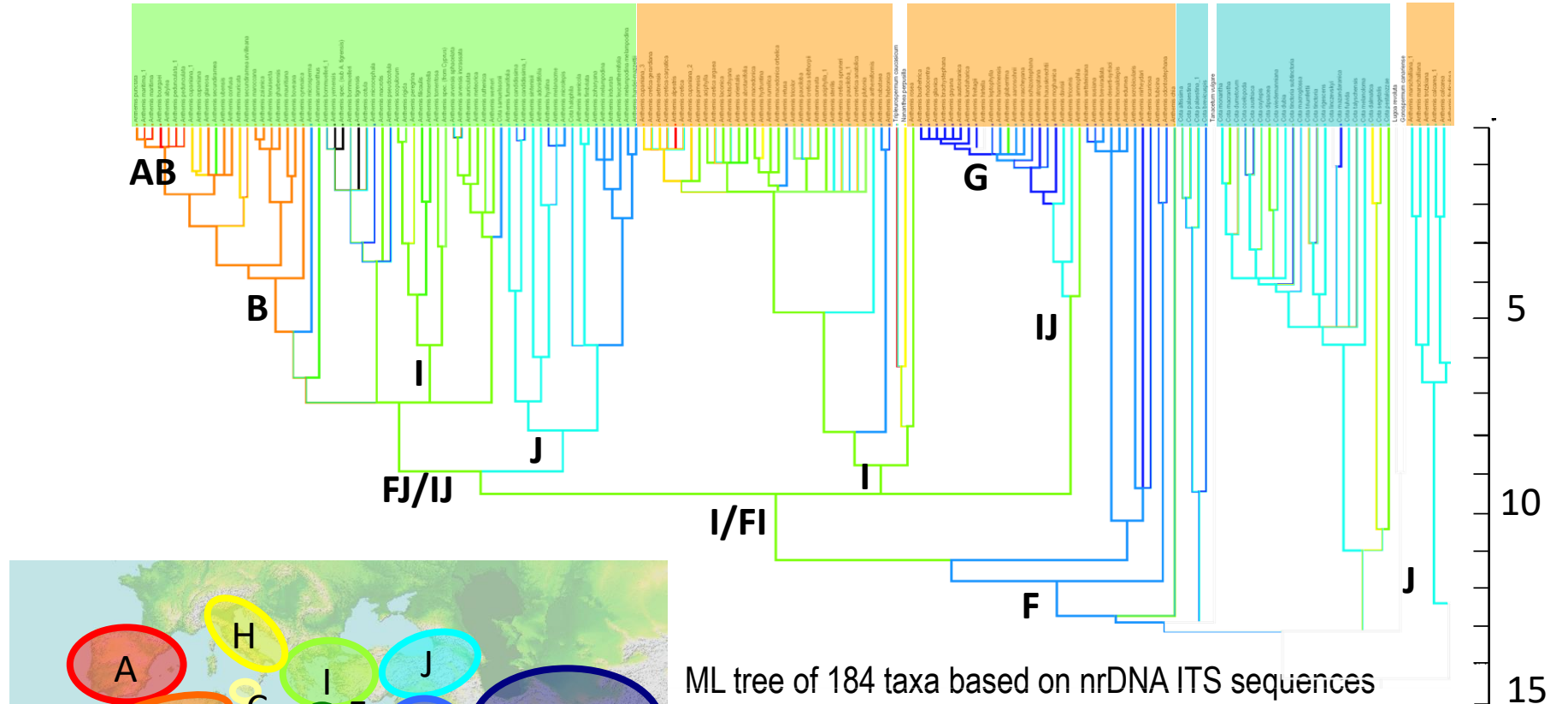


Tanacetum spec.

Anthemideae Cass.

subtribe Anthemidinae (Cass.) Dumort.

Taxonomy, evolutionary history, biogeography, and eco-climatological differentiation of *Anthemis* L. s.l.



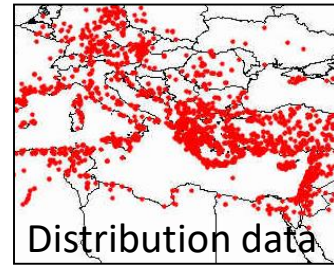
ML tree of 184 taxa based on nrDNA ITS sequences
Calibration with Penalized Likelihood (r8s)

Colonisation from the East to the West

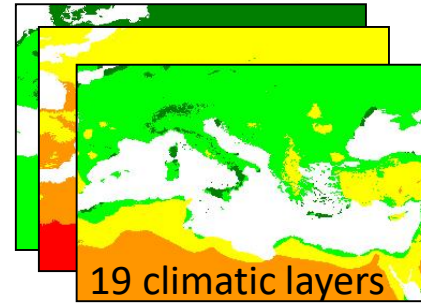
Anthemideae Cass.

subtribe Anthemidinae (Cass.) Dumort.

Taxonomy, evolutionary history, biogeography, and eco-climatological differentiation of *Anthemis* L. s.l.

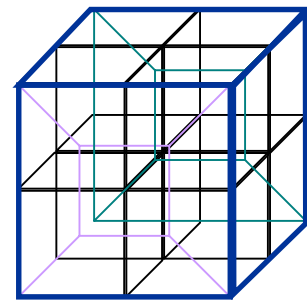


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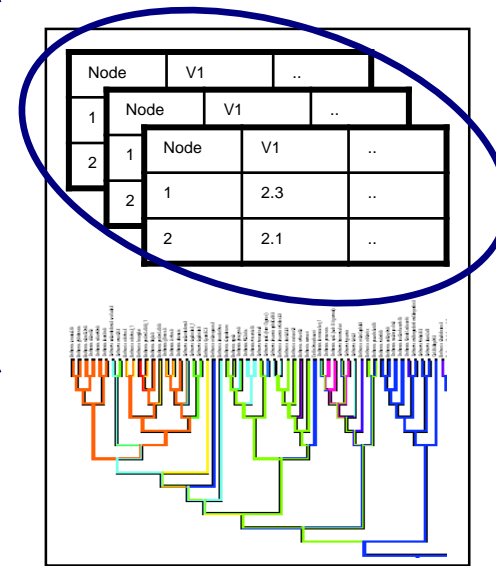


Sp.	V1	..
1	Sp.	V1
2	1	2.3
2	2	2.1

Climatic data for each terminal taxon (Max, Min, Mean)



