

New taxa of *Gundelia* (Compositae) from Armenia

E. Vitek*, G. Fayvush**, K. Tamanyan** & B. Gemeinholzer***

Abstract

Two new taxa, *Gundelia aragatsi* and *G. aragatsi* ssp. *steineri* are described. *Gundelia* was mainly treated as monospecific genus - this status cannot be maintained. The differences of the new taxa, the status of a probable further new species, *Gundelia* sp. (Garni), and the important characters for future research are discussed.

Key Words: Flora of Armenia; Compositae, *Gundelia*, *G. tournefortii*, *G. rosea*, *G. aragatsi*, *G. aragatsi* ssp. *steineri*; new species, systematics, taxonomy.

Kurzfassung

Zwei neue Taxa, *Gundelia aragatsi* und *G. aragatsi* ssp. *steineri* werden in der bisher meist als monospezifisch betrachteten Gattung *Gundelia* beschrieben. Die Unterschiede, der Status einer möglichen weiteren unterscheidbaren Art, *Gundelia* sp. (Garni), sowie die für die weitere Erforschung wichtigen Merkmale werden diskutiert.

Introduction

Gundelia tournefortii was known in Armenia from a restricted area around Garni (AVETISIAN 1995). In 2006 a non professional botanist, Alfred Steiner, member of a hiking tour group led by the authors, found a new population of *Gundelia* near Echegnadzor, c. 85 km SE of the earlier known area. Later in the same year the first author found another population of *Gundelia* on Mt. Aragats, c. 85 km WNW of the earlier known area. These populations are so different in their habit to the known one, that they could not be subsummarized under *G. tournefortii*, the only accepted name in the relevant floras for this area (VASIL'CHENKO I.T. 1961, KUPICHA 1984, RECHINGER 1989, AVETISIAN 1995, SOFIEVA 1961).

Material and methods

Material has been collected on the same localities in 2006, 2007, 2008 and 2009 at different times of the year. Specimens are deposited in W¹ and ERE, duplicates also in

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¹ Abbreviations for herbaria follow Index herbariorum: <http://sweetgum.nybg.org/ih/>

other herbaria. The material was morphologically evaluated. Furthermore, leaf material for DNA analysis has been transferred to Silicagel in the field and handed over to B. Gemeinholzer (Berlin). Total genomic DNA was isolated from 5 Armenian samples as well as from 10 dried herbarium specimens covering big part of the distribution range of the genus (details for specimens in Appendix 1). 24 mg per sample of mostly leaf material was taken. The samples were crushed and DNA was then extracted using Quiagen DNeasy Mini Kit and following standard procedure.

The ITS region was amplified in two overlapping parts using the primers ITS-A and ITS-C (BLATTNER 1999) for ITS 1, ITS2-D, ITS-B (BLATTNER 1999) for ITS 2 or ITS-A and ITS-B for the complete region. The following protocol during the Polymerase Chain Reaction (PCR) was used: initial denaturation 2 min at 94°C, denaturation 20 sec at 94°C, annealing 45 sec at 52°C, elongation 1 min at 72°C (40 cycles) and final extension 10 min at 72°C. PCR was carried out with a reaction volume of 11.5 µl core mix plus 1 µl DNA (1:10, 1:50 or 1:100 dilution depending on usability). The reaction volume contained 8.05 µl ddH₂O, 1.25 µl 10x buffer (Biotherm) and dNTP's (Fermentas), 0.25 µl BSA (BioLabs), 0.25 µl of each primer (10pmol/µl) and 0.04 µl 1u Taq-Polymerase (Biotherm). The PCR products were purified with Milipore DNA purification Kit (Roth) and then cycle sequencing was carried out using CEQ DCTS Quick Start Kit (Beckmann-Coulter) following the standard procedure. As sequencer a CEQ8000 (Beckmann-Coulter) was used. The sequences were edited in ChromasLite2000 (Technelysium Pty. Ltd., Helensvale, Australia) and aligned by hand using BioEdit (HALL 1999). As not for all sequences the 5.8S rDNA was amplified and there are no expected mutations anyway, this region was excluded for calculation. The alignments is available from B. Gemeinholzer upon request. The trees were reconstructed using MrBayes 3.1.2 (RONQUIST & HUELSENBECK 2003) and PAUP 4.0b10 (SWOFFORD 2002). A Bayesian Analysis was performed using gamma distribution rate variation among sites and 3 million generations of the MCMC chains in two independent runs, trees saved every 100 generations. The first 30 000 trees were discarded as burn-in for the analysis then reached stationarity. All other trees sampled were used to calculate a strict consensus tree.

The datasets were also analysed by using Maximum Parsimony. All heuristic searches were conducted in Paup 4.0b10 with equal weights, 1000 closest sequence additions and tree bisection-reconnection (TBR) branch swapping, permitting 10 trees to be held at each step. An evaluation of the trees was performed by using bootstrap analysis with 1000 replicates, equal weights, TBR swapping, MulTrees option in effect and 10 trees held at each step. The strict consensus tree of Bayesian inference was compared to the bootstrap 50% majority rule consensus tree. Trees were drawn using TreeView (PAGE 1996).

