

Research article**A new taxonomic arrangement of the Asian genus *Gundelia* (Asteraceae), including two subgenera and two sections****Mehmet FIRAT**^{ORCID}Van Yüziüncü Yıl University, Faculty of Education, Department of Biology, TR-65080 Van, Turkey
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Abstract: The recent taxonomical studies based on morphological data as well as ITS based molecular data suggested that the genus *Gundelia* L. (Asteraceae) should be divided into two subgenera; *Gundelia* L. subg. *Gundelia* (Type species: *G. tournefortii*) and *Gundelia* L. subg. *Anatolia* Firat **subg. nov.** (Type species: *G. anatolica*). Additionally, morphological data suggest that there should be two sections within the subgenus *Gundelia*; *Gundelia* L. subg. *Gundelia* sect. *Gundelia* (Type species: *G. tournefortii*) and *Gundelia* L. subg. *Gundelia* sect. *Komagenenses* Firat **sect. nov.** (Type species: *G. komagenensis*). All taxonomic and nomenclatural contributions provided in the current study and as well as the morphological affinities of the all established taxon.

Keywords: Assian, *Gundelia*, *Anatolia*, Asteraceae, new subgenus, sections

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Introduction

Gundelia tournefortii was described by Linnaeus (1753) [Type: Habitat in Armenia, Syria. Lectotype (Vitek and Jarvis, 2007): (Aleppo) Rauwolf (1583), Epitype (selected by Vitek and Jarvis, 2007): (Aleppo), Rauwolf]. For a long time, the genus *Gundelia* was thought to be monospecific, and all new taxa identified were synonymised to *G. tournefortii* (e.g. Rechinger, 1989; Kupicha, 1975; De Candolle, 1836).

In order of publication, *Gundelia glabra* Mill. (1768) [Type: near Baibout (Bayburt) in Armenia]. *Gundelia tournefortii* L. var. *glabra* (Mill.) DC. (1836). *Gundelia tournefortii* L. var. *araneosa* DC. (1836), nom. illegit. Effectively based on the typical *Gundelia tournefortii* L. *Gundelia tournefortii* L. [unranked/var.] β *tenuisecta* Boiss., Boissier (1875) [Type: Turkey in monte Berytdagh Cataoniae]. *Gundelia tournefortii* L. var. *asperrima* Trautv. (1876) [Type: In Turciae districtu Erzerum, in montibus Palanteken], *Gundelia asperrima* (Trautv.) Firat, is taxon raised to the rank of species by Firat (2017a).

Gundelia tournefortii L. var. *armata* Freyn & Sint. (1892) [Type: Armenia turcica. Egin in monte Hodschadur-Dagh]. *Gundelia armata* (Freyn & Sint.) Firat, is taxon raised to the rank of species by Firat (2019a). *Gundelia tenuisecta* Freyn & Sint. (1892) [Type: Armenia turcica, Egin: prope Szanduk]. *Gundelia tournefortii* var. *microcephala* Bornm. (1906) [Type: Inter Kermanschahan et Bagdad, prope Khanegyn (Chanekin) ad fines Persiae, Grenzstation]. *Gundelia microcephala* (Bornm.) Vitek, is taxon raised to the rank of species by Vitek (2018). *Gundelia tournefortii* L. f. *purpurascens* Bornm. (1936) [Type: Iter Persico-turcicum, Kurdistania, (Assyria orient.), in montis Kuh-Sefin reg. infer. ad pagum Schaklava ditionis Erbil], (*Gundelia purpurascens* Bornm. (1939) is actually published in synonymy only (as a nom. in sched.) and thus not validly published at the rank of a species, *Gundelia purpurascens* (Bornm.) Firat is taxon raised to the rank of species by Firat (2018a). *Gundelia rosea* M. Hossain & Al-Taey, (1984) [Type: Kurdistan region of Iraq, North of Atrush, c. 60 km NE of Mosul].