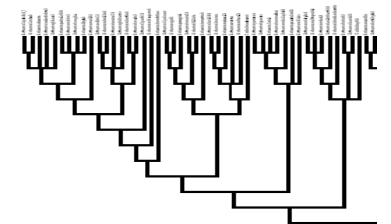
Hypercube representing the eco-climatological niche of each terminal taxon and ancestral node



Climatic data for ancestral nodes (Max, Min, Mean)

Optimization

+



Phylogeny

Anthemideae Cass.

subtribe Leucanthemopsidinae Oberpr. & Vogt

5 genera | 14 species | S Europe, N Africa

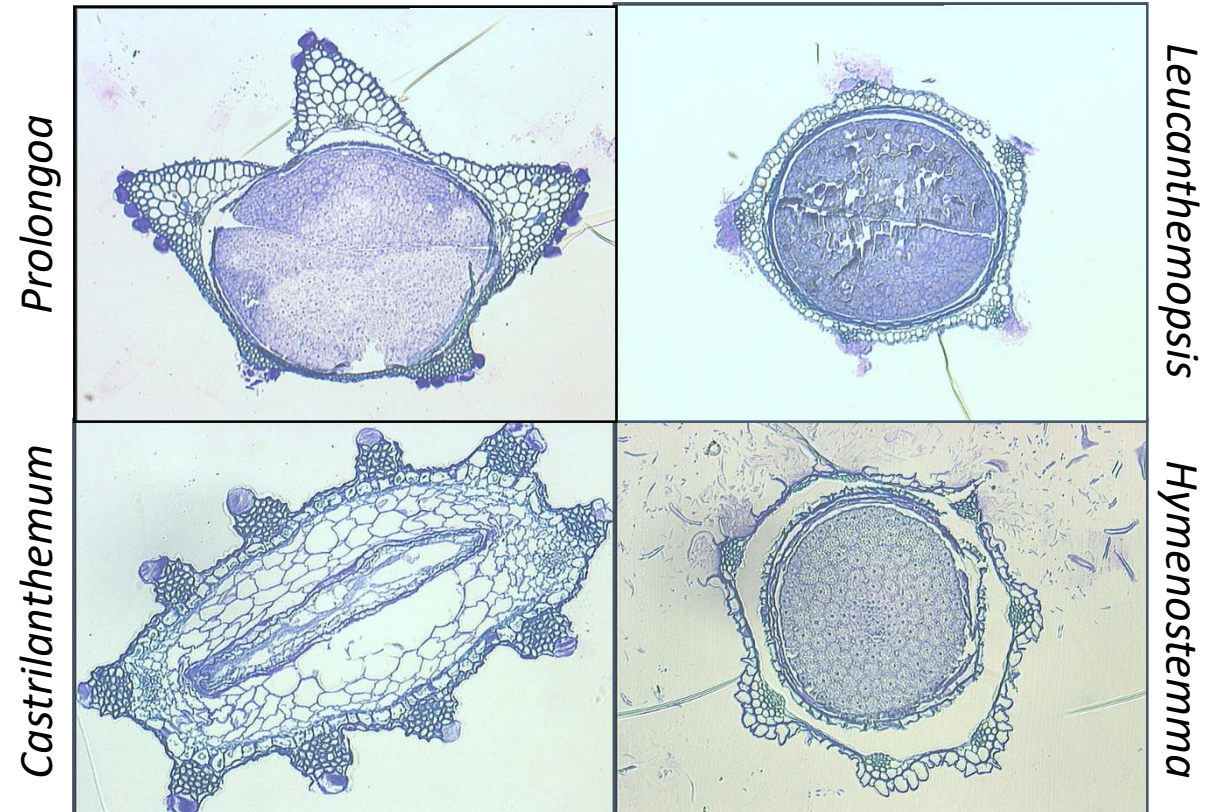
Castrilanthemum (1)
Hymenostemma (1)
Leucanthemopsis (9)
Phalacrocarpum (2)
Prolongoa (1)

- pales absent
- unpolarised endothelial tissue
- medifixed hairs
- $x = 9$



© Oberprieler

Leucanthemopsis longipectinata (Font Quer) Heyw.



Anthemideae Cass.

subtribe Leucanthemopsidinae Oberpr. & Vogt

Polyploidy in *Leucanthemopsis* (Girou) Heywood

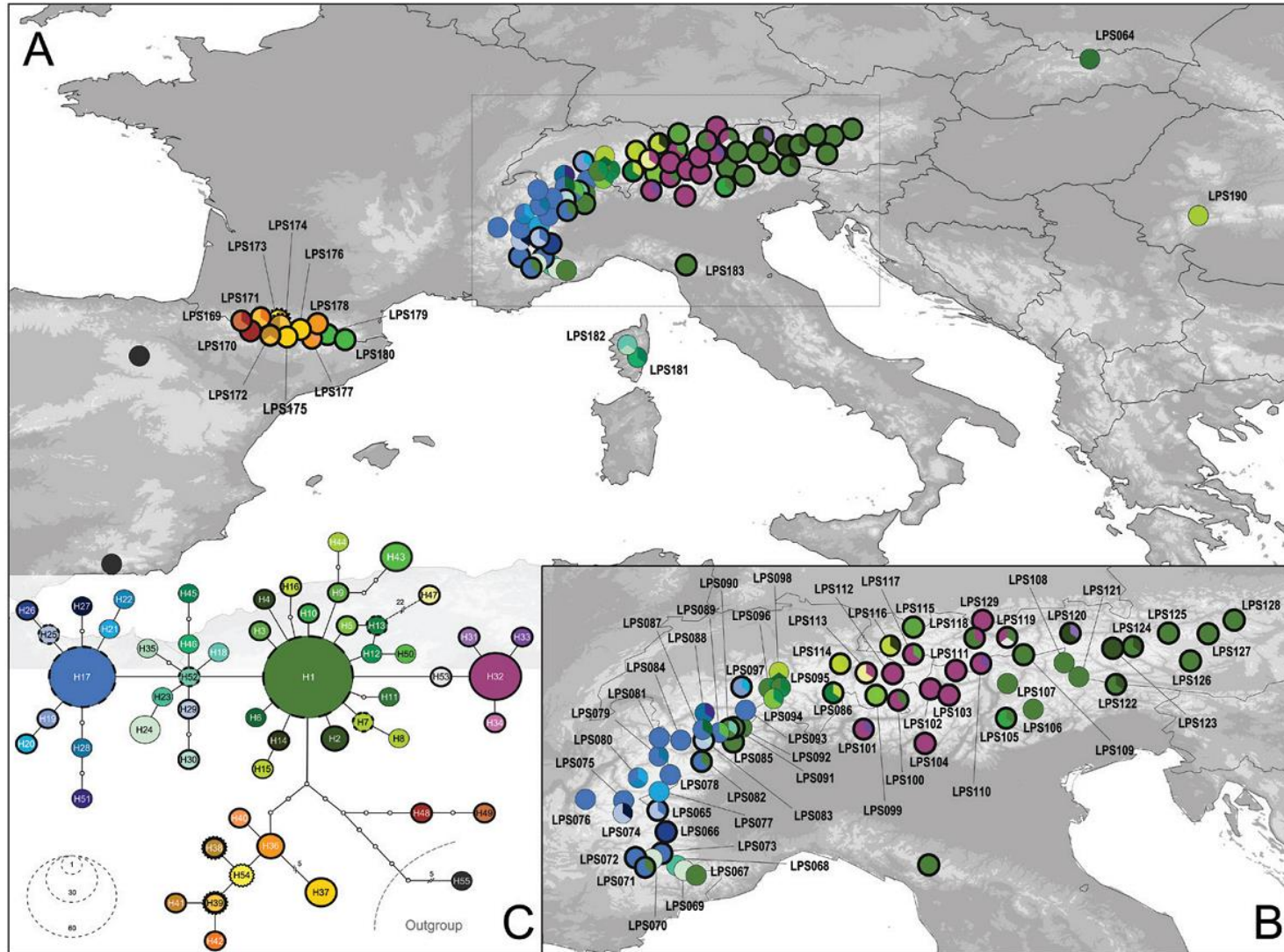
<i>L. alpina</i> (L.) Heywood (2x, 4x, 6x)	Pyrenees, Alps, Apennines, Carpathians
<i>L. pallida</i> (Mill.) Heywood (2x, 4x)	Iberian Peninsula
<i>L. flaveola</i> (Hoffmanns. & Link) Heywood (4x)	NW Iberian Peninsula
<i>L. pectinata</i> (L.) G. López & C. E. Jarvis (2x)	Sierra Nevada (Spain)
<i>L. pulverulenta</i> (Lag.) Heywood (2x)	Central Spain
<i>L. longipectinata</i> (Font Quer) Heywood (6x)	Rif Mountains (Morocco)