Results of DNA-analyses

The ITS region was amplified for a total of 15 individuals from throughout the genus distribution range. For calculations an already published sequence of *Gundelia tournefortii* (AY504691) with unknown providence was added as well as *Catananche caerulea* (AJ633465, AJ633466, AJ633467), *C. caespitosa* (AJ633468), *C. arenaria* (DB472), *Scorzonera purpurea* ssp. *purpurea* (AJ633477), *S. crispatula* (AJ633486), *S. villosa*

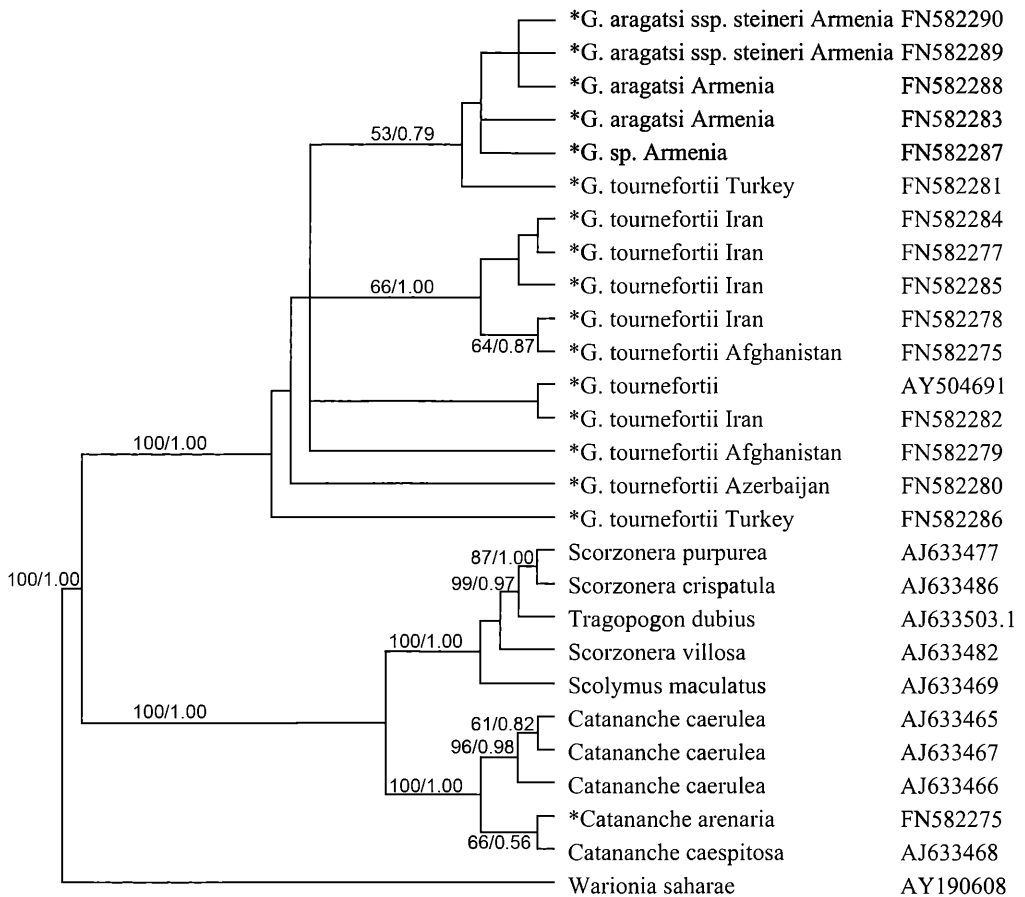


Fig. 1: Majority rule consensus tree of the MP analysis with bootstrap values > 50 presented first and posterior probabilities > 0.50 second. * are new results (vouchers see appendix 1).

(AJ633482), *Tragopogon dubius* (AJ633503), using *Warionia saharae* (AY190608) as outgroup. All calculations confirmed *Gundelia* to be monophyletic with strong statistical support (100% bootstrap support/1.00 likelihood support).

Within *Gundelia* the analysis of the ITS region revealed little differentiation. The Armenian specimen form a separate cluster together with one yellow flowered accession from Turkey branching off basally. However the whole clade is only supported by very low bootstrap and likelihood support (53%/0.79). The Armenian taxa of *Gundelia* feature close relationships.

The low genetic differentiation within the analyzed genetic marker reflects the limited variability of the ITS region within the genus due to recent differentiation or possibly pinpoints to a much more complex evolutionary picture of hybridization and adaptation. For further analyses additional material, especially doubtless *G. rosea* and material from the type area of *G. tournefortii* needs to be screened with molecular methods discriminating on a smaller scale.

