

The Sections of *Astragalus* L. With Bifurcating Hairs in Iran

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Abstract: In this study *Astragalus* L. with bifurcating hairs in sectional levels in Iran are discussed (subgenus *Cercidothrix* Bunge).

This subgenus has more than 800 species in the Old World. Major areas of species endemism for this subgenus occur in Turkey, Iran, Kazakhstan and Afghanistan. Iran, with 158 species, is one of the most important centres of diversity.

Leucocercis Bunge is the only endemic section for Iran, although other sections have some species in different countries. Thus having a knowledge of the distribution quality in other areas is also important. In reality, this study is part of the author's research on bifurcating *Astragalus* in the whole of the Old World.

In this article, the most important characteristics for the separation of the sections, the relationships between the sections and an identification key for the sections in Iran are presented. For each section a distribution map is provided.

Key Words: *Astragalus*, *Cercidothrix*, Fabaceae, Galegeae, Iran, Old World.

Introduction

Astragalus L. (GAVAN in Persian) is probably the largest genus of flowering plants, containing up to 3000 species (Lock & Simpson, 1991). This genus is a member of the legume family (Fabaceae) and is traditionally classified in the tribe Galegeae. The centre of development seems to be in the arid and semi-arid mountainous parts of the Northern Hemisphere (Polhill, 1981). It is most diverse in the Irano-Turkish region of south-western Asia, the Sino-Himalayan Plateau of south-Central Asia, the Central Asian region, and the Great Basin and Colorado Plateau of western North America (Polhill, 1981).

This paper is about the bifurcating hairy *Astragalus* sections. Bifurcating hairy *Astragalus* species are involved in the *Astragalus* subgenus *Cercidothrix* Bunge (Bunge, 1868), which is characterised by perennial growth and the presence of bifurcate hairs (Bunge, 1868). This subgenus has more than 800 species in the Old World, 158 (20%) of which occur in Iran and 89 (56%) of which are endemic (Ghahreman et al., 2002; Podlech, 2001). Iran is one of the largest centres of diversity for the genus, with approximately 700 species and an endemism rate of 57% (Ghahreman et al., 2002). Major areas of species endemism for this subgenus occur in Turkey, Iran,

Kazakhstan, Afghanistan and China, with 92, 89, 47, 41 and 33 endemic species reported, respectively (Ghahreman et al., 2002; Podlech, 2001). Like the groups with simple hairy, bifurcating hairy *Astragalus* species appear in many sections. The identification of some of these sections is simple. On the other hand, some sections are different; these contain many species and are complex. For example, section *Incani* DC. and section *Xiphidium* Bunge are complex and need to be revised.

In this paper, the most important characteristics for the separation of the sections, the relationships between the sections and an identification key for the sections in Iran are presented (figures 1 and 2), and for each section a distribution map has been prepared (figure 3).

A description of *A.* subg. *Cercidothrix* follows.

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.

Perennials, herbaceous, subshrubs, shrubs, very rarely densely studded with long spines formed by old leaf rachis, vested with bifurcate hairs; stipules connate or free, adnate to petiole or rarely not; leaves generally imparipinnate, rarely paripinnate, petioles marcescent; peduncles long or rarely very short; inflorescence dense or lax, elongated or contracted, many-flowered in the leaf axils; bract usually shorter than calyx, rarely longer; bracteoles absent or sometimes with two minute bracteoles; calyx cylindrical to campanulate, or cylindrical-campanulate, not inflated to bladderly-inflated in fruit, ruptured or not ruptured by the pod; calyx teeth usually equal or unequal, subulate, setaceous or linear; corolla purple, pink, violet or yellow; standard glabrous or rarely pubescent; pod erect or curved, sessile or stipitate, included in the calyx or exceeding, coriaceous or rarely membranous and bladderly-inflated, fully or partially bilocular, or rarely completely unilocular.

Distribution: Asia, Europe, Africa and rarely America.