Anthemideae Cass.

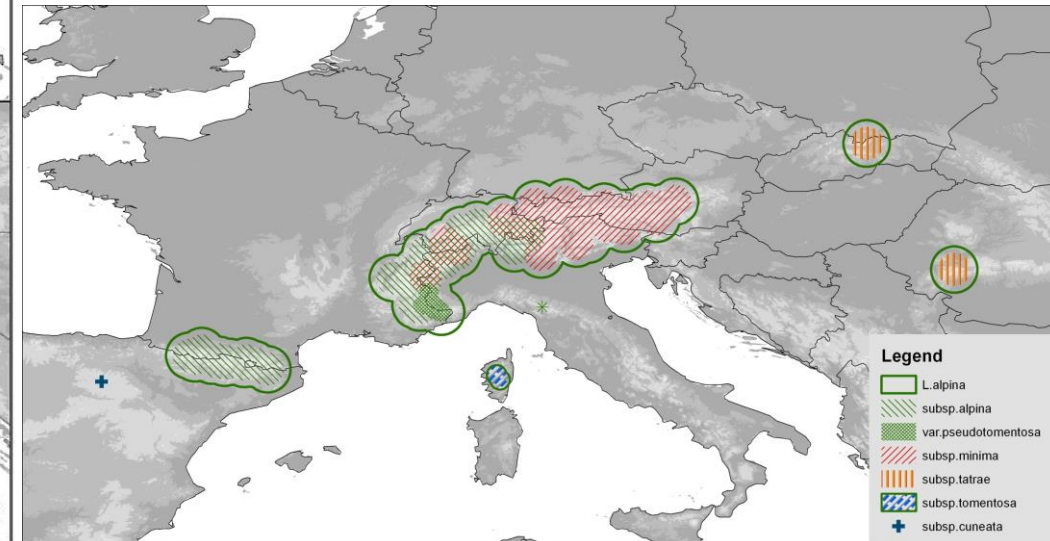
subtribe Leucanthemopsidinae Oberpr. & Vogt

Polyploidy in *Leucanthemopsis* (Girou) Heywood



Leucanthemopsis alpina (L.) Heywood

- subsp. *alpina* ($2n = 2x, 4x, 6x = 18, 36, 54$)
- subsp. *cuneata* (Pau) Heywood ($2n = 6x = 54$)
- subsp. *minima* (Vill.) Holub ($2n = 4x = 36$)
- subsp. *tatrae* (Vierh.) Holub ($2n = 2x = 18$)
- subsp. *tomentosa* ($2n = 2x = 18$)
- var. *pseudotomentosa* (Fiori) Marchi ($2n = 2x = 18$)



Anthemideae Cass.

subtribe Leucantheminae Bremer & Humphries

11 genera | 75 species | Europe, Siberia, N Africa

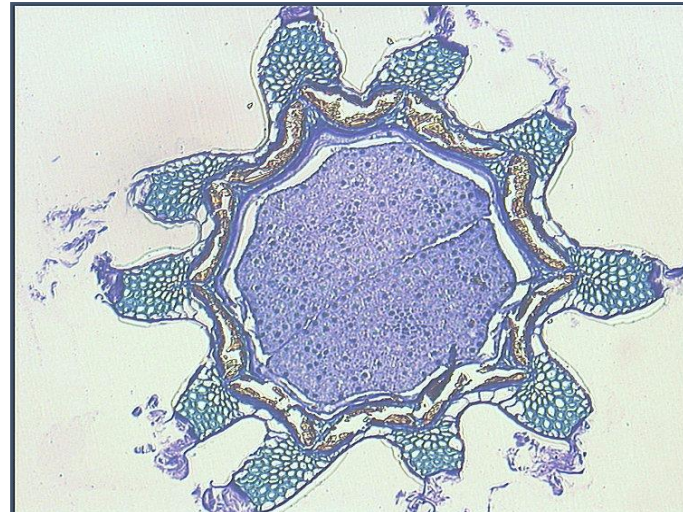
- pales absent
- unpolarised endothecial tissue
- basifixed hairs (→ medifixed)
- $x = 9$
- vallecular resin ducts

Chlamydophora (1)
Chrysanthoglossum (2)
Coleostephus (3)
Daveaua (1)
Glossopappus (1)
Heteromera (2)
Leucanthemum (45)
Mauranthemum (4)
Otospermum (1)
Plagius (3)
Rhodanthemum (15)