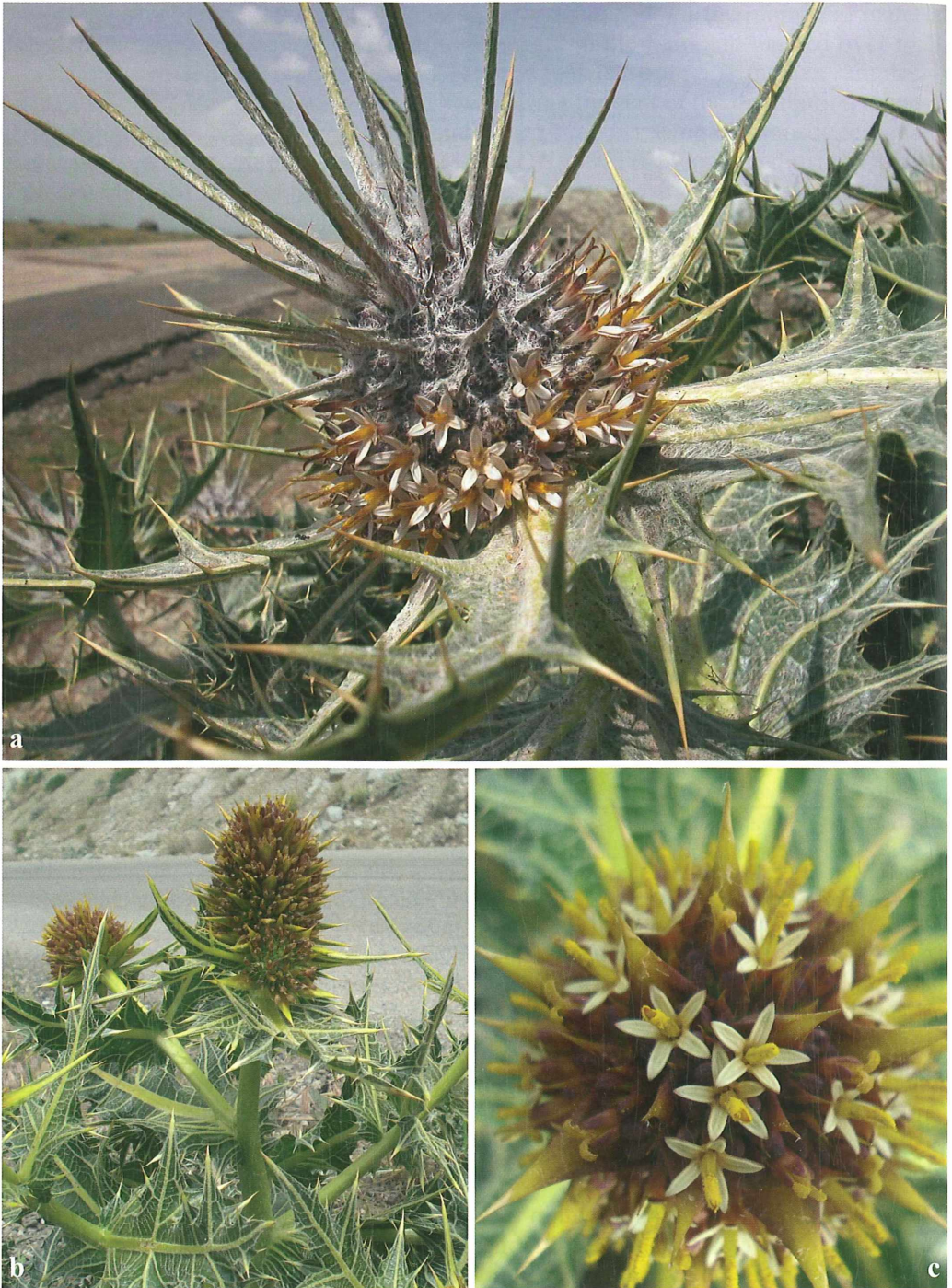


Fig. 2: a) *Gundelia tournefortii*, Karacadag bei Diyarbakir, SE-Turkey; b–c) Iran, Tehran, ca. 20 km to Karadj, Alborz mountains. – a) © G. Pils, b) © F. Ghahremaninejad.



Fig. 3: *Gundelia* sp., Armenia, near Garni: a) habitus, note the glabrous leaves; b) infructescence; c) single disseminule aggregated of 6 flowers; d) inflorescence with campanulate flowers, closed at \pm noon, e–f) flowers, opening in \pm late afternoon.



Fig. 4: *Gündelia aragatsi*: a) habitat mountain steppe; b–c) probable pollinators, b) honey bee, *Apis mellifera*, c) pollen feeding beetles, *Phyllopertha horticola*; d) disseminules aggregated of three flowers; e) rare orange flowers; f) widely open dark brown flowers.



Fig. 5: *Gundelia aragatsi* ssp. *steineri*: a) locality in shrubby steppe; b) disseminules aggregated of three flowers; c) unripe inflorescence; d) inflorescence with campanulate flowers; e–f) dark to blackish brown flowers opening late afternoon, g) rare orange flowers. – d) © A. Steiner.

Results of morphological analyses

Searching for a correct name for the three populations of *Gundelia* in Armenia it was realised, that the Linnean name of *G. tournefortii* was not fixed by a type. This was done by VITEK & JARVIS (2007), choosing material from Rauwolf as type and such connecting the name to cream flowering *Gundelias* in Aleppo (Syria) (RAUWOLF 1583).

Differences in flower colours have been used to distinguish *Gundelia tournefortii* f. *purpurascens* BORNM. (≡ *G. purpurascens* BORNM., nom. inval. in sched.) and var. *asperirima* TRAUTV. Later *G. rosea* has been described (AL-TAEY & HOSSEIN 1984). Other attempts to distinguish different units within *Gundelia* concentrated on the shape of leaves, form and length of bracts: var. *armata* FREYN & SINT., var. *tenuisecta* BOISS. (≡ *G. tenuisecta* (BOISS.) FREYN & SINT.). But these characters are obviously variable in both, *G. tournefortii* and *G. rosea* (AL-TAEY & HOSSEIN 1984) and therefore proved not to be useful for distinguishing taxonomic units. As consequence *G. rosea* was reduced to synonymy (e.g. RECHINGER 1989) and *Gundelia* treated as monospecific genus with the only variable species *G. tournefortii*.

