

Infrageneric Grouping of Turkish *Acantholimon* Boiss. (Plumbaginaceae) Assessed by Numerical Taxonomy

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Abstract: This study examines whether a satisfactory infrageneric grouping of Turkish *Acantholimon* can be obtained from phenetic clustering based on external vegetative and floral morphological characters. Forty-one morphological characters were selected and scored for the 52 species of *Acantholimon* found in Turkey and the data subjected to numerical taxonomic analyses. The results of this study suggest that there are basically three sections (*Staticopsis* Boiss., *Tragacantina* Boiss. and *Acantholimon*) and the sectional cut off line is drawn at 0.67 similarity level. A phenon line at 0.75 similarity level results in five subsections in sect. *Staticopsis* and three of these subsections (subsect. *Robustea* subsect. nov., subsect. *Dianthifoliaea* subsect. nov. and *Circinnatea* subsect. nov.) are described for the first time.

Key words: Numerical taxonomy • Infrageneric structure • *Acantholimon* • Turkey

INTRODUCTION

The family *Plumbaginaceae* Juss. has been subject to a few studies since it was first established as a sister group of *Polygonaceae* Juss. [1]. A detailed historical summary concerning the generic grouping of the *Staticoideae* was given by Karis [2] who also underlined many uncertainties concerning classification of the family [3]. Most of these problems are linked to delimitation and circumscription of the large genera, *Acantholimon* Boiss. and *Limonium* Mill., from which many small genera have been segregated [4, 5, 6].

The genus *Acantholimon* Boiss. comprises about 200 species in the world and its centre of diversity lies in the Irano-Turanin Region [7]. The genus was first described by E. Boissier [8].

Bunge [9] was the first researcher who prepared a monographic account of *Acantholimon* in which he classified 83 species under 7 sections. He placed the species of *Acantholimon* found in Turkey in three sections (*Armeriopsis* Boiss., *Staticopsis* Boiss. and *Tragacanthina* Bunge) and produced the first infrageneric grouping in the genus. While grouping *A. bracteatum* under sect. *Armeriopsis* he further splitted sect. *Staticopsis* into four series, namely *Rhodocalycina* (incl. *A. venustum*, *A. assyriacum*, *A. laxiflorum*, *A. petraeum*, *A. senganense* and *A. calvertii*);

Caryophyllaceae (incl. *A. araxanum*, *A. acerosum*, *A. kotschyi*, *A. armenum*, *A. caryophyllaceum*, *A. hausnechti* and *A. libanoticum*); *Androsacea* (incl. *A. hohenackerii*, *A. glumaceum*, *A. ulicinum*, *A. caesareum*, *A. huetii*, *A. puberulum*, *A. wiedemanni* and *A. lycanicum*) and *Microcalycina* (incl. *A. lepturoides*). Bunge placed only three species under the section *Tragacanthina* and further divided this section into two subsections, namely *Stenostoma* (incl. *A. quinquelobum* and *A. curviflorum*) and *Eurystoma* (incl. *A. tragacanthinum*).

Boissier [10] in his *Flora Orientalis*, followed a similar line with Bunge and didn't make any changes in sect. *Armeriopsis* and sect. *Tragacanthina*, but in sect. *Staticopsis*, he accepted the three subsections, *Rhodocalycina* (incl. *A. calvertii*, *A. venustum*, *A. laxiflorum*, *A. petraeum* and *A. senganense*), *Caryophyllaceae* (incl. *A. araxanum*, *A. hohenackerii*, *A. huetii*, *A. glumaceum*, *A. lycanicum*, *A. acerosum*, *A. caryophyllaceum*, *A. balansae*, *A. armenum*, *A. iconicum*, *A. kotschyi*, *A. libanoticum*, *A. echinus*, *A. wiedemanni* and *A. peroninii*) and *Microcalycina* (incl. *A. lepturoides*).

Mobayen [11] in his monographical study, treated the infrageneric grouping in the same way as Boissier [10] as far as the sections *Armeriopsis* and *Tragacanthina* are concerned. He also made some changes in sect.