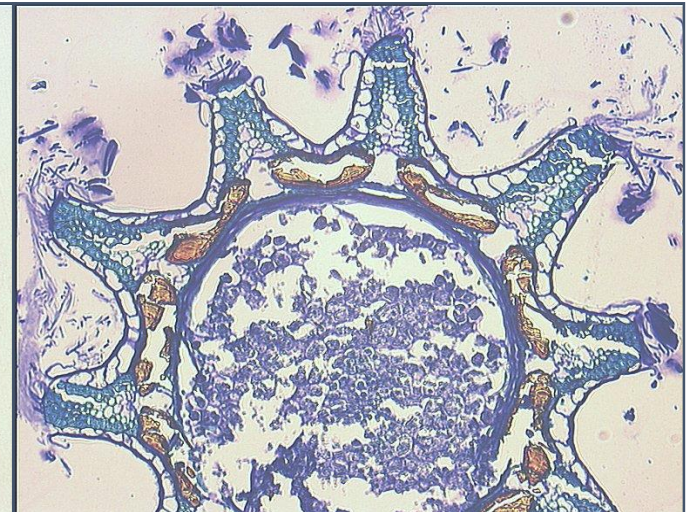


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Rhodanthemum catananche (Ball) Wilcox et al.



Rhodanthemum spec.



Leucanthemum spec.



THE TALE OF SNOW WHITE (*LEUCANTHEMUM*) AND ROSE RED (*RHODANTHEMUM*)



Anthemideae Cass.

subtribe Leucanthemeinae Bremer & Humphries

Polyploidy, reticulate evolution, and species delimitation in *Leucanthemum* and *Rhodanthemum*

LEUCANTHEMUM



20 diploid and 25 polyploid species

RHODANTHEMUM

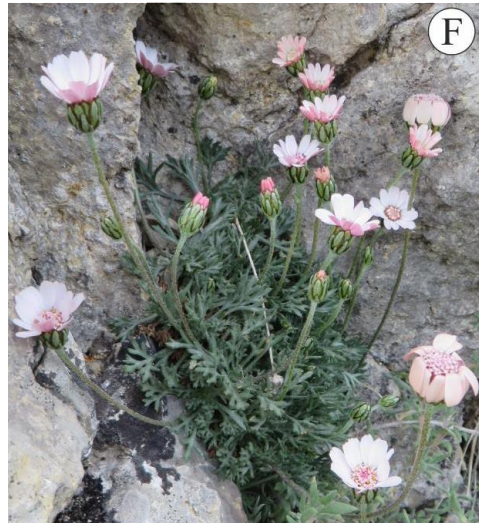
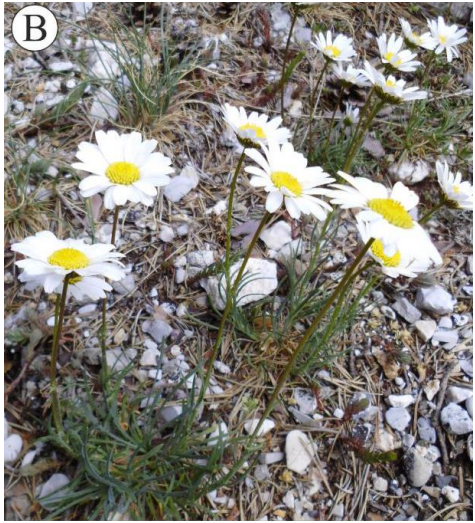
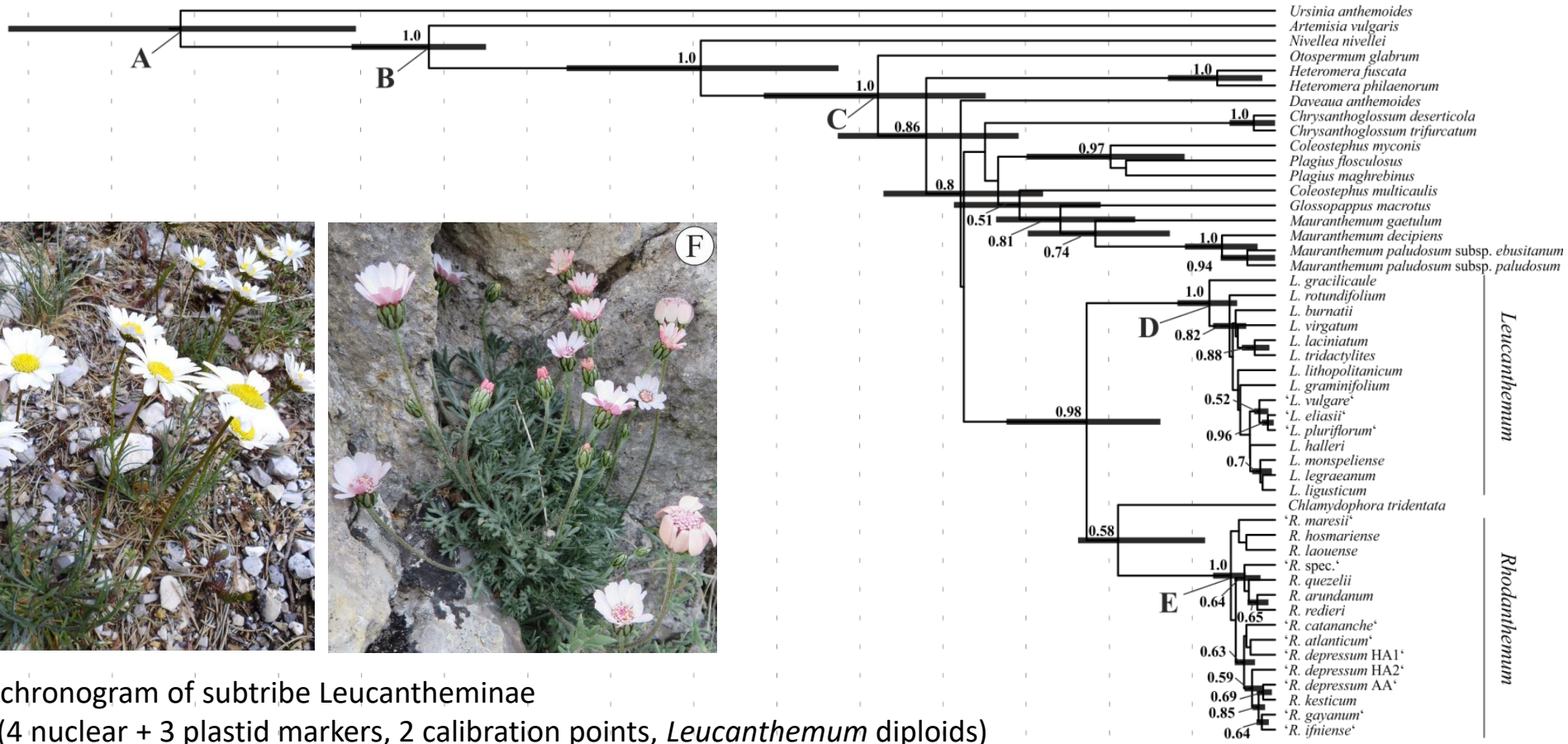