The three populations in Armenia differ in many characters from each other and from *G. tournefortii* and *G. rosea* (Table 1): Hairiness of leaves and inflorescence, flower colour and shape, observed respectively assumed pollinator, size and aggregation of disseminule. Therefore the two taxa, which cannot be assigned to any earlier known species are described here as new.

The third one has similar flower colour to *G. rosea*, but the drawing of the fruit of *G. rosea* in AL-TAEY & HOSSAIN (1984) show double size and different form - therefore also this population could constitute a well defined species. We refrain at the moment to describe it, unless *Gundelia glabra* MILLER, a taxon described from "near Baibout in Armenia" (now Bayburt, Turkey) put in synonymy to *G. tournefortii* by KUPICHA (1984), is clarified and typified - the epithet "glabra" and the description "acanthi aculeati folio, capite glabro" would perfectly fit the plants from the surroundings of Garni (c. 14 km E of Yerevan). The habitat is a forbs-grasses steppe with *Aegilops cylindrica*, *Avena sterilis*, *Bromus danthoniae*, *Bromus tectorum*, *Festuca valesiaca*, *Hordeum bulbosum*, *Koeleria macrantha*, *Secale montanum*, the forbs *Acroptilon repens*, *Anchusa orientalis*, *Cephalaria syriaca*, *Consolida orientalis*, *Falcaria vulgaris*, *Glaucium elegans*, *Hypecoum pendulum*, *Picnomon acarna*, *Reseda lutea*, *Roemeria refracta*, *Xeranthemum squarrosum*, and spring ephemeroïds *Iris elegantissima*, *Merendera trigyna*.

The authors discussed several times which taxonomic status should be given to the new *Gundelia* from Mt. Aragats. The dark brown flowers - especially in connection with the rare orange flowered plants - could be interpreted as extreme coloured variant of the yellow *G. tournefortii*. The findings of the differences in the aggregation of the flowers and the fruits (Fig. 6) were the last impetus to describe it as distinct species: *G. aragatsi*.

***Gundelia aragatsi* VITEK, FAYVUSH, TAMANYAN & GEMEINHOLZER, sp.n.**

Descriptio: Herba perennis, lactifera, crassicaulis. Folia alterna, pinnatisecta usque ad ± incomplete pinnatisecta, spinoso-dentata, superiora decrescentia et minus dissecta, arachnoidea. Inflorescentiae solitariae, usque ad 8 x 5 cm (bracteis inclusis), dense

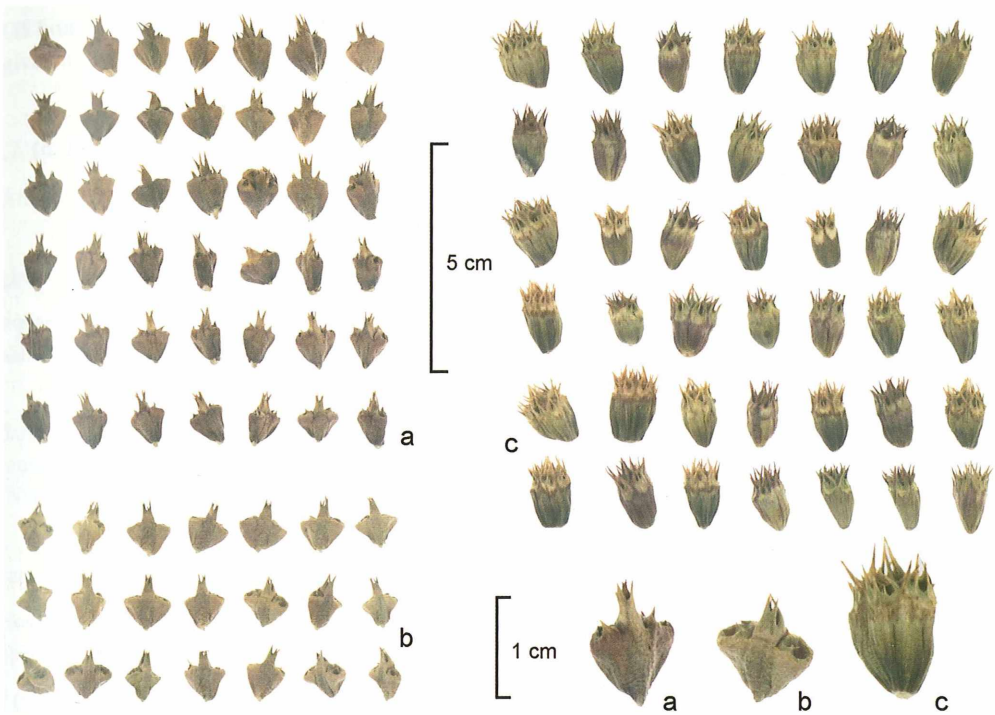


Fig. 5: Ripe disseminules of a) *Gundelia aragatsi*, Teher 11.7.2007, b) *G. aragatsi* ssp. *steineri*, Oganesian & al. 07-0055, c) *G. sp.* (Armenia), Teher 11.7.2007.

arachnoideae. Bracteae spinoso-marginatae, inflorescentiam vix excedentes, apice in spinam induratum protractae. Flores explicatae aperientes, fuscis ad pulli, rariter aurantiaci. Fructus fere 3 (–4) floribus compositi, usque ad 12 mm longi.