Staticopsis and recognised three subsections, namely *Candelabrata* (incl. *A. venustum*, *A. senganense*, *A. laxiflorum*, *A. petraeum*, *A. lepturoides*, *A. libanoticum*, *A. kotschyi*, *A. armenum*, *A. caryophyllaceum*, *A. baltanense* and *A. acerosum*) *androsacea* (incl. *A. calvertii*, *A. spirizianum*, *A. petuniflorum*, *A. huetii*, *A. glumaceum*, *A. lycanicum*, *A. wiedemannii*, *A. damassanum*, *A. saxifragiforme* and *A. hohenackerii*) and *Scabrellina* (incl. *A. avaxanum*).

Komarov in his *Flora of USSR* [12], used the infrageneric grouping of Boissier [10] and recognised three sections *Armeriopsis* (incl. *A. bracteatum*), *Staticopsis* (incl. *A. lepturoides*, *A. fominii*, *A. araxanum*, *A. caryophyllaceum*, *A. armenum*, *A. hohenackerii* and *A. glumaceum*) and *Tragacanthina* (incl. subsect. *Stenostoma* under which he placed *A. quinquelobum*).

Bokhari was the first person carried out an extensive taxonomic studies on the family Plumbaginaceae in Turkey where he recognised six genera (*Acantholimon* Boiss, *Limoniopsis* Lincz., *Limonium* Miller, *Armeria* Wild., *Goniolimon* Boiss. and *Plumbago* L.) and also described six new species in *Acantholimon* (*A. confertiflorum*, *A. halophilum*, *A. reflexifolium*, *A. dianthifolium*, *A. hypochaerum* and *A. strigillosum* [10, 13]. Bokhari [14] also investigated the stigma and pollen types in *Acantholimon* and *Limoniopsis*.

Rechinger [15] placed the species that also existed in Turkey under three section, *Acantholimon* (incl. *A. armenum*, *A. acerosum*, *A. dianthifolium*, *A. fominii*, *A. araxanum*, *A. senganense*, *A. caryophyllaceum*, *A. petraeum*, *A. venustum* and *A. hohenackerii*) and *Tragacanthina* (incl. *A. curviflorum*, *A. quinquelobum* and *A. tragacanthinum*).

Bokhari and Edmondson [16] recognised 25 species of *Acantholimon* in the *Flora of Turkey and the East Aegean Islands* vol.7 and also indicated the possibility of finding some additional species either imperfectly known (2 species) or doubtfully recorded (9 species). They recognised three sections in *Acantholimon* and their treatment of sect. *Acantholimon* (*Acantholimon*, *Tragacanthina* and *Staticopsis*) and sect. *Tragacanthina* were similar with the previous taxonomists. Their treatment of sect. *Staticopsis* included three subsections, *Caryophyllacea* (incl. *A. venustum*, *A. halophilum*, *A. acerosum*, *A. caryophyllaceum*, *A. armenum*, *A. kotschyi*, *A. confertiflorum*, *A. dianthifolium* and *A. libanoticum*); *Microcalycina* (incl. *A. spirizianum*) and *Androsacea* (incl. *A. glumaceum*, *A. caesareum*, *A. huetii*, *A. calvertii*, *A. hypochaerum*, *A. puberulum*,

A. reflexifolium, *A. ulicinum*, *A. damassanum*, *A. saxifragiforme* and *A. strigillosum*). The infrageneric grouping has been mainly based on the inflorescence types, flower number in each spikelet and leaf types but, nevertheless, the infrageneric classification seemed to be far from natural.

A more recent numerical taxonomic study based on the species of *Acantholimon* in Ankara province described the subsection *Halophiliacea* Dogan and Muvaffak in sect. *Staticopsis* [17]. A comprehensive revisional study on Turkish *Acantholimon* has been done by Dogan and Akaydın in 2003 who described 13 additional species of *Acantholimon*, namely *A. birandii* Dogan and Akaydın [18], *A. avanosicum* Dogan and Akaydın [19], *A. karamanicum* Akaydın and Dogan [20], *A. anatolicum* Dogan and Akaydın [21], *A. goeksunicum* Dogan and Akaydın, *A. koeycegizicum* Dogan and Akaydın [22], *A. turcicum* Dogan and Akaydın [23], *A. yildizelicum* Akaydın [24], *A. baskaleicum* Dogan and Akaydın, *A. artosense* Dogan and Akaydın, *A. hoshapicum* Dogan and Akaydın [25], *A. evrenii* Dogan and Akaydın [26] and *A. ekimii* Dogan and Akaydın besides some new records. This final study increased the total number of species of *Acantholimon* to 52 in Turkey [27]. Therefore, the main objective of this numeric taxonomic study is to construct a long lasting infrageneric classification of Turkish *Acantholimon* that may be as natural as possible.