15 diploid species

Anthemideae Cass.

subtribe Leucantheminae Bremer & Humphries

Polyploidy, reticulate evolution, and species delimitation in *Leucanthemum* and *Rhodanthemum*

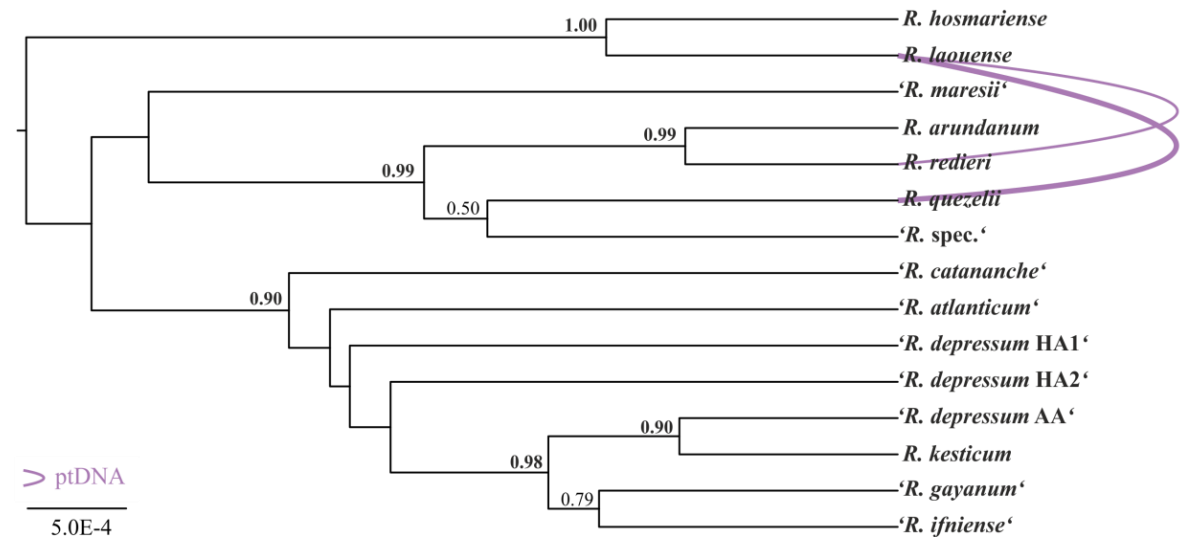
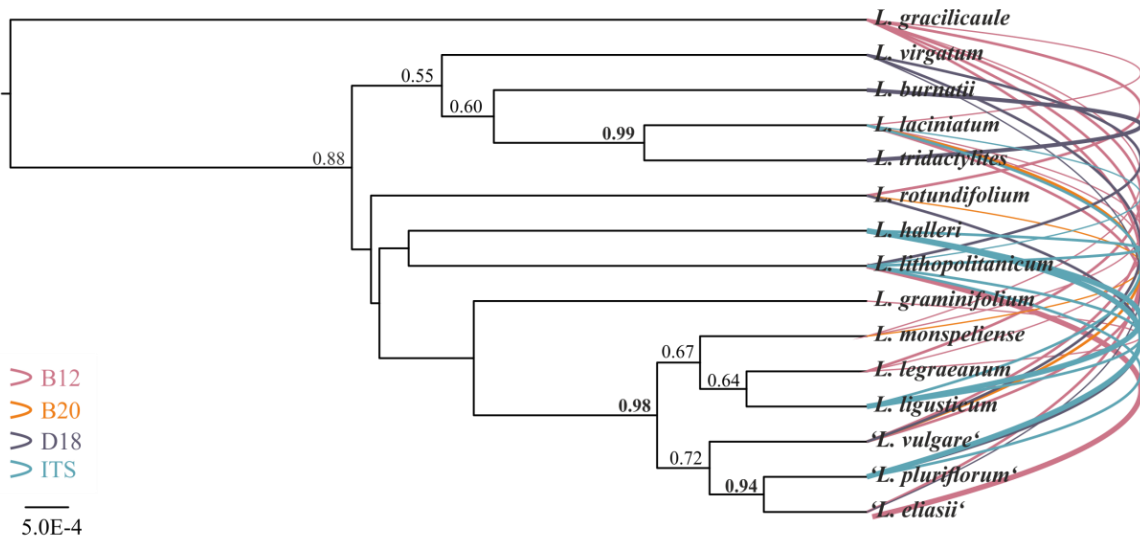
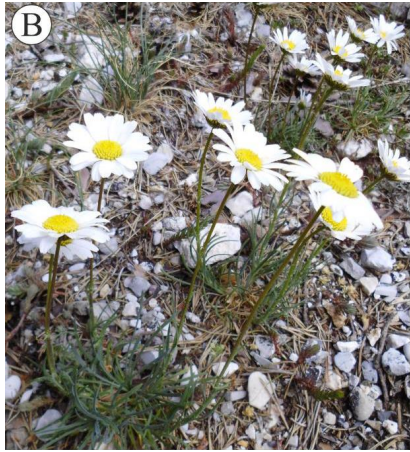


*BEAST chronogram of subtribe Leucantheminae (4 nuclear + 3 plastid markers, 2 calibration points, *Leucanthemum* diploids)

Anthemideae Cass.

subtribe Leucanthemeinae Bremer & Humphries

Polyploidy, reticulate evolution, and species delimitation in *Leucanthemum* and *Rhodanthemum*



*BEAST and JML analyses, 9 nuclear + 5 plastid markers

Anthemideae Cass.

subtribe Leucanthemeinae Bremer & Humphries

Polyploidy, reticulate evolution, and species delimitation in *Leucanthemum* and *Rhodanthemum*