Identification key

Diagnostic key to the sections of *Astragalus* subg. *Cercidothrix* in Iran as follows:

1. Each flower usually with two bracteoles
2. Leaves imparipinnate
3. Acaulescent plants; stipules free sect. *Incani*
3. Caulescent plants; stipules connate
4. Plant with long erect stems sect. *Uliginosi*
4. Plant with prostrate stems sect. *Synochreati*
2. Leaves paripinnate
5. Caulescent; corolla yellow; indumentum black and white; pod bilocular, long-stipitate . . . sect. *Caraganella*
5. Acaulescent or with short stems; corolla not yellow; indumentum white; pod unilocular, short-stipitate sect. *Leucocercis*
1. Bracteoles absent
6. Fruit calyx inflated
7. Leaflets 1-2 pairs, terminal leaflet larger (width: 2-3 cm) sect. *Macrocystodes*
7. Leaflets 2-more pairs, terminal leaflet equal to the others (width 1 or < 1 cm)
8. Stipules connate sect. *Onobrychoidei* (*A. asciocalyx*)

8. Stipules free
9. Leaves 10-20 cm long; flowers 15-30 sect. *Laguropsis*
9. Not as above (leaves shorter, flowers fewer). sect. *Vesicarii* DC.
6. Fruit calyx non-inflated
10. Pod bladderly-inflated, membranous
11. Pod with sparse indumentum or glabrous. sect. *Cystium*
11. Pod with dense indumentum. sect. *Erioceras* (*A. durandianus*)
10. Pod not bladderly, coriaceous
12. Stipules free
13. Caulescent; fruits with densely appressed indumentum, usually longer than two times the length of the calyx sect. *Xiphidium*
13. Acaulescent or with short stems; fruits not as above
14. Inflorescence sessile; calyx usually white hairy sect. *Trachycercis*
14. Inflorescence pedunculate; calyx usually white and black hairy (with parallel black and white lines) sect. *Erioceras*
12. Stipules connate
15. Calyx 4 mm long or shorter sect. *Craccina*
15. Calyx longer than 6 mm
16. Fruits 4-11 cm long and beak 1-7 cm sect. *Cytisodes*
16. Fruit shorter than above
17. Woody; leaflets 1-3 (6) pairs
18. Stems short; fruits with more seeds; corolla curved. sect. *Cremonoceras*
18. Stems developed (fruticose-suffruticose); fruits with few seeds; corolla straight . . . sect. *Ammodendron*
17. Herbaceous; leaflets more than above
19. Acaulescent or with short stems; standard usually orbicular or nearly so. sect. *Hololeuce*
19. Caulescent; standard elongate and attenuate upward.

