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. Dianthifoliea 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 Tragacantina 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 Rhodocalyxina (incl. A. venustum, A. assyriacum, A. laxiflorum, A. petraeum, A.senganense and A. calvertii); Caryophyllacea (incl. A. araxanum, A. acerosum, A. kotschyi, A. armenum, A. caryophyllyceum, A. hausechti and A. libanoticum); Androsacea (incl. A. hohenackerti, A. glumaceum, A. ulcinum, A. caesareum, A. huettii, A. puberulum, A. wiedemannii and A. lycaonicum) and Microcalycina (incl. A. lepturoides). Bunge placed only three species under the section Tragacantina and further divided this section into two subsections, namely Stenostoma (incl. A. quinquelobum and A. curviflorum) and Eurystoma (incl. A. tragacanthinum).


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

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. lepturodes, A. fomini, 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 Linecz., Limonium Miller, Armeria Wild., Gonolimon Boiss. and Plumbago L.) and also described six new species in Acantholimon (A. confertiflorum, A. halophilum, A. reflexifolium, A. dianthifolium, A. hypochoerum and A. strigillosum [10, 13]. Bokhari [14] also investigated the stigma and pollen types in Acantholimon and Limoniopsis.


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, Caryophyllaceae (incl. A. venustum, A. halophilum, A. acerosum, A. caryophyllaceum, A. armenum, A. kotschyi, A. confertiflorum, A. dianthifolium and A. libanotium); Microcalycina (incl. A. spirizianum) and Androsacea (incl. A glumaceum, A. caesareum, A. huetii, A. calvertii, A. hypochoerum, 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 Halophilicea Dogan and Muvaffak in sect. Staticopsis [17]. A comprehensive revisional study on Turkish Acantholimon has been done by Dogan and Akayd in 2003 who described 13 additional species of Acantholimon, namely A. birandii Dogan and Akaydn [18], A. avanosicum Dogan and Akaydn [19], A. karamanicum Akaydn and Dogan [20], A. anatolicum Dogan and Akaydn [21], A. goeksunicum Dogan and Akaydn, A. koeycegizicum Dogan and Akaydn [22], A. turcicum Dogan and Akaydn [23], A. yildizlicicum Akaydn [24], A. baskaleicum Dogan and Akaydn, A. artosense Dogan and Akaydn, A. hoshapicum Dogan and Akaydn [25], A. evrenii Dogan and Akaydn [26] and A. ekimii Dogan and Akaydn 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].
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 species, 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* [32], *Flora Iranica* [12], *Flora Europaea* [12], *Flora of Turkey and the East Aegean Islands* [16], *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 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 ( C. Hatay, Turkey). In the early years this species was placed under subsection *Rhodocalycina* in sect. *Staticopsis* by Bunge [9] and Boissier [10] but Mobayen [11] transferred this species under subsection *Candelabratea* 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 Akaydın subsect. nov. Folia 18-65 mm longae, 1-1.5 (2) mm latae, folia inferioribus circumnati recurvis vestitibus, 4-foliatis. Inflorescentiae 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 bruneo.

**Type: A. laxiflorum Boiss.**

The second subsection named as *Dianthifolia* includes 1 species of *Acantholimon* ( *A. dianthifolium*) which is also another local endemic from southeast Anatolia (C, Hakkari, Turkey). Formal description of this new subsection is given below.
Subsect. *Diantifoliae* Dogan and Akaydın subsection nov.

Folia 15-35 mm longae, 1.5-3 mm latae, gloauroviridis, Caulibus 1.5-5 cm longae, brevioribus quam folia, 1-foliates. Spiculae 6-12, 20-35 mm longae, densisimus, terminalis. Bracteis 6-8 mm longae, ovatalanceolatis. Bracteolis 7-8 mm longae, oblongolanceolatis. Calycis Folia 15-40 mm longae, 0.5-1.5 mm latae, folia 12-13 mm longae, limbo brunneo vel albus.

Type: *A. dianthifolium* Bokhari.

The third subsection named as subsection *Circinnatea* includes 6 species of *Acantholimon* ( *A. hypochaerum*, *A. koeyceziicum*, *A. calvertii*, *A. ekini*, *A. goeksunicum* and *A. huetii*). In the previous studies Boissier [10] placed *A. calvertii* under subsection *Rhodocalycina* and *A. huetii* under subsection *Caryophyllacea* of sect. *Staticopsis*. Later, Mobayen [11] transferred the both species to include *A. lycaonium*, *A. wiedemannii*, *A. yildizelicum*, *A. anatolicum*, *A. strigillosum*, *A. ulicinum*, *A. longae*, *foliis excedentibus*, *1-8 foliatis inflovescentiis vestitibus*. Spiculis 4-16, 11-17 mm longae. Bracteis 4.5-12 mm longae, longae. Scapus 2-27 cm longae, folis excedentibus, 1-8 foliatis inflovescentiis 2-5 ramosus, deucissimus. Spiculis 4-16, 11-17 mm longae. Calyczis 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. wiedemannii*, *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. Tragacantha 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. Robusta Dogan and Akaydın subsection nov.


Subsect. Diantifolia Dogan and Akaydın 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 Akaydın subsection nov.

Previous year’s 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. hypocharaem, A. koeyçeğizicum, A. calvertii, A. ekimii, A.goeksunicum and A. huetii.

Subsect. Androsaceae 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


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.


Sect. Tragacantha 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