Respectively, taxa defined in recent years *Gundelia aragatsi* Vitek, Fayvush, Tamanian & Gemeinholzer (2010) [Type: Armenia, Aragatsotn province, Mt. Aragats SW-slope, track between Avtona water reservoir and Kakavadzor], *Gundelia aragatsi* subsp. *steineri* Vitek, Fayvush, Tamanian & Gemeinholzer (2010) [Type: Armenia, Vayots Dzor province, main road to south Armenia, W of Yeghegnadzor, SE of crossroad to Erechgnadzor, slope S of river]. *Gundelia armeniaca* Nersesyan (2014) [Type: Armenia, Abovian region, surroundings of Geghadir village]. *Gundelia dersim* Vitek, Yüce & Ergin (2014) [Type: Turkey. Province Tunceli (Dersim): Ovacık, c. 11.7 km wsw Ovacık, 1.9 km Ene Ziyaret (fountains of river Munzur)]. *Gundelia munzuriensis* Vitek, Yüce & Ergin (2014) [Type: Turkey. Province Tunceli (Dersim): Ovacık, c. 2 km wsw Ovacık]. *Gundelia vitekii* Armağan (2016) [Type: Turkey, province Tunceli (Dersim), Tunceli Merkez, c. 8 km N of Tunceli, mountain slope nw of Tüllük Bucağı]. *Gundelia komagenensis* Firat (2016) [Type: Turkey. C7 Adıyaman: Kahta Province, Nemrut mountain]. *Gundelia colemerikensis* Firat (2016) [Type: Turkey. C9 Hakkâri: Hakkâri Province (Colemerik) from Karadağ hill to Berçelan plateau, open erode region and steppe]. *Gundelia cilicica* Firat (2016) [Type: Turkey. C5 Mersin: Erdemli province, Tozlu village, open forrest]. *Gundelia anatolica* Firat (2016) [Type: Turkey. B4 Kırıkkale: Delice province, Tuzkayası region]. *Gundelia mesopotamica* Firat (2017b) [Type: Turkey. C8 Mardin: 2-3 km from Mardin to Nusaybin, eroded slopes]. *Gundelia tehranica* Vitek & Noroozi (2017) [Type: Iran, Tehran, Tuchal Mt., above Velenjak]. *Gundelia siirtica* Firat (2019b) [Type: Turkey. C8 Siirt: Kurtalan District, 12 km from Kurtalan to Batman].

Following Firat (2016), important diagnostic characters in the genus *Gundelia* are the number of flowers forming one cephaloid (= flowers complex, heads of second order, pseudocephalia) in the synflorescence the size and shape of the fruit complex (disseminule), the color of the flowers, the indumentum in the synflorescence, the habitat, and flower closure at \pm noon, opening in \pm late afternoon.

Gundelia species are known by the local people under many names in Kurdish; e.g. "Kênger", "Qorav", "Kereng", "Kerenk", "Keven", "Kengel", and in Turkish; e.g. "Has kanger", "Acı kenger", "Eşek diken", "Kenger" (Firat, 2013).

Materials and Methods

During floristic surveys of *Gundelia*, in Turkey, Iraq, Iran, Cyprus, Syria and Nakhchivan, between 2014 and 2020, the revisionary work is based on field studies undertaken in 1470 different localities, and examination of both living material in the field and numerous herbarium specimens from various Turkish herbaria, (ANK, AEF, GAZI, HUB, ISTE, ISTF, VANF; acronyms according to Thiers 2020), as well as digital images of all type specimens from virtual herbaria.

