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FARROKH GHAREMANINEJAD

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Value of Trichome Characteristics for the Separation of Bifurcating Hairy *Astragalus* L. (*Fabaceae*) at the Sectional Level

Farrokh GHAHREMANI-NEJAD

Department of Biology, Faculty of Science, Teacher Training University of Tehran
(University of Tarbiat-Moallem), 49 Dr. Mofatteh Avenue, 15614 Tehran, IRAN

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Abstract: The attachment of hairs in sections of *Astragalus* L. may be either basal or lateral (bifurcate). This study focuses on *Astragali* with bifurcating hairs in the Old World (subgenus *Cercidothrix* Bunge). In this study, it appears that the ratio of hair arm length, and hair form and length are usually stable at the sectional level.

The proposition of uniting some sections based on morphological characters is confirmed by hair characters; for example, uniting sections *Tamias* Bunge, *Acantherioceras* Rech. f. and *Pseudoerioceras* Ulzjichutag with *Erioceras* Bunge.

The most important characters in the separation of the sections are macromorphological, but hair characters are also important and the usually show a good positive correlation.

Key Words: *Astragalus*, bifurcate hairs, *Cercidothrix*, *Fabaceae*, Old World.

The giant genus *Astragalus* L. (*Galegeae*: *Fabaceae*), with nearly 3000 species, is probably the largest genus of flowering plants (Lock & Simpson, 1991). Its species are placed in many sections. These sections are defined based on morphological characters such as stem length, stipule connation, leaf shape, inflorescence form and fruit state.

The attachment of the hairs in these sections may be either basal (basifixed or simple) or lateral (medifixed or bifurcate). Bifurcate hairs have two arms usually opposed in the same plane, being inflexible or curly.

This study focuses on bifurcating *Astragalus* in the Old World. These sections belong to *Astragalus* subgenus *Cercidothrix* Bunge, which is characterised by perennial growth and the presence of bifurcate hairs (Bunge, 1868). This subgenus has its main centre of diversity in Central Asia (based on Yakovlev et al., 1996).

It has to be mentioned that the Old World *Astragali* are different from those of the New World. The majority of *Astragalus* in the Old World have a basic $n = 8$, but its taxa in the New World present, with few exceptions, an aneuploid series of $n = 11, 12$ and 13 (Barneby, 1964).

The position of the genus in the New World (with nearly 400 species) is different. It is classified into seven

phalanxes (nearly equal to the subgenus) (Barneby, 1964). Three phalanxes specifically have simple hairs, two phalanxes specifically have bifurcate hairs and two phalanxes have both simple and bifurcate hairs. There are bifurcate and simple hair species inside some sections in the latter phalanx. However, in the Old World all the sections are uniform; simple hair sections specifically contain simple hair species, and bifurcate hair sections contain bifurcate hair species.

Astragalus subgenus *Cercidothrix* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg, 11, 16: 94 (1868).-
Lectotype (Podlech, 1982): *Astragalus incanus* L. 1763, Sp. Pl. ed. 2: 1072.

= *Astragalus* subgenus *Calycocystis* Bunge 1868, Mem. Acad. Imp. Sci. Saint Petersburg, 11, 16.

= *Astragalus* subgenus *Pogonophace* Bunge 1868, Mem. Acad. Imp. Sci. Saint Petersburg, 11, 16.

This subgenus has nearly 800 species in the Old World. Major centres of species endemism for this subgenus occur in Turkey, Iran, Kazakhstan, Afghanistan and China, with 92, 89, 47, 38 and 33 endemic species reported from these areas, respectively. Central Asia is the biggest and the most important centre of diversity,

with 310 species (201 endemic) (based on Yakovlev et al., 1996; Lock & Simpson, 1991; Kuntsun et al., 1993).

For this study some species from each of the *Astragalus* bifurcated sections in the Old World were examined in the herbarium of the Komarov Botanical Institute, St. Petersburg (LE), in 1998. For each section, usually one or two specimens of the one species (i.e. the section's lectotype) were selected. In all cases, some hair samples of the leaflet, calyx and fruit were examined, and the measurement of the hairs was carried out by light microscopy.

As a control, some specimens were selected from nine species of the section *Incani* DC. The results demonstrate a small range of hair character variation within the section. The arm ratios of the hairs in the leaflet, calyx

and fruit of these species are very similar (between 0.8 and 1 mm) (Fig. 1).