MATERIALS AND METHODS

For the purposes of present study 51 species as operationally taxonomic units (OTU) of *Acantholimon* found in Turkey are examined and scored for 41 different characters (Table 1). Data is organized in the form of a 52x41 matrix. This data set composed of both quantitative (metric) and qualitative (discrete) data. Discrete character states of 10th and 15th characters given as ranges in species' descriptions are averaged. The ranges given for some length properties are also averaged.

The analysis is done with Multi-Variate Statistical Package (MYSP) version 3.0 for Windows. Distance matrices for the data-sets were calculated using the Gower general similarity coefficient (GOWER) for mixed data [28]. Phenoframs using unweighted pair-group mathematical average (UPGMA) algorithms were generated from the distance matrices using CLUSTAR [29]. Principal coordinate analysis (PCORD) was run using NT – SYS [30].

Table 1: Characters scored for the species of *Acantholimon*

1. Cushion formation type; 2. Leaf length (mm); 3. Leaf width (mm); 4. Leaves heteromorphic or monomorphic; 5. Lower leaves...reflected or not; 6. Leaf texture; 7. Previous years leaf basis circinnate or not; 8. Scape length (cm); 9. Scapes' exertion; 10. # of scales in each scape; 11. Scale length (mm); 12. Scales / internodes ratio; 13. Inflorescence type; 14. Inflorescence length (cm); 15. Inflorescence spikelet number; 16. Floret number; 17. Spikelet length (mm); 18. Bract number in each floret; 19. Bract length (mm); 20. Bract / bracteoles ratio; 21. Bract texture; 22. Bract colour; 23. Bracteol length (mm); 24. Bracteol apex shape; 25. Bracteol texture; 26. Bracteol margin; 27. Bracteol colour; 28. Calyx type tubular or not; 29. Calyx length (mm); 30. Calyx tube length (mm); 31. Calyx tube straight or not; 32. Calyx tube / bracts ratio; 33. Calyx tube texture; 34. Calyx limb length (mm); 35. Calyx limb width (mm); 36. Calyx limb colour; 37. Calyx limb texture; 38. Calyx limb apex shape; 39. Calyx limb veins...excurrent or not; 40. Calyx tube / limb ratio; 41. Petal colour.

Since 2000, as a part of a revision of the genus *Acantholimon* in Turkey, extensive field surveys have been carried out all over the country and a large number of specimens, which were pressed carefully and dried using standard techniques for further laboratory analysis [31]. The specimens were identified with the keys provided by Bokhari and Edmondson [16] and the *Acantholimon* accounts given in various floras, such as *Flora Orientalis* [10], *Flora Iranica* [15], *Flora Europaea* [32], *Flora of USSR* [12] and *Flora of Syria, Palestine and Sinai* [33].

The specimens were also then compared with the type specimens, borrowed from the herbaria, as well as, the duplicates of Davis specimens obtained from Edinburgh (E) as a gift, cited in *Flora of Turkey and the East Aegean Islands* [16]. The supplements of the flora were also consulted [34]. The material of *Acantholimon* kept at various herbaria (ANK, E, EGE, G, GAZI, HUB, ISTF and K) was examined. The authorities are cited in accordance with Authors of Plant Names [35].

RESULT AND DISCUSSION

The phenogram resulting UPGMA clustering of similarity matrix is presented in Fig 1. Cluster analyses typically reflect distances for OTUs that are close together more accurately than for OTUs that are far apart [36]. The cluster analyses of the morphological properties support the recognition of three main clusters, each of which is treated as a section and the sectional cut off line is drawn at 0.67 similarity level.

The first cluster or phenon includes 44 species (incl. *A. laxiflorum*, *A. dianthifolium*, *A. hypochaerum*, *A. koeycegizicum*, *A. calvertii*, *A. ekimii*, *A. goeksunicum*, *A. huetii*, *A. lycaonicum*, *A. wiedemannii*, *A. yildizelicum*, *A. anaticum*, *A. strigillosum*, *A. ulicinum*, *A. puberulum*, *A. karamanicum*, *A. birandii*, *A. confertiflorum*, *A. turcicum*, *A. reflexifolium*, *A. caryophyllaceum*, *A. lepturoides*, *A. kotschyi*, *A. armenum*, *A. multiflorum*, *A. araxanum*, *A. damassanum*, *A. hohenackerii*, *A. halophilum*, *A. fominii*, *A. senganenese*, *A. spirizianum*, *A. petraeum* and *A. venustum*).