A *G. tournefortii* et *G. rosea* floribus fuscis et forma fructuum, ab *G. sp.* (Garni) indumento arachnoideo, floribus fuscis et forma fructuum differt.

Differs of *G. tournefortii* and *G. rosea* by the dark brown flowers and the form of the fruits composed only of three flowers, differs of *G. sp.* (Garni) by the dark brown flowers, the form of the fruits and the arachnoid hairs on leaves and inflorescence.

Distribution: Mt. Aragats, southwestern flank, around villages Baysiz and Kakavadzor; observed area with more than 2 km diameter, but probably also further north and north-east (Fig. 7).

Type: Armenia, Aragatsotn province, Mt. Aragats SW-slope, track between Avtona water reservoir and Kakavadzor, 1880 m s.m., 40°22'5"N/44°2'49"E, 2007-06-23 G. Fayvush, K. Tamanyan, H. Ter-Voskanyan, E. Vitek 07-1373 [holotype ERE, isotypes W (four sheets) 2009-18514–2009-18517, B, BC, BM, BRNU, E, MO, MSB, NY, WU].

Other material: Armenia, Aragatsotn province, SE slopes of Mt. Aragats, track from water reservoir below Avtona to Kakavadzor, 1890 m s.m., 40°22'5"N/44°2'49"E, 2006-06-05 E. Vitek 06-1218 [ERE, W 2009-18510–2009-18511, B]; – Armenia, Aragatsotn province, SE slopes of Mt. Aragats, road from Kakavadzor to Baysiz, 1760 m

Tab. 1: Comparison of characters of the Armenian taxa of *Gundelia* with *G. tournefortii* and *G. rosea*.

Character	<i>G. aragatsi</i> (Fig. 4)	<i>G. aragatsi</i> ssp. <i>steineri</i> (Fig. 5)
material	Armenia, S flank of Mt. Aragats	Armenia, near Echegnadzor
leaves	hairy	densely hairy*
inflorescence	densely hairy	densely hairy
Flower		
colour	outside blackish brown, inside dark brown, very rarely dark orange	outside greyish (rusty) brown to blackish brown, inside blackish brown, very rarely dark orange
shape of upper part	spread	campanulate
opening of flower	widely open during the day	closed during the day, opening afternoon (or dark sky)
observed flower visitors / probable pollinators	beetles (pollen feeders), <i>Phyllopertha horticola</i> (H. Schönmann, pers. comm.); honey bee, <i>Apis mellifera</i> (H. Zettel, pers. comm.)	? (possibly night butterflies)
flower aggregate of	3 (-5) flowers	3 flowers
ripe fruits** of	3 flowers	3 flowers
cypsela	(Fig. 6)	(Fig. 6)
form	± triangular	± triangular
size	9–12 × 6–9 × 3–5 mm	9–12 × 7–9 × 3–5 mm
transverse section	narrow ovate	narrow ovate
habitat	mountain steppe	shibliak
altitude, m s.m.	1700–1900	1000–1100

* Long, soft, multicellular hairs, for the evolutionary value of this character see KARIS & al. 2001.

** In the field in rare cases different numbers of flowers aggregating to one disseminule could be observed, especially in the lowermost and uppermost parts of inflorescences. The analysis of ripe fruits later in the year showed a nearly constant number.

Of *G. tournefortii* and *G. rosea* no fresh and living material could be investigated. The data given in floras can be used only with doubt - obviously there is more than one taxon (see discussion).

<i>G. sp.</i> (Garni) (Fig. 3)	<i>G. tournefortii</i> (Fig. 2)	<i>G. rosea</i>
Armenia, near Garni	based mainly on the type and photos	extracted from AL-TAEY & HOSSAIN (1984)
glabrous	hairy to densely hairy	?
± glabrous, with very few hairs on bracts	hairy to densely hairy	?
dark pink to purple, rarely whitish (NERSESYAN, pers. comm.)	creamy to yellow (green)	bright to light pink inside, deep purple outside
campanulate to slightly spread	spread	?
closed during the day, opening late afternoon (or dark sky)	widely open during the day	?
? (possibly night butterflies)	?	?
6(-9) flowers	5-7 (-?)*** flowers	more than 5-8 (-11)
6 flowers	5-7 flowers ***	?
obconical 11-15 × 7-11 × 7-11 mm	obconical 10-15 × 7 × 7 mm (AL-TAEY & HOSSAIN 1984, MEIKLE 1985)	obovoid 15-20 mm
± circle	± circle	cf. ± circle
± humid steppe	dry slopes, sometimes (semi-) ruderal, weed in fields	pine woodland, on red rocky soil
1500-1600	(0-) 100-2500 (PILS 2006, MEIKLE 1985)	800-900 (- ?)