L. coronopifolium (6x)

L. catalaunicum

L. montserratianum

22x
L. lacustre

12x
L. maximum

10x

L. pachyphyllum *L. glaucophyllum*



L. burnatii (2x)

L. favargeri

L. heterophyllum

L. platylepis

L. esterellense

L. illyricum

8x

L. atratum

L. aligulatum

L. maestracense

L. margaritae

L. sylvaticum

L. merinoi

L. adustum

L. pallens

6x

L. chloroticum

L. coronopifolium

L. corsicum

L. visianii

4x

L. ircutianum

L. pseudosylvaticum

L. delarbrei

L. meridionale

2x

L. laciniatum

L. vulgare

L. virgatum

L. tridactylites

L. gracilicaule

L. gaudinii

L. rotundifolium

L. pluriflorum

L. halleri

L. legraeum

L. pyrenaicum

L. cacuminis

L. burnatii

L. gallaecicum

L. graminifolium

L. lithopolitanicum

L. monspeliense

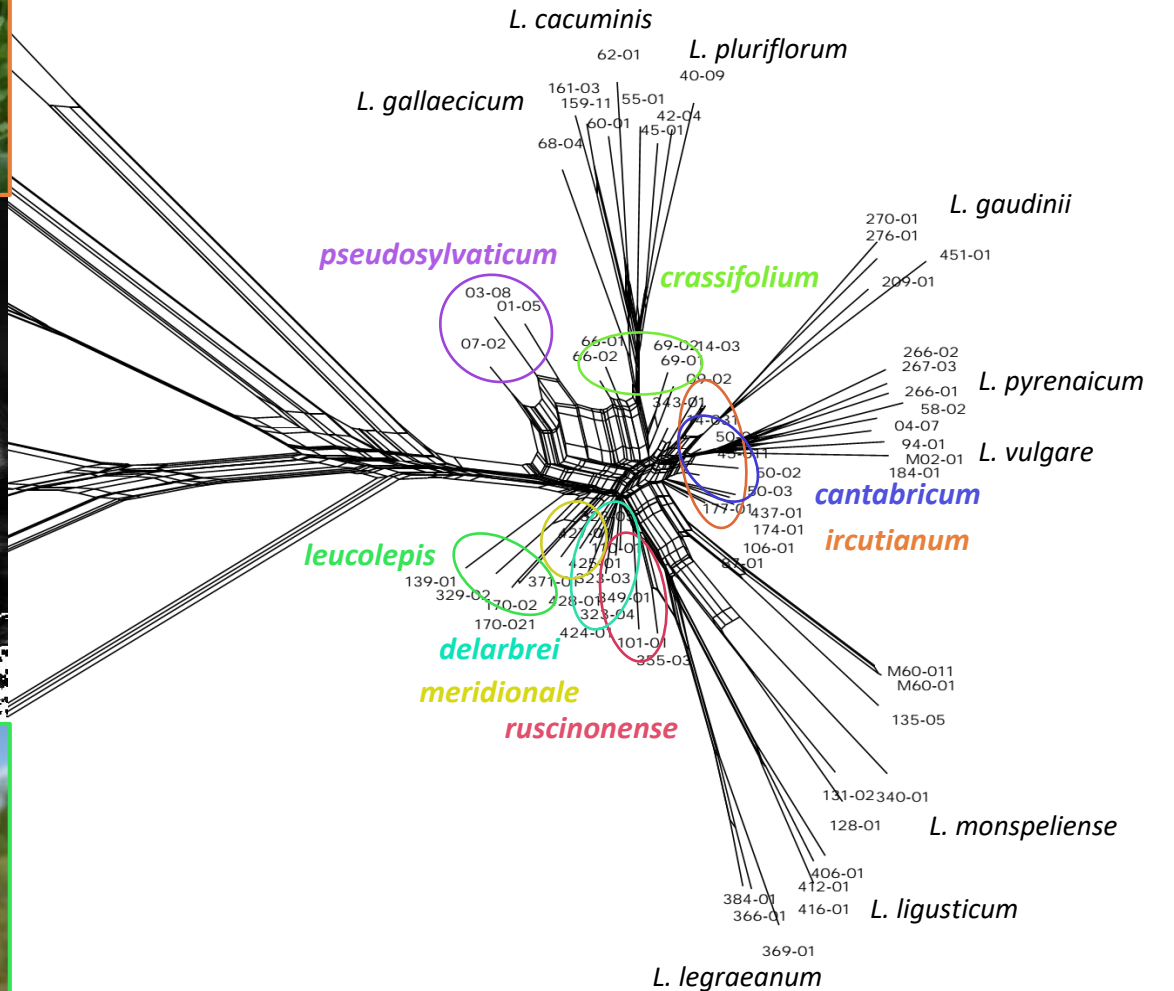
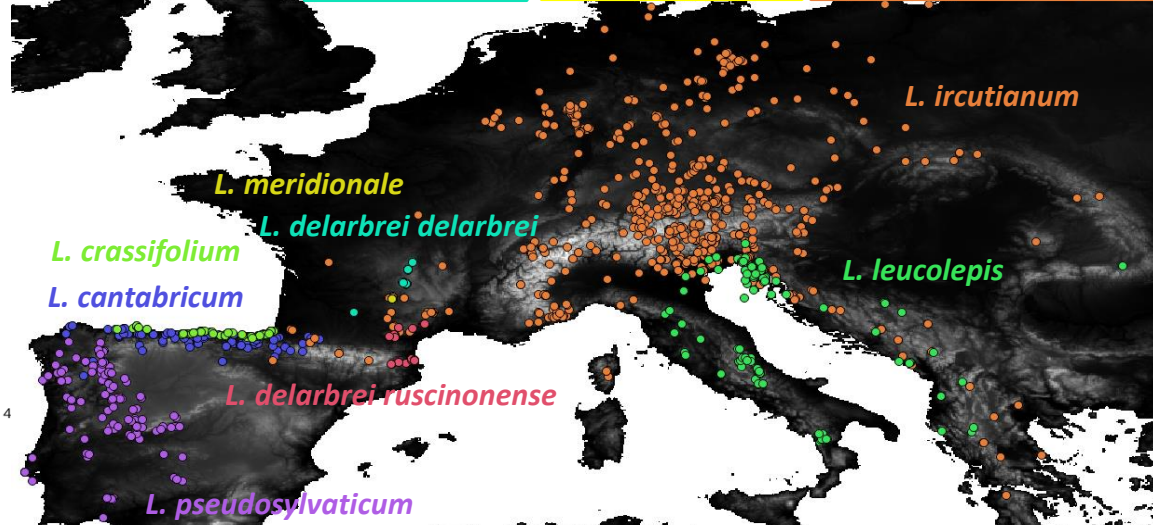
L. ligusticum

L. ageratifolium *L. eliasii*

Anthemideae Cass.