The specimens were cross-checked with the various *Gundelia* accounts given in the relevant literature: In the regional floras (Nikitin, 1960; Sofieva, 1961; Vasilchenko, 1961; Kupicha, 1975; Feinbrun-Dothan, 1978; Rechinger, 1989; Avetisian, 1995 etc.); *Gundelia tournefortii* Linnaeus (1753) is the only species of the genus *Gundelia* and all other names were recorded as synonyms. The new described species *Gundelia aragatsi* Vitek, Fayvush, Tamanyan & Gemeinholzer (2010), *Gundelia armeniaca* Nersesyan (2014) from Armenia, *Gundelia dersim* Vitek, Yüce & Ergin (2014), *Gundelia munzuriensis* Vitek, Yüce and Ergin (2014), *Gundelia vitekii* Armağan (2016), *Gundelia komagenensis* Firat (2016), *Gundelia colemerikensis* Firat (2016), *Gundelia cilicica* Firat (2016), *Gundelia anatolica* Firat (2016), *Gundelia mesopotamica* Firat (2017b) and *Gundelia siirtica* Firat (2019b) from Turkey, *Gundelia tehranica* Vitek and Noroozi (2017) from Iran. And added new record for the flora of Turkey *Gundelia rosea* M. Hossain & Al-Taey (Firat 2017c), *Gundelia armeniaca* Nersesyan (Firat 2018b), *Gundelia purpurascens* (Bornm.) Firat (Firat, 2018a). The resurrection and a new status of *Gundelia asperima* (Trautv.) Firat (Firat, 2017a), *Gundelia armata* (Freyn & Sint.) Firat (Firat, 2019b). Karyotype data for 12 taxa are reported in Genç and Firat (2019).

The taxonomic implications of taxa determined as "Art. 21 of the ICN" *Shenzhen Code*, (Turland et al. 2018).

Results and Discussion

Gundelia L. subg. *Gundelia* (Type species: *G. tournefortii*) (Figure 1 and Table 1).

Diagnosis: Subgenus *Gundelia* clearly differs from subgenus *Anatolia* by its general habit, all of cephaloid (in the middle of the synflorescence) of 3-8 flowers (*vs.* 6 flowers), floral leaves normally 2-5 (*vs.* 8-18),

disseminules; squamulose, obconical and triangular (*vs.* smooth or undulate, triangular and obconical).

Included species respectively.

Gundelia aragatsi Vitek, Fayvush, Tamanian & Gemeinholzer

Gundelia armata (Freyn & Sint.) Fırat

Gundelia armeniaca Nersesyan

Gundelia asperrima (Trautv.) Fırat

Gundelia cilicica Fırat

Gundelia colemerikensis Fırat

Gundelia dersim Vitek, Yüce & Ergin

Gundelia glabra Mill.

Gundelia komagenensis Fırat

Gundelia mesopotamica Fırat

Gundelia microcephala (Bornm.) Vitek

Gundelia munzuriensis Vitek, Yüce & Ergin

Gundelia purpurascens (Bornm.) Fırat

Gundelia rosea M.Hossain & Al-Taey

Gundelia siirtica Fırat

Gundelia tehranica Vitek & Noroozi

Gundelia tenuisecta Freyn & Sint.

Gundelia tournefortii L.

Gundelia tournefortii L. var. *tenuisecta* Boiss.

Gundelia vitekii Armağan

Taxonomical notes: According to the results of molecular phylogenetic analyses of *Gundelia* species, this subgenus clearly separated from the subgenus *Anatolia* with 0.89 posterior probability support (Tarıkahya Hacıoğlu & Fırat, 2017).

Gundelia L. subg. *Gundelia* sect. *Gundelia* (Type species: *G. tournefortii*) (Figure 2 and Table 1)

Diagnosis: Section *Gundelia* clearly differs from section *Komagenenses* by its cephaloid (in the middle of the synflorescence) of six flowers group [*vs.* cephaloid (in the middle of the synflorescence) of three flowers group], disseminules obconical (*vs.* triangular).

Included species respectively;

Gundelia armata (Freyn & Sint.) Fırat

Gundelia armeniaca Nersesyan

Gundelia cilicica Fırat

Gundelia colemerikensis Fırat

Gundelia dersim Vitek, Yüce & Ergin

Gundelia mesopotamica Fırat

Gundelia microcephala (Bornm.) Vitek

Gundelia purpurascens (Bornm.) Fırat

Gundelia rosea M. Hossain & Al-Taey

Gundelia siirtica Fırat

Gundelia tehranica Vitek & Noroozi

Gundelia tournefortii L.