The species of this section, sect. *Staticopsis* have monomorphic leaves, 1-flowered and 3-bracteated spikelets in which calyces are funnel shaped. This section was first recognized by Boissier [8] and up to recent years it was accepted as a different section by almost all researchers, namely Bunge [9], Mobayen [11], Komarov [12], Rechinger [15] and Bokhari and Edmondson [16].

A phenon line at 0.75 similarity level seems quite reasonable for the recognition of sub sectional grouping of Turkish *Acantholimon*. In sect. *Staticopsis* one can recognize 5 phenons or subsections. The first subsection includes only *A. laxiflorum* which is a local endemic found below Amanus Mountains in Arsuz (C₆ Hatay, Turkey). In the early years this species was placed under subsect. *Rhodocalycina* in sect. *Staticopsis* by Bunge [9] and Boissier [10] but Mobayen [11] transferred this species under subsect. *Candelabrata* in sect. *Staticopsis*. Bokhari and Edmondson [16] gave this species a variety status under *A. venustum* by means of examining wrong type specimen of *A. laxiflorum* that was actually a specimen of *A. venustum* [37]. This new subsection is described below:

subsect. *Robustea* Dogan and Akaydin subsect. nov.
Folia 18-65 mm longae, 1-1.5 (2) mm latae, folia inferioribus circinnati recurvis vestitibus, 4-foliatis. Inflorescentiis simplex-elongatis. Spiculis 16-36, 13-15 mm longae. Bracteis 6-8 mm longae. Bracteolis 9-11 mm longae, oblongo-lanceolatis. Calycibus 11-14 mm longae, limbo 8-9 mm diametro, limbo fusco vel brunneo.

Type: *A. laxiflorum* Boiss.

The second subsection named as *Diantifolia* includes 1 species of *Acantholimon* (*A. dianthifolium*) which is also another local endemic from southeast Anatolia (C₉ Hakkari, Turkey). Formal description of this new subsection is given below.