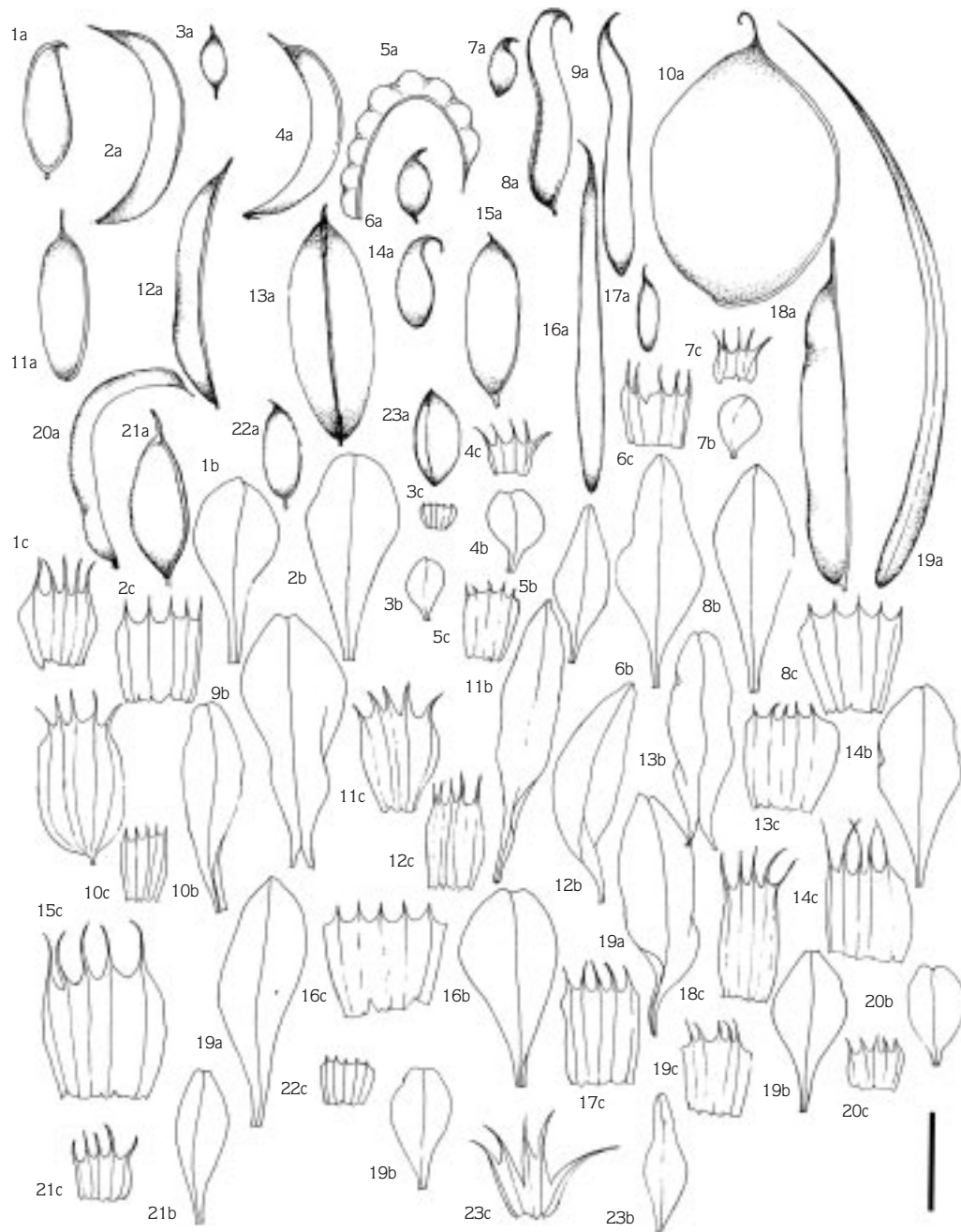


Figure 1. The Fruit, Standard and Calyx. 1. *A. uliginosus* L. (sect. *Uliginosi*); 2. *A. fragrans* Willd. (sect. *Synochreati*); 3. *A. austriacus* Jacq. (sect. *Craccina*); 4. *A. ui-eilakensis* F.Ghahremani. (sect. *Craccina*); 5. *A. ornithopodioides* Lam. (sect. *Ornithopodium*); 6. *A. onobrychis* L. (sect. *Onobrychoidei*); 7. *A. hololeucus* Boiss. & Buhse (sect. *Hololeuce*); 8. *A. erioceras* Fisch. & C.A.Mey. (sect. *Erioceras*); 9. *A. acantherioceras* Rech.f. (sect. *Erioceras*); 10. *A. physodes* L. (sect. *Cystium*); 11. *A. humilis* M.Bieb. (sect. *Trachycercis*); 12. *A. incanus* L. (sect. *Incani*); 13. *A. frickii* Bunge (sect. *Incani*); 14. *A. laguroides* Pall. (sect. *Laguropsis*); 15. *A. chrysomallus* Bunge (sect. *Macrocytodes*); 16. *A. xiphidium* Bunge (sect. *Xiphidium*); 17. *A. vesicarius* L. (sect. *Vesicarii*); 18. *A. cytisodes* Bunge (sect. *Cytisodes*); 19. *A. gigantirostratus* Maassoumi, Ghahr., F.Ghahremani & Matin (sect. *Cytisodes*); 20. *A. ochreatus* Bunge (sect. *Cremerceras*); 21. *A. ammodendron* Bunge (sect. *Ammodendron*); 22. *A. stocksii* Benth. ex Bunge (sect. *Caraganella*); 23. *A. mucronifolius* Boiss. (sect. *Leucocercis*); Scale bar = 1 cm.