Table 1. Genus *Gundelia* cephaloid numbers, subgenus and section

Taxon	Cephaloid Number	Subgenus	Section
<i>Gundelia anatolica</i> Fırat	6	<i>Anatolia</i>	"-"
<i>Gundelia armata</i> (Freyn & Sint.) Fırat	6-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia armeniaca</i> Nersesyan	5-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia cilicica</i> Fırat	6(-7)	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia colemerikensis</i> Fırat	(3-)5-6	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia dersim</i> Vitek, Yüce & Ergin	6-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia mesopotamica</i> Fırat	6-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia microcephala</i> (Bornm.) Vitek	6-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia purpurascens</i> (Bornm.) Fırat	6-7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia rosea</i> M.Hossain & Al-Taey	(6-)7-8	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia siirtica</i> Fırat	(6-)7	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia tehranica</i> Vitek & Noroozi	7-8	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia tournefortii</i> L.	5-6(-7)	<i>Gundelia</i>	<i>Gundelia</i>
<i>Gundelia aragatsi</i> Vitek, Fayvush, Tamanian & Gemeinholzer	3(-5)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia asperrima</i> (Trautv.) Fırat	3(-4)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia glabra</i> Mill.	3-5(-6)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia komagenensis</i> Fırat	3(-4)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia munzuriensis</i> Vitek, Yüce & Ergin	3-5(-7)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia tenuisecta</i> Freyn & Sint.	3-5(-6)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia tournefortii</i> L. var. <i>tenuisecta</i> Boiss.	3-5(-6)	<i>Gundelia</i>	<i>Komagenenses</i>
<i>Gundelia vitekii</i> Armağan	3(-5)	<i>Gundelia</i>	<i>Komagenenses</i>