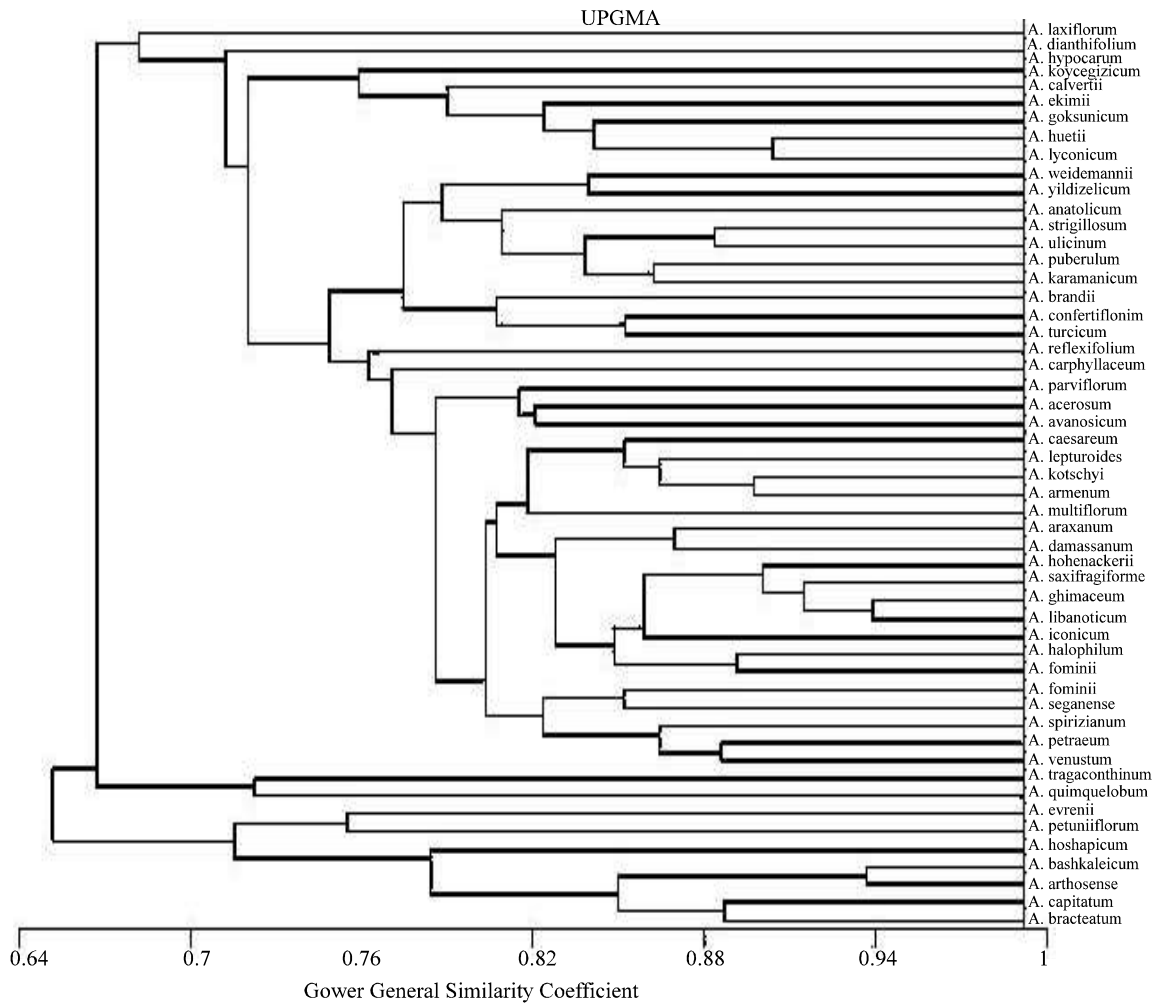


Fig. 1: The phenogram resulting UPGMA clustering of similarity matrix belonging to Turkish *Acantholimon* species

Subsect. *Dianthifolia* Dogan and Akaydin subsect. nov.

Folia 15-35 mm longae, 1,5-3 mm latae, glaucoviridis, Caulibus 1,5-5 cm longae, brevioribus quam folia, 1-foliates. Spiculae 6-12, 20-35 mm longae, densissimus, terminalis. Bracteis 6-8 mm longae, ovatalanceolatis. Bracteolis 7-8 mm longae oblongolanceolatis. Calycis 12-13 mm longae, limbo brunneo vel albus.

Type: *A. dianthifolium* Bokhari.

The third subsection named as subsect. *Circinnatea* includes 6 species of *Acantholimon* (*A. hypochaerum*, *A. koyceğizicum*, *A. calvertii*, *A. ekimii*, *A. goksunicum* and *A. huetii*). In the previous studies Boissier [10] placed *A. calvertii* under subsect. *Rhodocalycina* and *A. huetii* under subsect. *Caryophyllacea* of sect. *Staticopsis*. Later, Mobayen [11] transferred the both species to subsect. *Androsacea*. In the same way Bokhari and

Edmondson [16] treated the both species. Therefore, based on the differences in morphology a new subsection is defined and described. Formal description of new subsection as follows.

Subsect. *Circinnatea* Dogan and Akaydin subsect. nov.

Folia 15-40 mm., longae, 0,5-1,5 mm latae, folia inferioribus circinnati recurvis vestitibus. Scapus 2-27 cm longae, foliis excedentibus, 1-8 foliatis inflorescentiis 2-5 ramosus., deucissimus. Spiculis 4-16, 11-17 mm longae. Bracteis 4,5-12 mm., longae, oblongo-lanceolatis. Calycibus 11-15 mm longae, limbo 5,5-9 mm diametro, limbo fuso-brunneo vel albus.

Type: *A. calvertii* Boiss.

Subsect. *Androsacea* of sect. *Staticopsis* seems to include *A. lycaonium*, *A. wiedemanni*, *A. yildizelicum*, *A. anatolicum*, *A. strigillosum*, *A. ulicinum*, *A.*

puberulum, *A. karamanicum*, *A. birandii* and *A. confertiflorum*. The remaining species of sect. *Staticopsis* are all placed under subsection. *Caryophyllacea*.