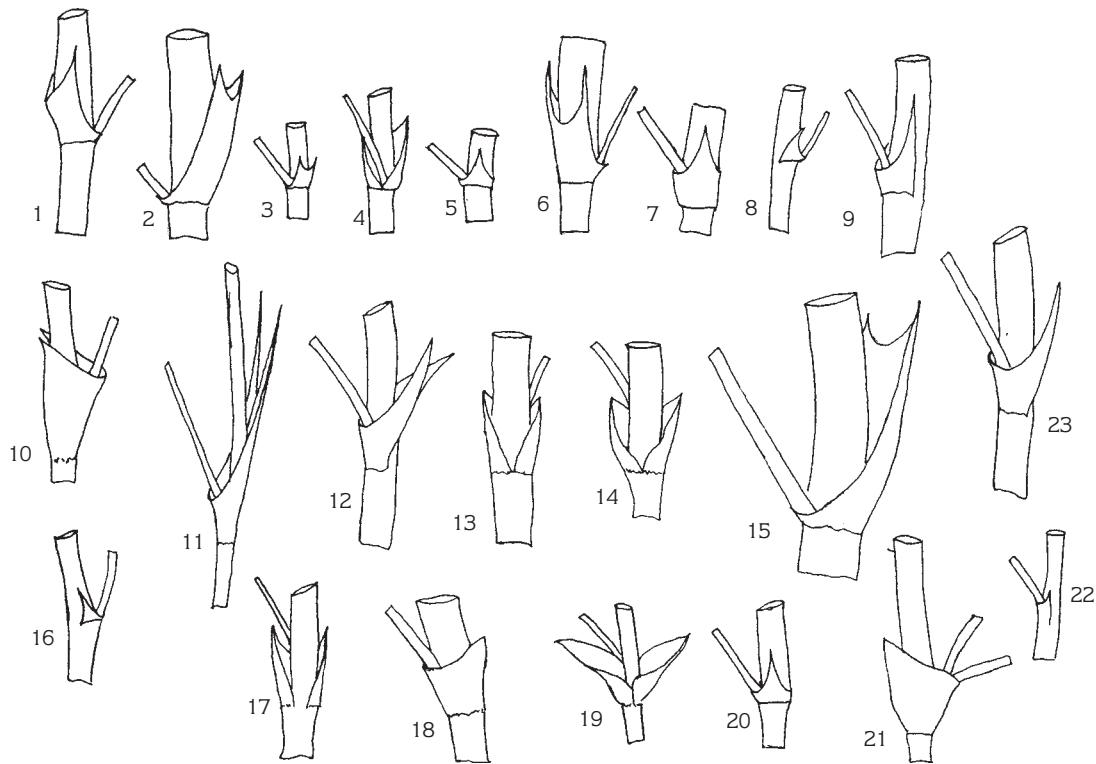


Figure 2. The Stipules. 1. *A. uliginosus* L. (sect. *Uliginosi*); 2. *A. fragrans* Willd. (sect. *Synochreati*); 3. *A. austriacus* Jacq. (sect. *Craccina*); 4. *A. ui-eilakensis* F.Ghahremani. (sect. *Craccina*); 5. *A. ornithopodioides* Lam. (sect. *Ornithopodium*); 6. *A. onobrychis* L. (sect. *Onobrychoidei*); 7. *A. hololeucus* Boiss. & Buhse (sect. *Hololeuce*); 8. *A. erioceras* Fisch. & C.A.Mey. (sect. *Erioceras*); 9. *A. acantherioceras* Rech.f. (sect. *Erioceras*); 10. *A. physodes* L. (sect. *Cystium*); 11. *A. humilis* M.Bieb. (sect. *Trachycercis*); 12. *A. incanus* L. (sect. *Incani*); 13. *A. frickii* Bunge (sect. *Incani*); 14. *A. laguroides* Pall. (sect. *Laguropsis*); 15. *A. chrysomallus* Bunge (sect. *Macrocystodes*); 16. *A. xiphidium* Bunge (sect. *Xiphidium*); 17. *A. vesicarius* L. (sect. *Vesicarii*); 18. *A. cytisodes* Bunge (sect. *Cytisodes*); 19. *A. gigantirostratus* Maassoumi, Ghahr., F.Ghahremani & Matin (sect. *Cytisodes*); 20. *A. ochreatus* Bunge (sect. *Creloceras*); 21. *A. ammodendron* Bunge (sect. *Ammodendron*); 22. *A. stocksii* Benth. ex Bunge (sect. *Caraganella*); 23. *A. mucronifolius* Boiss. (sect. *Leucocercis*); Scale bar = 1 cm.

