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Arctium getting entangled to *Cousinia (Asteraceae: Cardueae)*

Abstract

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As a workbench study related to a revision of the genus *Arctium* (meanwhile published), a cladistic analysis of the genera *Arctium* and *Cousinia* p.p. is presented. The data matrix includes 30 (micro-)morphological characters for 26 species. *Cousinia* is shown to be paraphyletic, with the paraphyletic *C.* subg. *Cynaroides* closely related to *Arctium* s.str., which is itself monophyletic.

Introduction

A revision of *Arctium* L. (Duistermaat 1996) included at an early stage the tracking of possible outgroups (i.e. supposed sister groups) for a cladistic analysis. In this context *Cousinia amplissima* was analysed. This species, originally described in *Lappa* Scop. (a synonym of *Arctium*), fits the description of *Arctium* very well, e.g. on account of its phyllaries with a hooked apex and its unarmed leaves. There are some differences as well, e.g. in life form and in quantitative characters such as corolla size. Hooked phyllaries are present in 6 "arctioid" species of *Cousinia* Cass., out of over 600 species in that genus. Why, then, are the "arctioid" species incorporated in *Cousinia* and not in *Arctium?*

Cousinia is an extremely polymorphic genus, in which almost all morphological trends present in the *Cardueae* are realized (Rechinger 1972: 3). It has been subdivided into three subgenera and 50 sections (Černeva 1988: 19-24). The 6 "arctioid" species are placed in three sections of *C.* subg. *Cynaroides,* whose remaining four sections comprise another 14 species. *C.* subg. *Cousinia* is largest, with 14 sections and over 500 species, whereas *C.* subg. *Hypacanthoides* comprises only 10 species in 4 sections. In general, the sections themselves seem rather homogeneous.

The genus *Cousinia* is characterized by the combination of free pappus setae (not connate or fused into a basal ring) with fimbriate basal anther appendages (Hoffmann 1890: 317; Rechinger 1979: 87). Both character states are present in the "arctioid" *Cousinia* species. *Arctium* is also characterized by a free pappus, but the basal appendages of the anthers are described as entire. However, during my revision of *Arctium* I found that fimbriate appendages do occur in *Arctium*. This calls for a re-assessment of generic delimitation. A cladistic analysis was performed, and its results are presented and discussed here.

Material and methods

I studied 5 species of *Arctium* (or species groups in the case of *A. lappa* s.l. and *A. tomentosum* s.l.) and a selection of 20 *Cousinia* species, viz. all 6 "arctioid" species, one species from each of the other 4 sections of *C.* subg. *Cynaroides,* one randomly chosen species of *C.* subg. *Hypacanthoides*, and 9 randomly chosen species from nine different sections of *C.* subg. *Cousinia,* as follows:

Arctium: A. atlanticum (Pomel) H. Lindb., *A. lappa* L. (s.l.), *A. minus* Bernh., *A. nemorosum* Lej., *A. tomentosum* Mill.

Cousinia subg. *Cynaroides: C. amplissima* (Boiss.) Boiss., *C. anomala* Franch., *C. arctioides* Schrenk, *C. korolkovii* Regel & Schmalh., *C. lappacea* Schrenk, *C. pentacantha* Regel & Schmalh., *C. pseudarctium* Bornm., *C. tomentella* C. Winkl., *C. triflora* Schrenk, *C. umbrosa* Bunge

Cousinia subg. *Hypacanthoides: C. macilenta* C. Winkl.

Cousinia subg. *Cousinia: C. congesta* Bunge, *C. eryngioides* Boiss., *C. freynii* Bornm., *C. microcarpa* Boiss., *C. oligocephala* Boiss., *C. parviceps* Rech. f. & Köie, *C. pseudostenolepis* Rech. f. & Edelb., *C. scariosa* Regel, *C. tenella* Fisch. & C. A. Mey.

In total 30 characters were used, describing life form, leaves, phyllaries, setae, cypsela, pappus, corolla, anthers, style, and pollen (studied by SEM and LM). The characters and their states were as follows:

1. plant unarmed (0), or spiny (1);
2. synflorescence racemose (0), corymbose (1), or with single capitule (2);
3. capitule pedunculate (0), or sessile (1);
4. middle involucral bract without (0), or with (1) appendage;
5. apex of middle involucral bract not spiny (0), with one spine (1), or several spines (2);
6. apex of middle involucral bract without (0), or with (1) hook;
7. receptacular scales absent (0), or present (1);
8. receptacular scales needle-like (1), narrowly spatulate (2), or present as ridges (3);
9. achene smooth (0), with ridges (1), or winged (2);
10. achene with flat (0), or truncate apical plate (1);
11. pappus hairs inserted on a ring-shaped tissue (0), connate at base (1), or free (2);
12. length of corolla limb ≤ 0.8 (0), ≤ 1.15 (1), ≤ 1.5 (2), ≤ 2.1 (3), ≤ 3.0 (4), or > 3.0 times length of tube (5);
13. length of longest corolla lobe < 0.3 (0), < 0.5 (1), or ≥ 0.5 times total length of limb (2);
14. corolla glabrous (0), with multicellular hairs on limb (1) or on entire corolla (2);
15. filament glabrous (0), verrucate (1), or hairy (2);
16. basal appendage of anthers entire (0) or fimbriate (1);
17. length of basal appendage of anthers ≤ 0.5 (0), ≤ 1.0 (1), ≤ 1.5 (2), or > 1.5 mm (3);
18. length of apical appendage of anthers < 1.0 (0), < 2.0 (1), < 3.0 (2), or < 4.0 mm (3);
19. ring of sweeping hairs absent (0) or present (1) (just) below stylar branches;