Sect. *Tragacanthina* that includes *A. quinquelobum* (incl. *A. curviflorum*) and *A. tragacanthinum* could be divided into two subsections, namely subsection. *Stenostoma* Boiss. (incl. *A. quinquelobum*) and subsection. *Eurystoma* (incl. *A. tragacanthinum*)

The third cluster treated as sect. *Acantholimon* includes 8 species of *Acantholimon* (*A. evrenii*, *A. petuniiflorum*, *A. hoshapicum*, *A. bashkaleicum*, *A. artosense*, *A. capitatum* and *A. bracteatum*) in which the species have heterophyllous leaves, 2-5 flowered and 2-6 bracteate spikelets and funnel shaped calyces. Sect. *Acantholimon* was first recognized Boissier [8] but in the later years it was named as sect. *Armeriopsis* by Bunge [9], Boissier [10], Mobayen [11] and Komarov [12]. As far as the newly described *A. evrenii* as well as *A. petuniiflorum* are concerned sect. *Glumaria* Boiss may be included in this section as a subsection.

CONCLUSION

Nevertheless, the classification obtained by numerical taxonomic methods appears to give more information than those of conventional methods on the relationship between OTUs used in this study. Therefore, the classification obtained in this study would be expected to approximate natural grouping better than the previous studies. The present study is somewhat limited because it is based on only the Turkish species. A comprehensive study covering all of the *Acantholimon* species seems to be necessary to construct a satisfactory infrageneric classification.

The infrageneric grouping based on the findings of this numerical taxonomic study is given below.

Sect. *Staticopsis* Boiss.

Leaves monomorphic. Inflorescence spicate, simple or branched; spikelets 2-ranked, 1-flowered, 3-bracteate. Calyx infundibular.

Subsect. *Robustea* Dogan and Akaydin subsection nov.

Previous year's leaf bases circinnate. scapes 18-38 cm long exceeding leaves. Inflorescence simple lax spicate. spikelets 16-36, 13-15 mm. Calyx limb brownish - purple. Type: *A. laxiflorum* Boiss.

Subsect. *Diantifoliea* Dogan and Akaydin subsection. nov. Previous year's leaf bases not circinnate. Scapes 1.5-5 cm

length, shorter or slightly longer than leaves. Inflorescence densely distichous spikes. Spikelets 6-12, 12-15 mm. Calyx limb white or pale pink.

Type: *A. dianthifolium* Bokhari

Subsect. *Circinnatea* Dogan and Akaydin subsection. nov.

Previous year leaf bases circinnate. Scapes 2-27 cm. long, exceeding leaves. Inflorescence 2-5 branched dense spike. spikelets 4-16, 11-17 mm. Calyx limb brownish-purple or occasionally white.

Type: *A. calvertii* Boiss.

Species included: *A. hypochaerum*, *A. koeyceğizicum*, *A. calvertii*, *A. ekimii*, *A. goeksunicum* and *A. huetii*.

Subsect. *Androsacea* Bunge

Previous year's leaf bases not circinnate. Inflorescence a simple or shortly branched spike, spikelets densely congested terminally. Calyx limb white.

Type: *A. ulicinum*

Species included: *A. lycanicum*, *A. wiedemannii*, *A. yildizelicum*, *A. anatolicum*, *A. strigillosum*, *A. ulicinum*, *A. puberulum*, *A. karamanicum*, *A. birandii* and *A. confertiflorum*.

Subsect. *Caryophyllacea* Bunge.

Previous year's leaf bases usually not circinnate. Inflorescence a simple, usually lax, 2-ranked spike. Calyx limb white.

Type: *A. caryophyllaceum* Boiss.

Species included: *A. turcicum*, *A. reflexifolium*, *A. caryophyllaceum*, *A. parviflorum*, *A. acerosum*, *A. avanosicum*, *A. caesareum*, *A. lepturoides*, *A. kotschyi*, *A. armenum*, *A. multiflorum*, *A. araxanum*, *A. libanoticum*, *A. iconicum*, *A. halophilum*, *A. fominii*, *A. senganense*, *A. spirizianum*, *A. petraeum* and *A. venustum*.

Sect. *Tragacanthina* Bunge.

Leaves heterophyllous; Inflorescence a lax very diffuse panicle. Spikelets 1-flowered, 3-bracteate. Calyx tubular.

Type: *A. tragacanthinum* (Jaub. and Spach) Boiss.

Species included: *A. quinquelobum* (incl. *curviflorum*) and *A. tragacanthinum*

Sect. *Acantholimon*

Leaves heterophyllous; spring leaves persistent.

Inflorescence capitate, consisting of condensed spikes. Spikelets 2-5--flowered, 2-6--bracteate. Calyx infundibular. Type: *A. bracteatum* (Girard) Boiss.