- 20. Fruits usually many times longer than the calyx, curved sect. *Ornithopodium*
- 20. Fruits shorter, equal or somewhat longer than the calyx sect. *Onobrychoidei*

The sections of *Astragalus* subg. *Cercidothrix* in Iran are as follows:

[The distributions, number of the species of each section, and phytogeographical discussions are based on the following references: Aytaç (2000), Chater (1968), Davis (1970), Ghahreman et al. (2002), Kuntsun et al. (1993), Lock & Simpson (1991), Maassoumi et al. (1999, 2000), Podlech (2001), Rechinger et al. (1958, 1959, 1961, 1969), Townsend (1974) and Yakovlev et al. (1996)].

1. *Astragalus* L. Sect. *Ammodendron* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 109, 1868.
Lectotype (Podlech, 1990): *A. ammodendron* Bunge

This section, which was originally established by Alexander Bunge (1868) with 19 species, is now represented by 49 species.

Characteristics. Shrubs or subshrubs, often becoming more or less leaflet-less with age. Stipules connate. Inflorescence usually lax, short pedunculate. Bracteoles absent. Calyx campanulate or nearly so, not inflated in fruit. Pod bilocular, coriaceous, slightly longer than the calyx.

Phytogeography. *Astragalus* section *Ammodendron* has its centre of diversity in the Turkestanian floristic province (Takhtajan, 1986) of the Irano-Turanian region,

with vast distribution in the Armeno-Iranian province of the region. The species of this section are distributed in Central Asia, South Asia, the Middle East, East Asia, West Asia, the Caucasus, North Africa and Eastern Europe.

Distribution in Iran. This section is concentrated, with its psammophyte species, mainly in the central, southern and eastern parts of Iran. In the northern region the more mesophile species penetrate. The southern areas of Iran are nearly the extreme ranges of the section. This section has 11 species, of which seven are endemic in Iran. Two of the endemic species are *A. ammodendroides* Bornm. and *A. kavirensis* Freitag. The species *A. squarrosus* Bunge is a desert woody plant with a vast range, from Uzbekistan to south of the Persian Gulf. These species grow at an altitude of between 20 and 3500 m in Iran.

Relationships. The closest relative sections are *Cremonoceras* Bunge and *Cytisodes* Bunge. It differs from them in its shrubby habit and fruit shape.

2. *Astragalus* L. Sect. *Caraganella* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 6, 1868. - Lectotype (spec. unic.): *A. stocksii* Bunge

This section was originally established by Alexander Bunge (1868) with one species, and is now represented by four species.

Characteristics. Spiny, shrubs, with some basifixed hairy. Stipules free (non-connate). Heterophyllous leaves on long shoots paripinnate with a spinous rachis, those on short shoots imparipinnate. Inflorescence short pedunculate, lax. Bibracteolate. Calyx campanulate, not inflated in fruit. Corolla yellow. Pods long-stalked, bilocular, coriaceous.

Phytogeography. *Astragalus* section *Caraganella* has its centre of diversity in the Armeno-Iranian floristic province (Takhtajan 1986) of the Irano-Turanian region. The species of this section are distributed in South and West Asia.

Distribution in Iran. This section is concentrated mainly in the southeastern parts of Iran. This small section has two species, of which one is endemic to Iran. The Iranian species are *A. memoriosus* Pakravan, Nasseh & Maassoumi (endemic) and *A. stocksii* Bunge. The section had a continuous habitat in an area between Iran, Afghanistan and Pakistan. These species are all desert

plants. However, *A. memoriosus*, with a separate distribution, in a different climate, in the Golestan Forest, grows in the northern region of Iran (Pakravan et al., 1994). These species grow at an altitude of between 700 and 1350 m in Iran.

Relationships. This section is well distinguished from all other sections of the subgenus by the combination of minute bracteoles and bracts, long-stalked fruit, having some basifixed hairs etc. This section is close to woody sections of the subgenus.

3. *Astragalus* L. Sect. *Craccina* (Steven) Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 97, 1868. - Lectotype (Podlech 1990): *A. austriacus* Jacq.

= *Craccina* Steven, Bull. Soc. Imp. Naturalistes Moscou 29: 144, 1868.

This section, which was originally established by Alexander Bunge (1868) with 10 species, is now represented by 23 species.