***The complex structure of the inflorescence of *Gundelia* with disseminules aggregated of 5-7 flowers is described by CLASSEN-BOCKHOFF & al. 1989. It is supposed that the investigated material from SW-Turkey is *G. tournefortii*

s.m., 40°21'41"N/44°3'41"E, 2006-06-05 E. Vitek 06-1233 [ERE, W 2009-18503–2009-18504]; – Armenia, Aragatsotn province, Mt. Aragats SW-slope, above road Kakavadzor - Baysiz, 1720 m s.m., 40°21'41"N/44°3'41"E, 2007-06-23 G. Fayvush, K. Tamanyan, H. Ter-Voskanyan, E. Vitek 07-1405 [ERE, W 2009-18512]; – Armenia, Aragatsotn province, SE slope of Mt. Aragats, NE of Baysiz, 1860 m s.m., 40°22'14"N/44°03'47"E, 2009-06-10 G. Fayvush, K. Tamanyan, E. Vitek 09-0839 [ERE, W 2009-18588–2009-18589]; – Armenia, Aragatsotn province, SE slope of Mt. Aragats, E of Baysiz, 1810 m s.m., 40°21'46"N/44°04'11"E, 2009-06-10 G. Fayvush, K. Tamanyan, E. Vitek 09-0840 [ERE, W 2009-18505–2009-18507]; – (fruits) Armenia, Aragatsotn province, SE slopes of Mt. Aragats, track from water reservoir below Avtona to Kakavadzor, 1875 m s.m., 40°21'59"N/44°2'44"E, 2007-07-11 S. Ter-Pogoshyan [ERE, W 2009-18773, B, BC, E, NY].

The habitat on Aragats mountain is an intensively grazed mountain meadow-steppe with tragacanth elements: *Gundelia aragatsi*, *Astragalus microcephalus*, *Achillea millefolium*, *Dactylis glomerata*, *Poa bulbosa*, *Scutellaria orientalis*, *Cerintho minor*, *Lotus caucasicus*, *Rindera lanata*, *Cousinia brachyptera*, *Anisantha tectorum*, *Alkanna orientalis*, *Prangos ferulacea*, *Asperula glomerata*, *Lappula barbata*, and rare and very sparse shrubs: *Cotoneaster integerrimus*, *Rhamnus cathartica*, *Crataegus meyeri*.

The name remembers the locality on Mt. Aragats.

The population near Echegnadzor is without any doubt closely related to *G. aragatsi* - also confirmed by the low genetic differentiation (Fig. 1) - but they should be differed taxonomically. Based on the marked differences in habitat and pollinator (opening time of flowers), and some morphological differences (e.g. shape and colour of flowers) the rank of subspecies seems to be adequate, and therefore these plants are described as *Gundelia aragatsi* ssp. *steineri*.

***Gundelia aragatsi* ssp. *steineri* VITEK, FAYVUSH, TAMANYAN & GEMEINHOLZER ssp.n.**

Descriptio: Herba perennis, lactifera, crassicaulis. Folia alterna, pinnatisecta usque ad ± incomplete pinnatisecta, spinoso-dentata, superiora decrescentia et minus dissecta, arachnoidea. Inflorescentiae solitariae, usque ad 8 x 5 cm (bracteis inclusis), ± dense arachnoideae. Bractea spinoso-marginatae, inflorescentiam vix excedentes, apice in spinam induratum protractae. Flores campanulati, aperientes post meridiem, umbrini. Fructus fere 3 floribus compositi, usque ad 12 mm longi.

A *Gundelia aragatsi* floribus umbrinis aperientibus post meridiem, altitudine distributionis et habitatione differt.

Differs of *G. aragatsi* by the campanulate flowers, opening in the afternoon (or at dark sky), and in growing in a different altitude and habitat.

Distribution: Only the type locality known, one population in an area of c. 100 × 200 m (Fig. 7).

Type: Armenia, Vayots Dzor province, mainroad to south Armenia, W of Yeghegnadzor, SE of crossroad to Erechgnadzor, slope S of river, 1050 m.s.m, dry rocky slope, 39°44'21"N/45°15'3"E, 2009-06-01 G. Fayvush, K. Tamanyan, E. Vitek 09-0700 [holotype ERE, isotypes W 2009-18513, B, BC, E, MO, MSB, NY, WU].