subtribe Leucanthemeinae Bremer & Humphries

Polyploidy, reticulate evolution, and species delimitation in *Leucanthemum* and *Rhodanthemum*



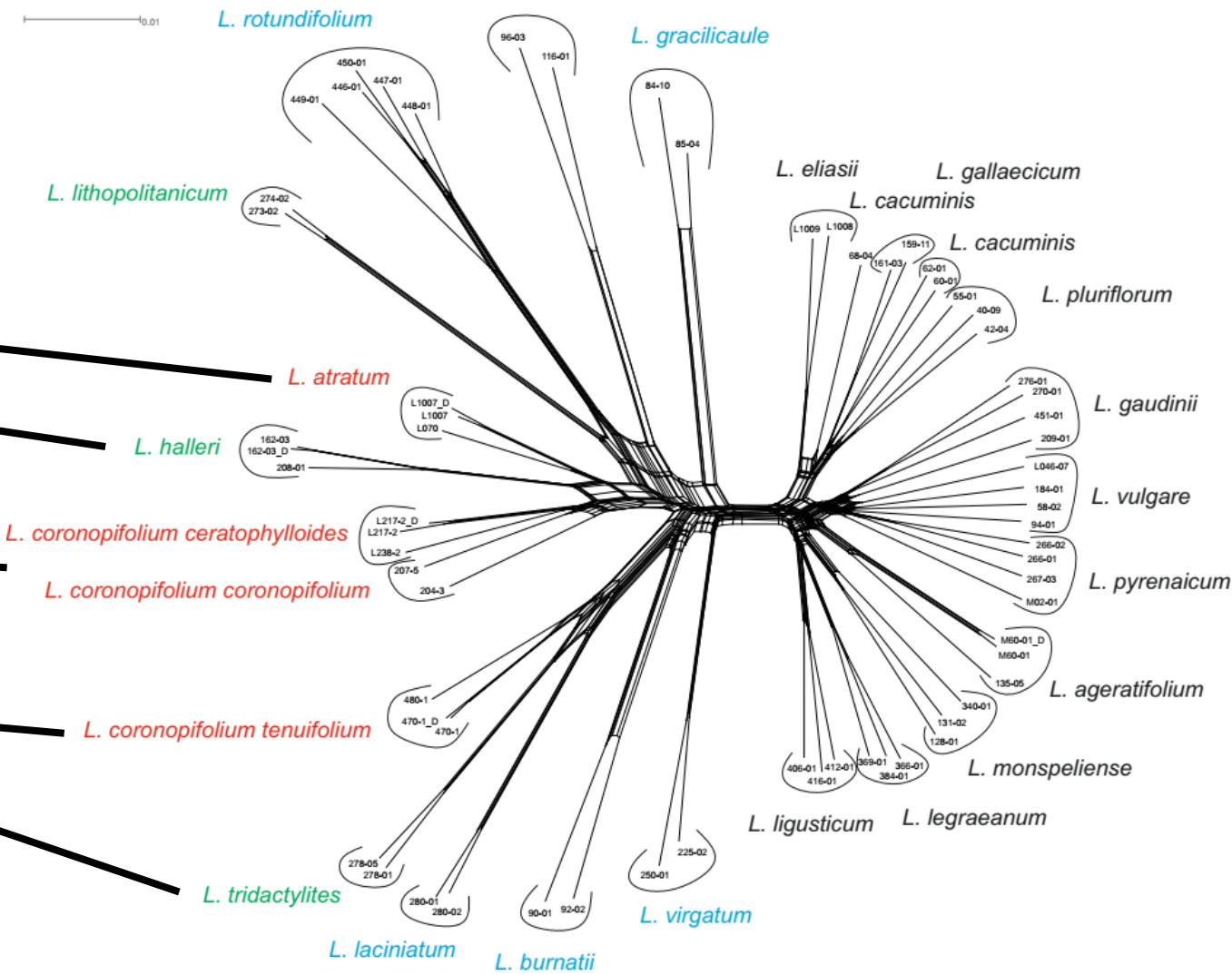
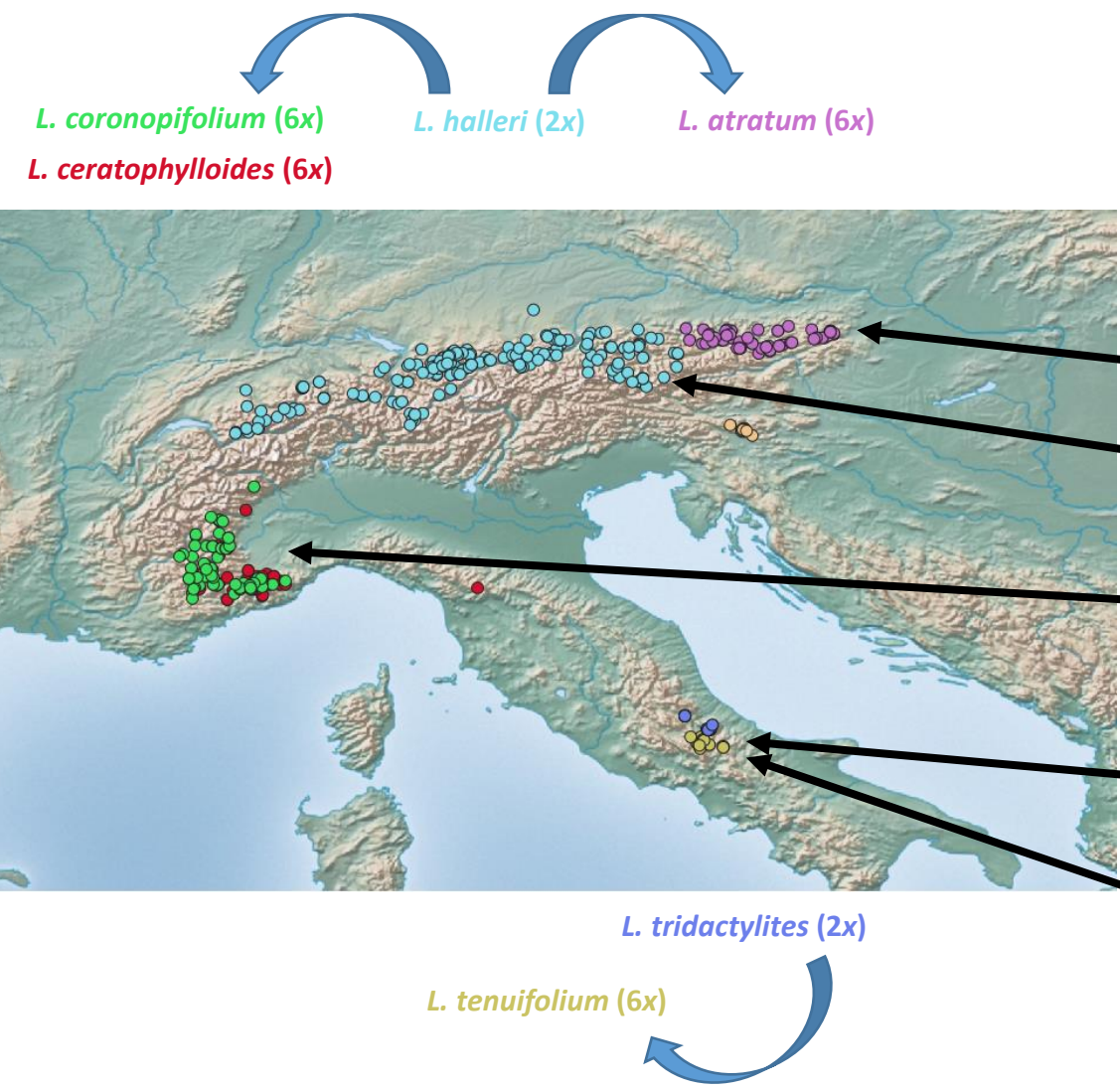
Species delimitation in *Leucanthemum* tetraploids