20. stylar branches dorsally without (0) or with (1) many scattered sweeping hairs;
21. length of stylar branches ≤ 0.8 (0), ≤ 1.4 (1), ≤ 2.0 (2), or ≤ 5.0 mm (3);
22. colour of corolla pale pink to purple (0), or white to yellow (1);
23. colour of anther pale pink to purple (0), or white to yellow (1);
24. pollen with costae near mesoaperture only (0), or with costae equatoriales (1);
25. diameter of perforations in tectum 0.03-0.06 (0), 0.09-0.11 (1), or 0.16-0.22 µm (2);
26. shape of pollen: p/e ≤ 1.40 (0), or > 1.40 (1);
27. leaves entire to shallowly lobed (0), pinnatifid (1), or pinnatipartite (2);
28. cauline leaves petiolate (0), sessile (1), or decurrent (2);
29. pollen not (0) or echinate (1);
30. plant annual (0), biennial (1), perennial (2).

The study is based on herbarium material from BM, L, LE, W, and WU. Voucher specimens for character analyses are cited in Duistermaat (1996: 19-20; the voucher for *Cousinia tomentella,* now considered a synonym, is cited under *Arctium umbrosum*).

For cladistic analysis the parsimony-based computer algorithm HENNIG86 (Farris 1988) was used. The options *mhennig, bb, xsteps w,* and *nelsen* (strict consensus tree) were applied. The data were submitted all unordered. *Onopordum acanthium* L. was chosen as outgroup, primarily because its cypselas have the same apical plate type as *Arctium* and *Cousinia* (Dittrich 1977: 1011). The pappus of *Onopordum* L. (setae connate at the base) is unique within the *Cardueae* but is otherwise more similar to the pappus of *Arctium* and *Cousinia* (free setae) than of other *Cardueae* (setae fused into a basal ring).

Results

The cladistic analysis, after two times of iterative weighting, resulted in 40 equally parsimonious trees, all with a length of 230 steps, consistency index *(ci)* = 60 and retention index *(ri)* = 84. The strict consensus tree is shown as Fig. 1. Judging from this tree, *Cousinia* is not a monophyletic genus. Even *C.* subg. *Cousinia* does not seem to be monophyletic. The basic dichotomy in the cladogram is between most of the species of *C.* subg. *Cousinia* (species No. 17-22, 24, 25) on one side and *Cousinia* species No. 6-16 plus *Arctium* on the other side. Both clades are supported by a number of apomorphies (e.g. features of pollen and style) and parallel developments. Most interesting in this respect is the aberrant stylar type of the above-mentioned species of *C.* subg. *Cousinia.* Whereas the style of typical *Cardueae* has a thickening covered with straight hairs below the articulation of the stylar branches (Dittrich 1977: 1002), no such thickening is present in *C.* subg. *Cousinia,* where the stylar branches are covered with long, slender hairs almost for their whole length. To my knowledge this feature has not so far been mentioned for this tribe; it is known in, e.g., the *Vernonieae* (Hoffmann 1890: 106; Bremer 1987: 218).

Arctium plus *Cousinia* subg. *Cynaroides* (including the "non-arctioid" species No. 12-15) form a clade against *C. macilenta (C.* subg. *Hypacanthoides).* It is supported by two apomorphies (phyllaries, showing a reversal in the clade) and four parallel developments (leaves, position of hairs on the corolla, and cypsela). The base of this clade is a trichotomy. One subclade is formed by all species of *Arctium.* It is supported by four parallel developments including life form, presence of verrucae on the anther filaments, and relative length of parts of the corolla. The next subclade is formed by one of the species of *C.* subg. *Cynaroides, C. arctioides.* The third subclade contains all other species of *C.* subg. *Cynaroides*, which would thus be a paraphyletic taxon.