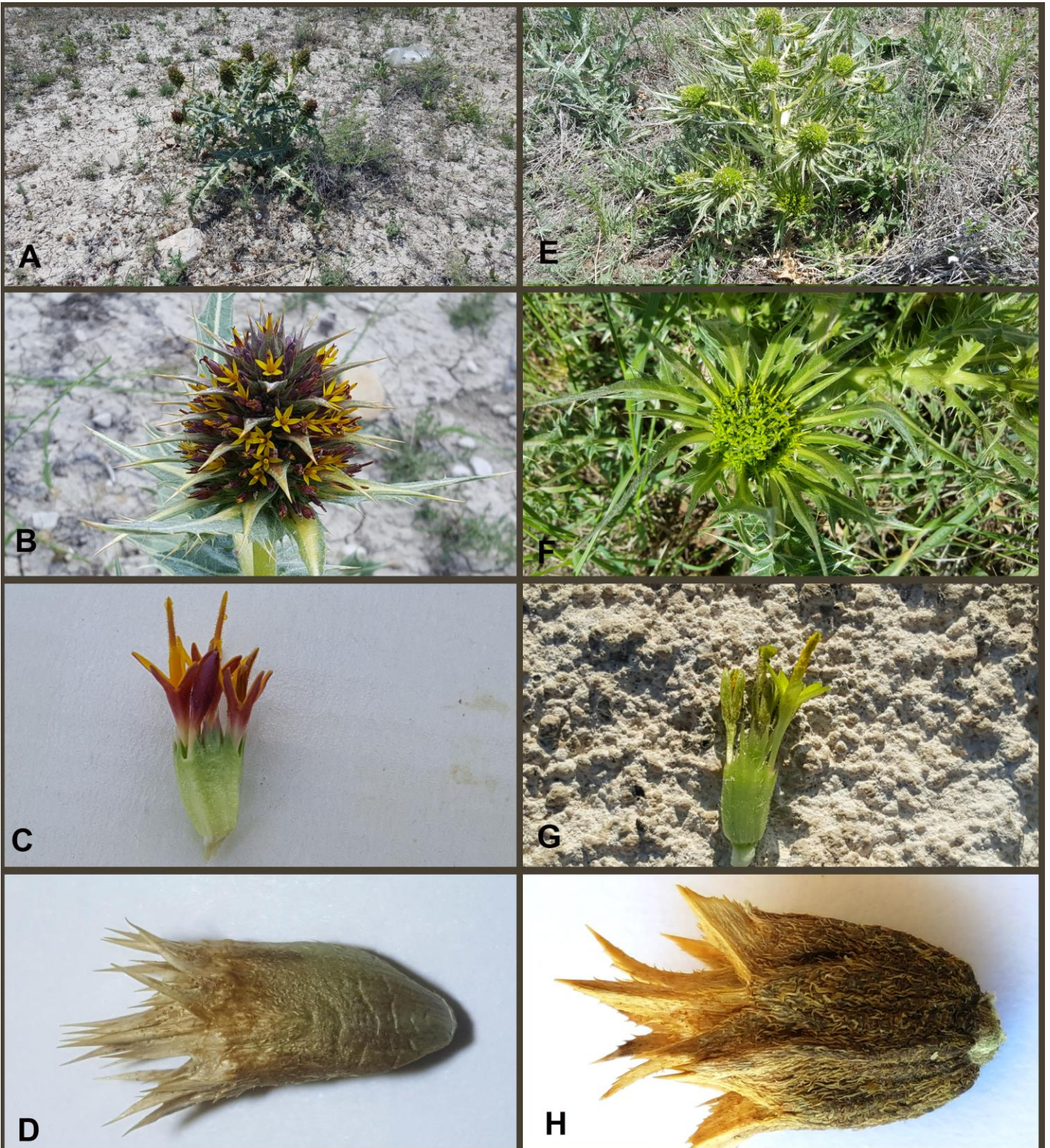


Figure 1. Subgenus *Gundelia*; **A**-habit, **B**-synflorescence and four floral leaves, **C**-detail of cephaloid compound of six flowers, **D**-ripe disseminules, subgenus *Anatolia*; **E**-habit, **F**-synflorescence and sixteen floral leaves, **G**-detail of cephaloid compound of six flowers, **H**-ripe disseminules.

Taxonomical notes: The section *Gundelia* are morphologically close to the species group with cephaloid

(in the middle of the synflorescence) of six flowers (Firat, 2017) and ripe disseminules more or less obconical. The

cephaloids of this section consist of 5-8 flowers, but synflorescences the bottom few cephaloids and top cephaloids (to 15 flowers) do not follow this rule. *Gundelia colemerikensis* normally is 5-6 flowers, but it can be seen in 3 flowers even if it is less in between.

Gundelia L. subg. *Gundelia* sect. *Komagenenses* Firat **sect. nov.** (Type species: *G. komagenensis*) (Figure 2 and Table 1).

Diagnosis: Section *Komagenenses* clearly differs from section *Gundelia* by its cephaloid (in the middle of the synflorescence) of three flowers group [vs. cephaloid (in the middle of the synflorescence) of six flowers group] disseminules triangular (vs. obconical).

Included species respectively;

Gundelia aragatsi Vitek, Fayvush, Tamanian & Gemeinholzer

Gundelia asperrima (Trautv.) Firat

Gundelia glabra Mill.

Gundelia komagenensis Firat

Gundelia munzuriensis Vitek, Yüce & Ergin

Gundelia tenuisecta Freyn & Sint.

Gundelia tournefortii L. var. *tenuisecta* Boiss.

Gundelia vitekii Armağan

Taxonomical notes: The section *Gundelia* are morphologically close to the species group with cephaloid (in the middle of the synflorescence) of three flowers (Firat 2017) and ripe disseminules more or less triangular. The cephaloids of this section consist of 1-5 flowers, but synflorescences the bottom few cephaloids and top cephaloids (to 15 flowers) do not follow this rule. Since speciation continues within the genus, there are little deviation in this grouping in some species. *Gundelia glabra* and *Gundelia tournefortii* var. *tenuisecta* normally is 3-5 flowers, but it can be seen in six flowers even if it is less in between.

Gundelia L. subg. *Anatolia* Firat **subg. nov.** (Type species: *G. anatolica*) (Figure 1 and Table 1).