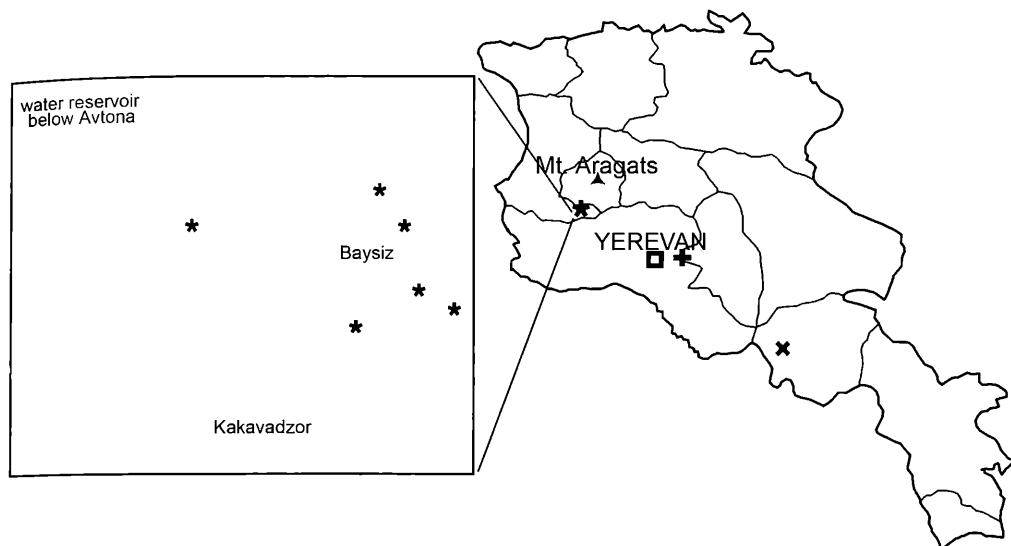


Fig. 7: Map of Armenia with the floristic provinces (TAKHTAJAN 1954) and the localities of *Gundelia aragatsi* (*), *G. aragatsi* ssp. *steineri* (x) and *Gundelia* sp. (+) based on specimens and field notes. For better orientation Yerevan (■) and Mt. Aragats (▲) are shown.

Other material: Armenia, Vayots Dzor province, mainroad to south Armenia, W of Yeghegnadzor, SE of crossroad to Erechgnadzor, 2006-07-26 H. Ter-Voskanyan, A. Aslanyan [ERE]; – Armenia, Vayots Dzor province, mainroad to south Armenia, W of Yeghegnadzor, SE of crossroad to Erechgnadzor, slope S of river, 1050 m.s.m, dry rocky slope, 39°44'21"N/45°15'3"E, 2007-06-11 M. Oganessian, H. Ter-Voskanyan, E. Vitek 07-0055 [ERE, W 2009-18501–2009-18502, B, MSB, NY].

The habitat in the gorge of Arpa river is a Shibliak formation, in which *Gundelia aragatsi* ssp. *steineri* is a main dominant of the community, accompanied by shrubs: *Atraphaxis spinosa*, *Eurotia ceratoides*, *Rosa spinosissima*, and herbs: *Achillea millefolium* s.l., *Aegilops cylindrica*, *Artemisia fragrans*, *Melica transsilvanica*, *Stachys inflata*, *Thymus kotschyanus*.

The name is given in honour of Alfred Steiner (Oberwaltersdorf, Austria), who detected this population.

Discussion

Earlier attempts for distinguishing taxa within *Gundelia* using flowers colour, the length of the bracteose leaves in the inflorescence and the form of the leaves failed. These characters are variable and obviously the leaf characters are not correlated with natural taxonomic units. Therefore *Gundelia* for long time was seen as monospecific genus. The description of *Gundelia rosea* has been ignored or this taxon was treated as synonym to *G. tournefortii*. The here reported new results show that *Gundelia* is not monospecific, there are clearly distinguishable species within the genus. The important characters seem to be flower colour, shape and size of fruits and possibly also the differences of the

indumentum. The ITS tree shows several clades, but the material cannot be correlated with these morphological characters at the moment, because for many of the herbarium collections part of this information is lacking. Future collected material with full information will allow a clearer picture on the evolution of *Gundelia*.

Acknowledgements

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References

- AL-TAEY R.A. & HOSSAIN M., 1984: Studies in *Gundelia*: I, a new species from Iraq. – Not. Roy. Bot. Gard. Edinb. 424: 39–44.
- AVETISIAN V.E., 1995: *Gundelieae*. – In: AVETISIAN V.E. & OGANESIAN M.E. (eds.): *Flora Armenii* 9: 212–216.
- BLATTNER F.R., 1999: Direct amplification of the entire ITS region from poorly preserved plant material using recombinant PCR. – *BioTechniques* 27: 1180–1186.
- BORNMÜLLER J., 1939: *Iter Persico-turcicum 1892–1893*. Beiträge zur Flora von Persien, Babylonien, Assyrien, Arabien. – *Bot. Centralbl., Beih.* 60B: 181–228.
- CLASSEN-BOCKHOFF R., FROEBE H.A. & LANGERBEINS D., 1989: Die Infloreszenzstruktur von *Gundelia tournefortii* L. (Asteraceae). – *Flora* 182: 463–479.
- FREYN J., 1892: *Plantae novae Orientalis*. – *Oesterr. Bot. Z.* 42: 165–170.
- GEMEINHOLZER B., OBERPRIELER CH. & BACHMANN K., 2006: Screening the applicability of molecular markers for plant identification using the ITS 1 sequences of Asteraceae species belonging to the tribes Lactuceae and Anthemideae. – *Taxon* 55: 173–187.
- HALL T.A., 1999: BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. – *Nucleic Acids Symp. Ser.* 41: 95–98.
- KARIS P.O., ELDENÄS P. & KÄLLERSJÖ M., 2001: New evidence for the systematic position of *Gundelia* L. with notes on delimitation of Arctoteae (Asteraceae). – *Taxon* 50: 105–114.
- KUPICHA F.K., 1984: *Gundelia*. – In: DAVIS P.H., MATTHEWS V.A., KUPICHA F.K., PARRIS B.S. (eds.): *Flora of Turkey and the East Aegean Islands* 5: 325–326.
- MEIKLE, R.D., 1985: *Flora of Cyprus*. – Kew: Royal Botanic Gardens.
- MILLER P.M., 1768: *Gardeners Dictionary*, ed. 8: GUN. – London.
- NERSESYAN A.A. & NAZAROVA E.A., 1989: Karyosystematic study of *Gundelia tournefortii* (Asteraceae). – *Bot. Žurn.* 74: 837–839.
- PILS G., 2006: *Flowers of Turkey - a photo guide*. – Eigenverlag Pils.
- RAUWOLF L., 1583: Aigentliche beschreibung der Raiß, so er vor diser zeit gegen Auffgang inn die Morgenländer, fürnemlich Syriam, Judaeam, Arabiam, Mesopotamiam, Babyloniam, Assyriam, Armeniam u. nicht ohne geringe mühe unnd grosse gefahr selbs volbracht: neben vermeldung vil anderer seltsamer und denckwürdiger sachen, die alle er auff solcher erkundiget, gesehen und observiert hat. – Laugingen.
- RECHINGER K.H., 1989: *Gundelia*. – In: RECHINGER K.H. (ed.) *Flora Iranica*, 164: 107–109.