Leaflet Indumentum

The length of the leaflet hairs varies between 0.2 and 2.5 (3.5) mm. The length of the hairs in 62% of the species is less than 1 mm, and 36% of them are between 1 and 1.75 mm, and 2% have hairs longer than 1.75 mm.

The most symmetrical hairs are in the sections *Hypsophilus* Bunge, *Ammodendron* Bunge, *Leucophysa* Bunge, and *Chomutoviana* Fedtsch., and the most asymmetrical hairs are present in the sections *Irinea* Boriss., *Onobrychoidei* DC., and *Uliginisii* Gray.

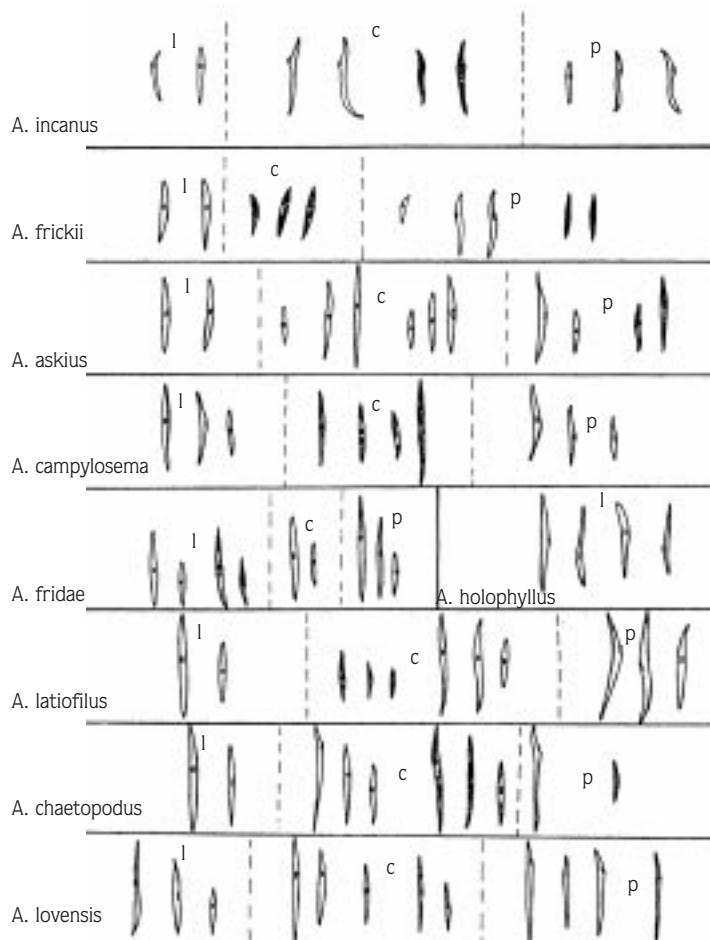


Figure 1. Some species of the section *Incani*; (l = leaflet hairs; c = calyx hairs; p = pod hairs) x 10.

Calyx Indumentum

The length of the calyx hairs varies between 0.2 and 3 mm. The length of the hairs in 70% of the species is less than 1 mm, and 30% of them are between 1 and 1.8 mm. The longest hairs are in *A. chaetodon* Bunge (3 mm) [sect. *Chaetodon* Bunge], *A. roseus* Ledeb. (2.4 mm) [sect. *Tanythrix* Bunge], and *A. pelliger* Fenzl (2.5 mm) [sect. *Sisyrophorus* Bunge]. The shortest hairs are in *A. stocksii* Bunge (0.2 mm) [sect. *Caraganella* Bunge], and *A. austriacus* Jacq. (0.2 mm) [sect. *Craccina* Bunge].

In contrast to the leaflets, which have a minimum size of hair arms ratio of 0.17 [in *A. cytisodes* Bunge, belonging to sect. *Cytisodes* Bunge], the calyx hairs (in fruiting state) are sometimes very asymmetrical. For example, in *A. xanthotrichus* Ledeb. (sect. *Cysticalyx* Bunge) this ratio is between 0.03 and 0.09. In some sections with asymmetrical hairs, there are even simple hairs, i.e. sections *Ammodendron*, *Chaetodon*, *Cremoceras* Bunge, *Cystium* Bunge, *Cytisodes* and *Laguopsis* Bunge.