Species included: *A. bracteatum*, *A. capitatum*, *A. artosense*, *A. bashkalecicum*, *A. hoshapicum*, *A. petuniiflorum* and *A. evrenii*.

REFERENCES

- Chase, M.V., D.E. Soltis, R.G. Olmstead, D. Morgan, D.H. Les, B.D. Mishler, C.M.R. Duval, R.A. Price, H.G. Hills, Y. Qui, K.A. Kron, J.H. Rettig, E. Conti, J.D. Almer, J.R. Manhart, K.J. Systma, H.J. Michaels, W.J. Kress, K.G. Karol, W.D. Clark, M. Hedren, B.S. Gaut, R.K. Jansen, K.J. Kim, C.F. Wimpee, J.F. Smith, G.R. Furnier, S.H. Straus, Q.Y. Xiang, G.M. Plunkett, P.S. Soltis, S.M. Swensen, S.E. Williams, P.A. Gadek, C.J. Quinn, L.E. Eguiarte, E. Golemberg, G.H. Learn, S.C.H. Graham Barret, S. Dayanandan and V.A. Albert, 1993. "DNA sequence phylogenetics of seed plants: an analysis of the plastid gene *rbcL*.", *Annals of the Missouri Botanical Garden*, 80: 528-580.
- Karis, P.O., 2004. "Taxonomy, phylogeny and biogeography of *Limonium* sect. *Pteroclados* (Plumbaginaceae), based on morphological data.", *Bot. J. Linn. Soc.*, 144: 461-482.
- Lledo, M.D., P.O. Karis, M.B. Crespo, M.F. Fay and M.W. Chase, 2001. "Phylogenetic position and taxonomic status of the genus *Aegialitis* and subfamilies *Staticoideae* and *Plumbaginoideae* (Plumbaginaceae): evidence from plastid DNA sequences and morphology.", *Plant Systematics and Evolution*, 229: 107-124.
- Linczevski, I.A., 1985. "Notulae de Limoniaceis, 6. *Novosti Systematiki Vysshikh Rasteniy*.", 22: 200-207.
- Lledo, M.D., M. Erben and M.B. Crespo, 2003. "Myriolepis, a new genus segregated from *Limonium* (Plumbaginaceae).", *Taxon*, 52: 67-73.
- Lledó, M.D., M. Erben and M.B. Crespo, 2005. "Myriolimon, a new name for the recently published *Myriolepis* (Plumbaginaceae).", *Taxon*, 54: 811-812.
- Bokhari, M.H., 1970. "Materials for a *Flora of Turkey* XXII: *Plumbagmaceae*.", *Notes Royal Botanic Garden, Edinburgh*, 30: 295-304.
- Boissier, E., 1846. *Diagnoses Plantarum Orientalium Novarum*, Ser. 1, 7 :69 (Jul.-Oct.).
- Bunge, A., 1872. Die Gattung *Acantholimon* Boiss. *Mem. de l' Academie Imperiale des Sciences de St.-Petersbourg*, VII. Serie, t 27 f. 8: 1-72.
- Boissier, E., 1879. *Flora Orientalis*, 4 : 823-854. *Reg. Acad. Scient.*, Basel.
- Mobayen, S., 1964. Revision taxonomique du genre *Acantholimon*. Tehran.
- Komarov, V.L., ed. 1967., *Flora U.R.S.S.* vol. 18 (Engl. Transl.) Israel Program for Scientific Translations, Jerusalem.
- Bokhari, M.H., 1972a. "Synopsis of *Plumbaginaceae* in Turkey.", *Notes Royal Botanic Garden, Edinburgh* 30: 57-77.
- Bokhari, M.H., 1972b. "A brief review of stigma and pollen types in *Acantholimon* and *Limonium*.", *Notes Royal Botanic Garden, Edinburgh*, 32: 79-84.
- Rechinger, K.H. and H. Schiman-Czeika, 1974. *Flora Iranica: Plumbaginaceae*, Akademische Druck- u. Verlagsanstalt No: 108. Graz-Austria.
- Bokhari, M.H. and J.R. Edmondson, 1982. *Acantholimon* Boiss. In: Davis PH, ed. *Flora of Turkey and the East Aegean Islands*, vol. 7. Edinburgh: Edinburgh University Press, 478-502.
- Muvaffak, A., M. Doğan and C.C. Bilgin, 2001. "Numerical Taxonomic Study of the Genus *Acantholimon* Boiss. (*Plumbaginaceae*) in Ankara Province.", *Israel Journal of Plant Sciences*, 49: 297-300.
- Doğan, M. and G. Akaydın, 2001. "A New Species of *Acantholimon* Boiss. (*A. birandii* sp. nov.) (Plumbaginaceae) from the Central Anatolian Steppe in Turkey.", *Nordic Journal of Botany*, 21: 481-484.
- Doğan, M. and G. Akaydın, 2002a. "A New Species of *Acantholimon* Boiss. (Plumbaginaceae) from Central Anatolia, Turkey.", *Botanical Journal of the Linnean Society*, 138: 365-368.
- Akaydın, G. and M. Doğan, 2002. "A new species of *Acantholimon* Boiss. (Plumbaginaceae) from Western Taurus Mountains of Turkey.", *Israel Journal of Plant Sciences*, 50: 67-71.
- Doğan, M. and G. Akaydın, 2002b. "A New Species of *Acantholimon* Boiss. (Plumbaginaceae) from Ankara, Turkey.", *Botanical Journal of the Linnean Society*, 140: 443-448.
- Doğan, M. and G. Akaydın, 2003a. "Two new species of *Acantholimon* sect. *Staticopsis* (Plumbaginaceae) from Turkey.", *Annales Botanici Fennici*, 40: 53-58.
- Doğan, M. and G. Akaydın, 2003b. "An undescribed species of *Acantholimon* Boiss. Sect. *Staticopsis* Boiss. (Plumbaginaceae) from Turkey.", *Israel Journal of Plant Sciences*, 51: 231-236.