- RONQUIST F. & HUELSENBECK J.P., 2003: MrBayes 3: Bayesian phylogenetic inference under mixed models. – *Bioinformatics* 19: 1572–1574.
- SOFIEVA R.M., 1961: *Gundelia* L. – In: Flora of Azerbajdzhan 8: 347–348.
- TAKHTAJAN A.L., 1954: Flora Armenii 1. – Yerevan: Akademia Nauk.
- VASIL'CHENKO I.T., 1961: *Gundelia* L. – In: SHISHKIN B.K. & BOBROV E.G. (eds.): Flora SSSR 26: 862.
- SWOFFORD D.L., 2002: PAUP*: Phylogenetic analyses using parsimony (* and other methods). 4.0 Beta. – Sinauer Associates, Sunderland, MA.
- VITEK E. & JARVIS C.E., 2007: The typification of *Gundelia tournefortii* L. (Compositae). – *Ann. Naturhist. Mus. Wien, B*, 108: 267–272.

Appendix 1: Material used for DNA-analyses. The complete data of the specimens from W can be found in Virtual Herbaria (<http://herbarium.univie.ac.at/database/search.php>).

Taxon	database number	voucher	origin	annotation
<i>G. aragatsi</i> ssp. <i>steineri</i> 1	FN582290	W 2009-0018501	Armenia	
<i>G. aragatsi</i> ssp. <i>steineri</i> 2	FN582289	W 2009-0018501	Armenia	
<i>G. aragatsi</i>	FN582288	W 2009-0018514	Armenia	
<i>G. aragatsi</i>	FN582283	W 2009-0018510	Armenia	
<i>G. sp.</i>	FN582287	W 2009-0018774	Armenia	
<i>G. tournefortii</i>	FN582281	W 1976-0007273	Turkey	
<i>G. tournefortii</i>	FN582284	W 2001-0011207	Iran	
<i>G. tournefortii</i>	FN582277	W 1965-0015396	Iran	
<i>G. tournefortii</i>	FN582285	W 2001-0010125	Iran	
<i>G. tournefortii</i>	FN582278	W 1965-0017153	Iran	
<i>G. tournefortii</i>	FN582276	W 1994-0005375	Afghanistan	var. <i>armata</i>
<i>G. tournefortii</i>	AY504691			
<i>G. tournefortii</i>	FN582282	W 1958-0000263	Iran	
<i>G. tournefortii</i>	FN582279	W 1976-0001491	Afghanistan	
<i>G. tournefortii</i>	FN582280	W 1975-0005807	Azerbaijan	
<i>G. tournefortii</i>	FN582286	B	Turkey	
<i>Scorzonera purpurea</i>	AJ633477	GAT	Poland	cultivated
<i>Scorzonera crispatula</i>	AJ633486	GAT	France	cultivated
<i>Tragopogon dubius</i>	AJ633503.1	GAT	Germany	cultivated
<i>Scorzonera villosa</i>	AJ633482	GAT	Germany	cultivated
<i>Scolymus maculatus</i>	AJ633469	GAT	Netherlands	cultivated
<i>Catananche caerulea</i>	AJ633465	GAT	Germany	cultivated
<i>Catananche caerulea</i>	AJ633467	GAT	France	cultivated
<i>Catananche caerulea</i>	AJ633466	GAT	Netherland	cultivated
<i>Catananche arenaria</i>	FN582275	B	Morocco	
<i>Catananche caespitosa</i>	AJ633468	GAT	Germany	cultivated
<i>Warionia saharae</i>	AY190608			

Appendix 2: Material of *Gundelia* sp. especially used for comparison:

Armenia, Kotayk province, E of Yerevan, road from Geghadir to Garni, 1555 m s.m., 40°8'23"N/44°39'45"E, 2007-06-18 K. Tamanyan, M. Oganessian, E. Vitek 07-0738 [ERE, W 2009-18499–2009-18500, B]; – (fruits) Armenia, Kotayk province, E of Yerevan, road from Atsavan to Garni, 1533 m s.m., 40°08'25"N/44°39'44"E, 2007-07-11 S. Ter-Pogoshyan [ERE, W 2009-18774, B, NY].

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Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

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