Ott et al. (in prep.)

Anthemideae Cass.

subtribe Leucanthemeinae Bremer & Humphries

L. graminifolium



NeighborNet (SPLITSTREE) based on GBS data (9,852 loci, 324,131 SNPs)

Anthemideae Cass.

subtribe Santolininae Willk.

5 genera | 23 species | S Europe, N Africa, SW Asia

Chamaemelum (2)

Cladanthus (5)

Mecomischus (2)

Rhedinolepis (1)

Santolina (13)

- pales present
- unpolarised endothecial tissue
- basifixed hairs (→ medifixed)
- $x = 9$
- pericarp thin
- saccate tubular florets

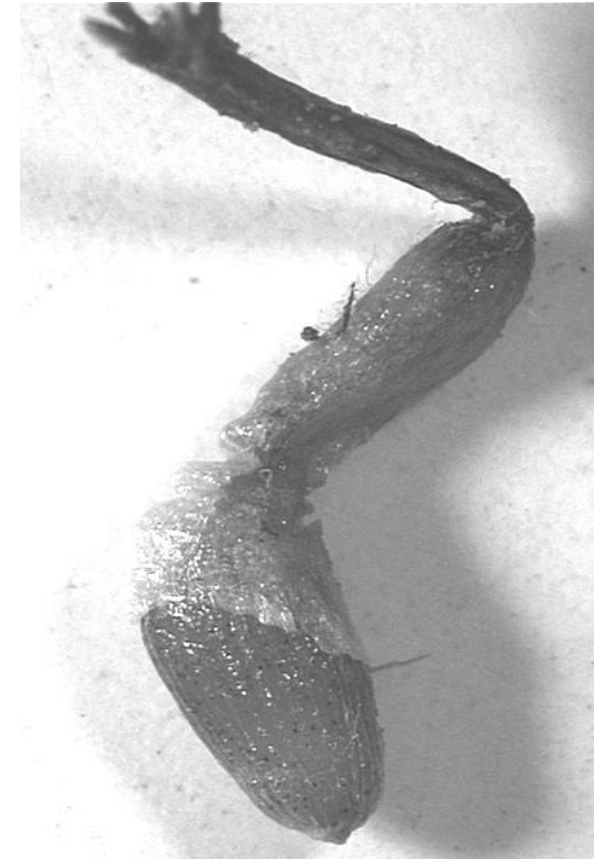


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Santolina chamaecyparissus L.



Chamaemelum spec.



Cladanthus spec.

Anthemideae Cass.

subtribe Glebionidinae Oberpr. & Vogt

4 genera | 29 species | S Europe, N Africa, Macaronesia

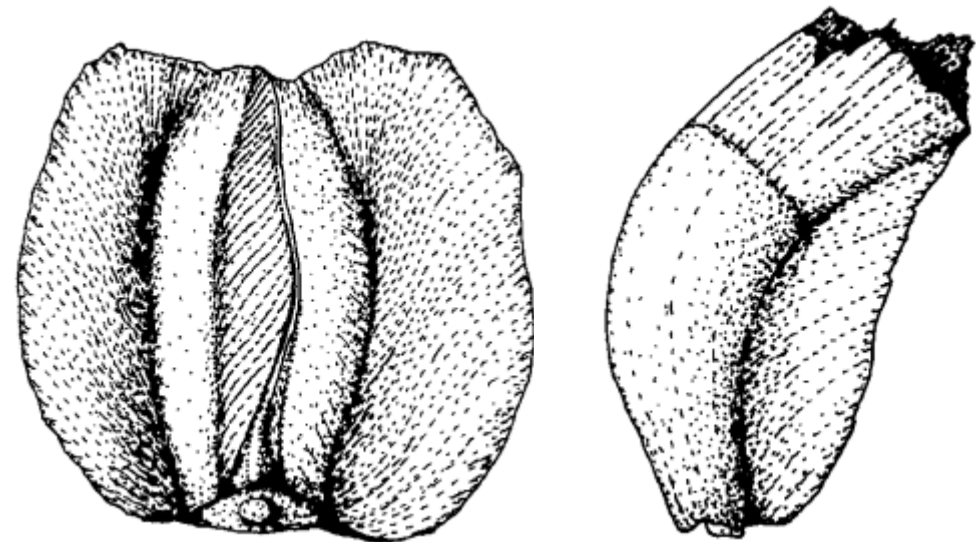
Argyranthemum (25)

Glebionis (2)

Heteranthemis (1)

Ismelia (1)

- pales absent
- unpolarised endothelial tissue
- basifixed hairs
- $x = 9$
- achenes laterally compressed



Argyranthemum foeniculaceum (Willd.) Webb ex Sch.Bip.

© Oberprieler et al. (2007)



© Schönfelder

Ismelia carinata (Schousb.) Sch.Bip.

DFG SPP 1991



TAXON-OMICS

New approaches to discovering and naming biodiversity

Stefan Ried

Agnes Scheunert

Tankred Ott

Anja Heuschneider

Florian Wagner

Ulrich Lautenschlager

Sarah-Maria Eder

Alisha Töpfer

Marco Dorfner



Greetings from my working group!

Thank you for your kind attention.