Diagnosis: Subgenus *Anatolia* clearly differs from subgenus *Gundelia* by its general habit, all of cephaloid (in the middle of the synflorescence) of 6 flowers (vs. 3-8 flowers), floral leaves normally 8-18 (vs. 2-5), disseminules; smooth or undulate, triangular and obconical (vs. squamulose, obconical and triangular).

Included species;

Gundelia anatolica Firat.

Taxonomical notes: According to the phylogenetic tree based on ITS sequences, *Gundelia anatolica* seems to be a sister derived from all other Anatolian *Gundelia* species with a 0.89 posterior probability high clade credibility value (Tarıkahya Hacıoğlu and Firat, 2017). Consequently, the phylogenetic information gives an important clue to name *G. anatolica* as a subgenus. This subgenus is represented only by the species *Gundelia anatolica* Firat. The pollen characters of *Gundelia* genus did not sufficiently separate from most species except for *G. anatolica*. While pollen characters of *Anatolia* subgenus is P/E ratio (0.98), shape (oblate-spheroidal), spine length (3.4 μ), colpus (25.8μ) and porus length (6.5 μ); *Gundelia* subgenus are seen to be P/E ratio (0.98-1.06), shape (prolate-spheroidal to oblate-spheroidal), spine length (3.9-5.8 μ), colpus (28.8-39 μ) and porus length (6.1-8.7μ) (Firat & Selvi, 2021 “in prepared”). In the study of the Genç and Firat (2019), three chromosome types (A, B and C) were determined according to the position of the secondary constrictions of *Gundelia* chromosomes. According to those studies, results Type C chromosomes was observed in all the investigated taxa accept *G. anatolica*.

Comments

Flowers color, flowers number and hair condition of *Gundelia* sp. should be carefully observed and noted while it is fresh in the field. It is difficult to diagnose from dry material after it turns into a herbarium sample. The total number of species in *Gundelia* increased to twentyone, two sections; *Gundelia* L. subg. *Gundelia* sect. *Gundelia* and *Gundelia* L. subg. *Gundelia* sect. *Komagenenses* Firat, and two subgenus; *Gundelia* L. subg. *Gundelia* and *Gundelia* L. subg. *Anatolia* Firat.

The species of *Gundelia* are currently distributed in the East Mediterranean region, Asia Minor, Transcaucasia, Iran and Afghanistan. Their distribution areas are as follows: Cyprus, Lebanon, Jordan, Turkey, Israel and Syria: *Gundelia tournefortii*; Armenia: *Gundelia aragatsi* and *Gundelia armeniaca*; Nakhchivan: *Gundelia aragatsi*; Iraq: *Gundelia microcephala*, *Gundelia rosea* and *Gundelia purpurascens*; Iran: *Gundelia microcephala* *Gundelia rosea*, and *Gundelia tehranica*; Turkey: *Gundelia anatolica*, *Gundelia armata*, *Gundelia armeniaca*, *Gundelia asperrima*, *Gundelia cilicica*, *Gundelia colemerikensis*, *Gundelia dersim*, *Gundelia glabra*, *Gundelia komagenensis*, *Gundelia mesopotamica*, *Gundelia munzuriensis*, *Gundelia purpurascens*, *Gundelia rosea*, *Gundelia siirtica*, *Gundelia tenuisecta*, *Gundelia*

tournefortii, *Gundelia tournefortii* var. *tenuisecta* and *Gundelia vitekii*.