Pod Indumentum

The length of the pod hairs varies between 0.1 and 4.2 (7.5) mm. The length of the hair in 25% of the species is more than 2 mm. The longest hairs are found in *A. chrysomallus* Bunge (7.5 mm) [sect. *Macrocystodes* Popov] and *A. erioceras* Fisch. & C.A.Mey. (3 mm) [sect. *Erioceras* Bunge]. The shortest hairs are in *A. ornithopodioides* Lam. (0.1 mm) [sect. *Ornithopodium* Bunge] and *A. frickii* Bunge (0.2 mm) [sect. *Incani*].

Similar to the calyx hairs, pod hairs are usually asymmetrical. For example, *A. erioceras* [sect. *Erioceras*] and *A. mucronifolius* Boiss. [sect. *Leucocercis* Bunge] have 0.01, and *A. ammodytes* Pall. [sect. *Ammodytes* Bunge], and *A. nivalis* Kar. & Kir. [sect. *Hypsophilus* Bunge] have a 0.02 average hair arms ratio.

Some sections like *Cysticalyx*, *Laguopsis*, *Leucocercis* and *Vesicarii* DC. sometimes have simple hairs on their pods.

Generally, the most important characters in the separation of the sections are macromorphological characters. After that, hair characters may provide a good measure to separate sections. It should be noted that the ratio of the length of the hair arms, form of the hairs (appressed, flexible), and length of the hairs are usually stable at sectional level.

Some of these bifurcate species have a few simple hairs as well (especially on the calyx or fruit). In this case, the majority of the hairs are very asymmetrical. The best example is *A. pelliger* (from sect. *Sisyrophorus*). This species and its section are endemic to Turkey. The existence of simple hairs on the indumentum of its calyx is mentioned in its description in the Flora of Turkey (Davis, 1970). With the study of the type specimen (Th. Kotschy 125, type, LE!) by the author, it was found that the hairs are very asymmetrical (arm ratio = 0.06-0.10), and not simple (Fig. 2). This finding may be true for other species of this section as well (Davis, 1988; Aytac, 2000).

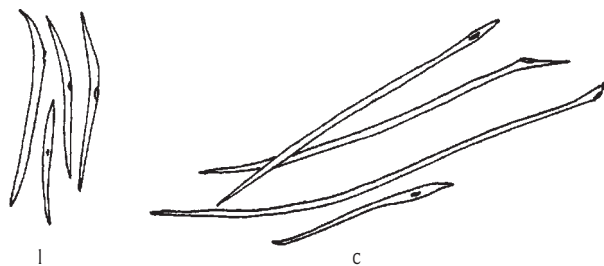


Figure 2. *A. pelliger*; (l = leaflet hairs; c = calyx hairs) x 20.

The hair form in some sections is unique; for example, it is very unusual in the section *Leucophysa* (*A. candidissimus* Ledeb.: C.A.Mey., type, LE!) and some of its hairs are long-stipitate (Fig. 3).



Figure 3. *A. candidissimus*: Unusual hairs on the fruit; x 20.

Some of the sections of this subgenus do not have good separating characters and could be synonyms. For example, the sections *Acantherioceras* Rech.f. [*A. acantherioceras* Rech.f. (M. E. K ie 4450, type, WI)], *Tamias* Bunge [*A. turczaninovii* Kar. & Kir. (Karelin & Kirilov 275, type, LE!)], and *Pseudoerioceras* Ulzichutag [*A. rudolfii* Ulzichutag (Kamelin & Darijmaa 509, type, LE!)] are very similar to the section *Erioceras* [*A. erioceras* (Karelin, type, LE!)]. Not only they are similar

to each other, they also have some common characters, e.g. short stem (usually), non-connate stipules, non-appressed indumentum, black and white hairs on the calyx, and lacking bracteoles. The proposition of uniting these sections based on morphological characters is confirmed by hair characters as well. The hair characters for these sections are shown in Figure 4. In all of these taxa the fruit hairs are very asymmetrical and non-appressed.