Conclusion and discussion

With the main monograph of *Arctium* (Duistermaat 1996) published since this paper was written, it remains as a kind of workbench report, documenting an important inter

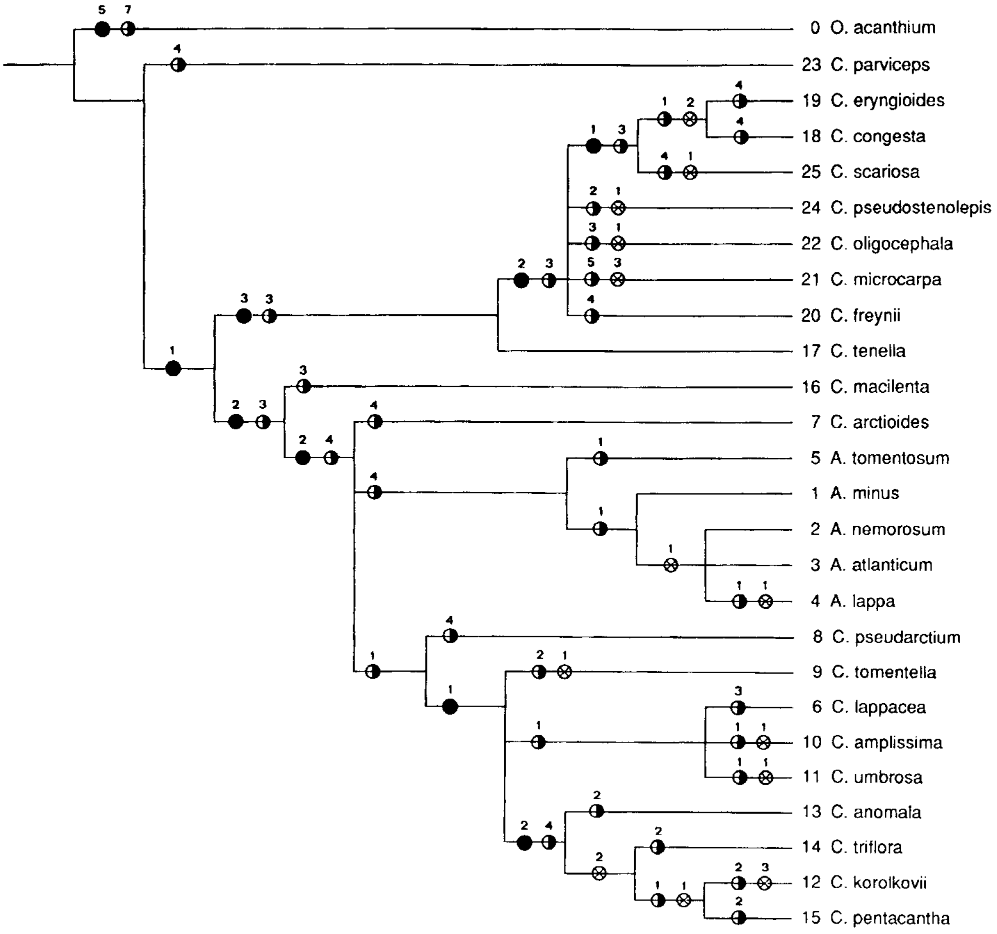

Fig. 1. The strict consensus tree of 40 equally parsimonious trees with a length of 230, *ci* = 60, and *ri* = 84. The numbers above the black dots indicate the number of real apomorphies; above the half open dots, the number of parallel developments; above the open crossed dots, the number of reversals.

mediate landmark. It demonstrates that *Arctium* is monophyletic but is nested within the genus *Cousinia*, which is therefore paraphyletic. If phylogeny is to be the basic criterion for generic delimitation, as I think it should, then *Cousinia* in its traditional circumscription cannot be maintained.

It would have been possible to maintain *Arctium* as presently delimited. The life form, biennial versus perennial, which is difficult to observe, would then have been the most important key character separating *Arctium* from the "arctioid" species of *Cousinia*. It would also have been possible to incorporate *C.* subg. *Cynaroides* as a whole into *Arctium*. Such a genus would have a polythetic set of characters: *Arctium* and the "arctioid" species having a hooked phyllary apex and a purple corolla; the other species, non-hooked phyllaries and a yellow corolla. The character state "hooked apex of the phyllaries" defines an easily recognizable genus, the one that I have meanwhile accepted under the denomination of *Arctium* (sensu lato).

The present cladogram (Fig. 1), which does not yet bear out my later *Arctium* s.l. as a monophyletic entity, could not provide a suitably firm basis to decide in which genus the species of *Cousinia* subg. *Cynaroides* are best placed. One reason is that, in view of the stylar type, the position of *C.* subg. *Cousinia* within the *Cardueae* is doubtful. Its species cannot therefore be considered as close relatives of *Arctium*. The main conclusion to be drawn from this cladogram is that *Cousinia* as presently circumscribed, even with the "arctioid" species removed (Duistermaat 1996), remains paraphyletic. The taxonomic fate of *C.* subg. *Hypacanthoides* and of what remains of *C.* subg. *Cynaroides* is still in limbo, pending further analysis bearing on a more representative sample of species of these groups.

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