24. Akaydın, G., 2004. "A new species of *Acantholimon* Boiss. Sect. *Staticopsis* Boiss. (Plumbaginaceae) from North Anatolia, Turkey.", Nordic Journal of Botany, 22: 679-682.
25. Doğan, M. and G. Akaydın, 2004. "Three new species with two flowered spikelets in *Acantholimon* (Plumbaginaceae) from East Anatolia, Turkey.", Botanical Journal of the Linnean Society, 144: 497-505.
26. Doğan, M. and G. Akaydın, 2005. "A new species of *Acantholimon* Boiss. sect. *Glumaria* Boiss. (Plumbaginaceae) from Elazığ, Turkey.", Botanical Journal of the Linnean Society, 149: 351-356.
27. Doğan, M. and G. Akaydın, 2007. "Synopsis of Turkish *Acantholimon* Boiss. (Plumbaginaceae).", Botanical Journal of the Linnean Society, (in press.)
28. Gower, J.C., 1971., A general coefficient of similarity and some of its properties. Biometrics, 27: 857-871.
29. Marshall, K. and H.C. Romesburg, 1976. CLUSTAR and CLUSTID programs for hierarchical cluster analysis. Logan:Dept.Forestry and Outdoor Rec.,Utah State Univ.
30. Rohlf, F.J., J. Kishbaugh and D. Kirk, 1981. NT-SYS, numerical taxonomy system of multivariate statistical programs. Dept. Ecol. Evol., New York: State Univ., Stony Brook.
31. Davis, P.H. and V.H. Heywood, 1973. Principles of Angiosperm Taxonomy, Robert E. Kieger Publishing Company, Huntington, New York, 558.
32. Moore, D.M. 1972. In Tutin, T.G. *et al.* Flora Europaea, 3: 30. Cambridge Univ. Press, Cambridge.
33. Post, G.E., 1933. *Flora of Syria, Palestine and Sinai*, Beirut. American Press, 510-511.
34. Davis, P.H., R. Mill and K. Tan, 1988. Flora of Turkey and the East Aegean Islands vol.10 (Supplement). Edinburgh: Edinburgh Univ. Press.
35. Brummitt, R.K. and C.E. Powell, eds. 1992. Authors of Plant Names. Royal Botanic Gardens, Kew, London. ISBN 947-643-44-3.
36. Rohlf, F.J., 1970. "Adaptive hierarchical clustering schemes.", Syst. Zool., 19: 58-52.
37. Doğan, M., H. Duman and G. Akaydın, 2003., "Taxonomy and Conservation Status of *Acantholimon laxiflorum* Boiss. ex Bunge (Plumbaginaceae).", Turkish Journal of Botany, 27: 447-452.