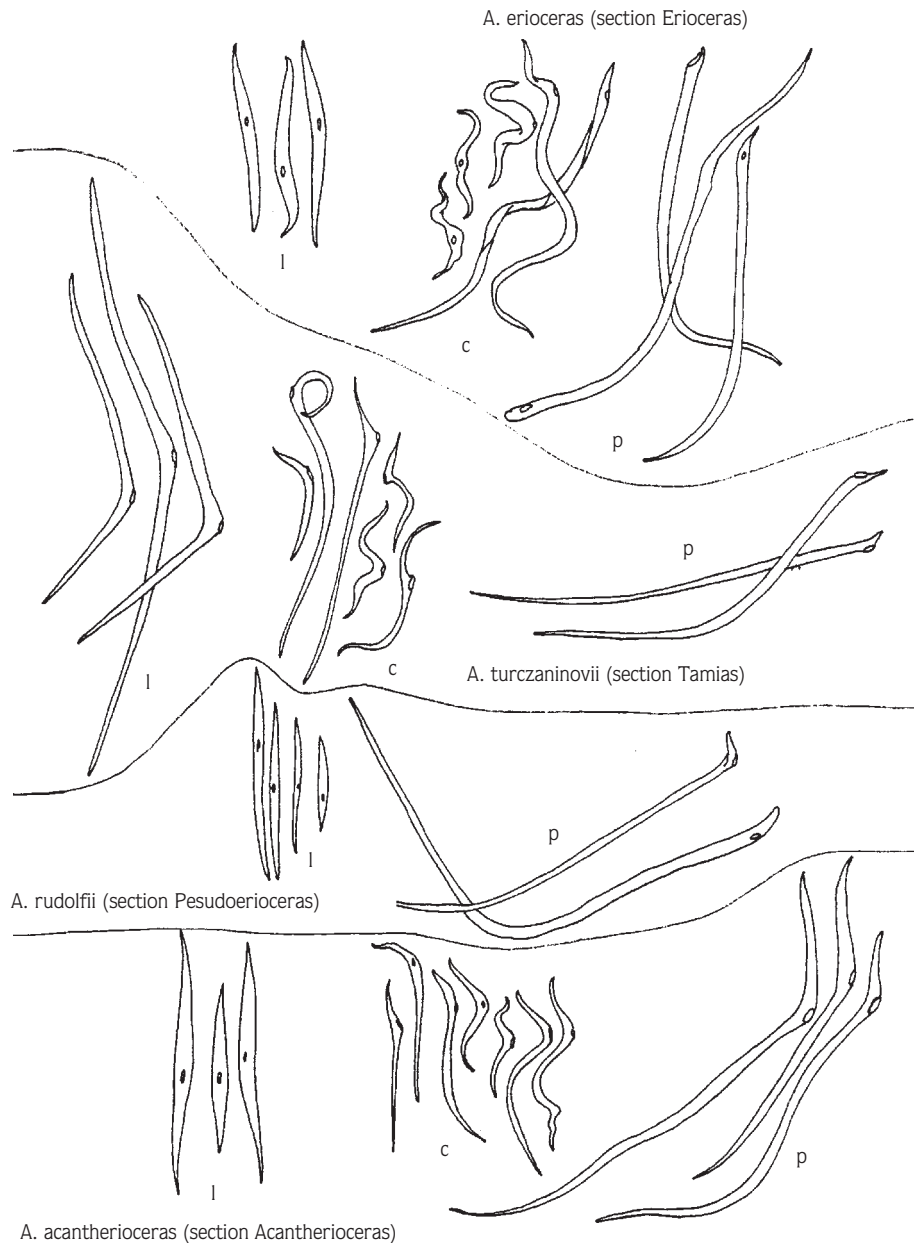


Figure 4. *A. erioceras*, *A. turczaninovii*, *A. rudolfii*, *A. acantherioceras*; (l = leaflet hairs; c = calyx hairs; p = pod hairs) x 20.

The closest section to *Erioceras* is *Xiphidium* Bunge. The differences between them are especially noticeable with regards length of stem and hair characters. The section *Xiphidium* has an appressed indumentum and more symmetrical and uniform hairs.

The best kind of indumentum to use for comparing sections is on the pod and the calyx. In vegetative parts (e.g. leaflets), the hairs are so similar to each other that no distinction can be made. For example the sections, *Xiphidium* and *Erioceras*, which are different morphologically and have dissimilar pod and calyx hairs, are very similar in leaflet indumentum.

Finally, it is proposed we more closely study bifurcate hair characters in order to illuminate intersectional relationships. Hence, it seems appropriate to provide details of hair characters in the original description of the species.

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Phylogenetic relationships between sections within the subgenus *Cercidothrix* are still not entirely understood, and future molecular systematic work will be necessary to help us better understand the sectional placement of many Old World *Astragali*.

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