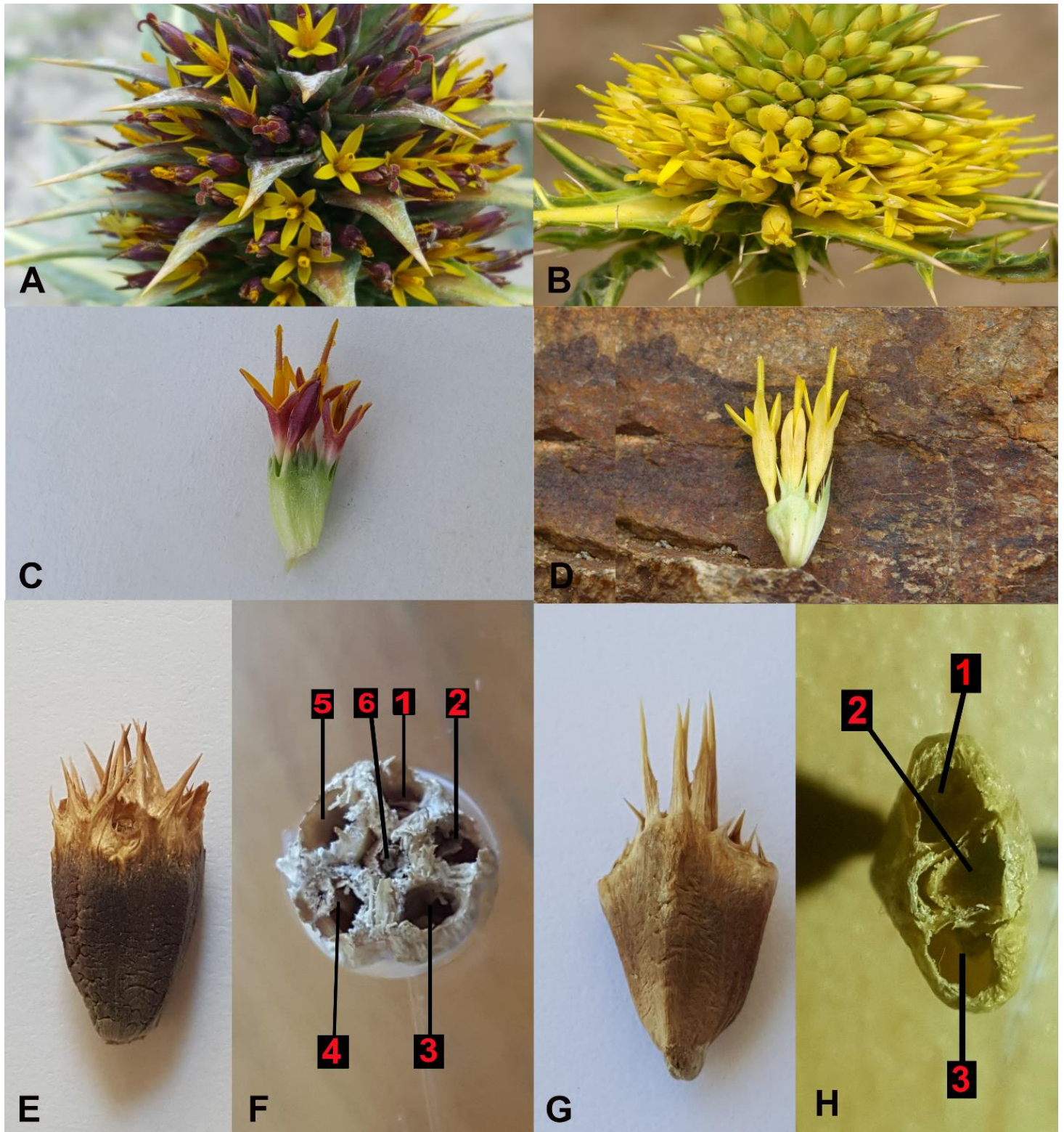


Figure 2. Section *Gundelia*; **A**-synflorescence, **C**-detail of cephaloid compound of six flowers, **E**-ripe disseminules, **F**-six hole of ripe disseminules: Section *Komagenenses*; **B**-synflorescence, **D**-detail of cephaloid compound of three flowers, **G**-ripe disseminules, **H**-three hole of mature disseminules.

On the basis of current studies and taking newly described species into account, it is possible to claim that the genus still deserves much attention in order to clarify its taxonomy. *Gundelia* genus variation and mutant is very common (especially bracts, flowers number, leaf and indumentum). Hybrids occur between some species. Hybridization should be considered when defining new species. In the current knowledge of the genus *Gundelia*, the diversity center of the genus seems to be the mountainous dry steppes of the eastern and southeastern Anatolia region.

Ethical Approval

The author does not declare ethical approval.

Conflicts of Interest

The author declares that they have no conflict of interest.

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