Characteristics. Herbaceous plants, usually with well-developed stems, sometimes from a woody base. Stipules connate or not. Leaves imparipinnate, the petiole usually marcescent. Bracteoles absent. Calyx campanulate or nearly so, not inflated in fruit. Inflorescence usually elongate and lax. Pods sessile or nearly so, usually bilocular.

Phytogeography. *Astragalus* section *Craccina* has a vast distribution from the Circumboreal region (Takhtajan, 1986) to China. The species of this section are distributed in Central Asia, the Middle East, East Asia, North Asia, West Asia, the Caucasus and Europe.

Distribution in Iran. This section has one endemic species in south Central Iran, *A. huthianus* Freyn & Bornm. For this section 22 species have been reported above 40 degrees latitude, and the report of a single species (Freyn, 1897) in Kerman province (Iran) at 30 degrees latitude, represents a difficult challenge in the interpretation of the migration. Hence the study of type species is essential. Based on the original description it is similar to section *Onobrychoidei* DC. and may be a candidate for this section. This species grows at an altitude of between 2900 and 3000 m in Iran.

Relationships. The closest relative of this section is section *Irinaea* Boriss. Their floral characteristics are

similar. Section *Craccina* differs from *Irinaea* in having bilocular fruit, and usually its wing is longer than the keel. Section *Irinaea* has some species in Tajikistan, Pakistan, India and Afghanistan.

4. *Astragalus* L. Sect. *Creloceras* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 127, 1868. -
Lectotype (spec. unic.): *A. ochreatus* Bunge

= Sect. *Cercidophaca* Podlech & Maassoumi in Davis & Hedge,
Festschrift: 77, 1989.

This section, which was originally established by Alexander Bunge (1868) with one species, is now represented by three species.

Characteristics. Shrublets. Leaves with few leaflets, imparipinnate. Stipules connate. Inflorescence pedunculate. Calyx campanulate, not inflated in fruit. Bracteoles absent. Pod usually long curved into a semi-circle, usually acute at both ends, bilocular.

Phytogeography. *Astragalus* section *Creloceras* has its centre of diversity in the Armeno-Iranian floristic province (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in Central Asia and West Asia.

Distribution in Iran. This small section has two species (*A. ochreatus* Bunge, *A. campylanthoides* Bornm.), of which one is endemic (*A. ochreatus*) in Iran. Its distribution range is a relatively continuous range from West Iran to South-west Turkmenistan and to North-west Afghanistan. This section is concentrated mainly from the southern Elburz Mts. to North-east Iran. From Northeast Iran, it penetrates to a small area in Turkmenistan and Afghanistan. This taxon is in fact a semi-endemic section for Iran. These species grow at an altitude of between 300 and 2130 m in Iran.

Relationships. The closest section to this section is section *Ammodendron*. Section *Creloceras* differs from *Ammodendron* in having longer fruit, shorter fruit stipe and a shorter habit.

5. *Astragalus* L. Sect. *Cystium* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 113, 1868. -
Lectotype (Podlech, 1990): *A. physodes* L.

= Sect. *Xerophysa* (Steven) Barneby, Mem. New York Bot. Gard.
13: 1167, 1964.

= *Xerophysa* Steven, Bull. Soc. Imp. Naturalistes Moscou 29: 147,
1856.

This section, which was originally established by Alexander Bunge (1868) with six species is now represented by 15 species.

Characteristics. Nearly acaulescent plants. Stipules more or less connate. Leaves imparipinnate, the petiole marcescent. Inflorescence contracted, long-pedunculate. Bracteoles absent. Calyx cylindrical, not inflated in fruit. Pods sessile or nearly so, inflated, membranous, glabrous or nearly so.

Phytogeography. *Astragalus* section *Cystium* has its centre of diversity in the Turkestanian floristic province (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in Central Asia, South Asia, East Asia, North Asia, West Asia, the Caucasus and Europe.

Distribution in Iran. This section has two species, of which one is endemic (*A. didymophysus* Bunge) and concentrated in the Elburz Mts. (from the northwest to the north-east of Iran), and Kopet-Dagh Mt. (in the north-east of Iran). These species grow at an altitude of between 1900 and 2800 m in Iran.

Relationships. The closest relatives of this section are *Paracystium* Gontsch., *Leucophysa* Bunge and *Erioceras* Bunge. It differs from *Erioceras*, *Paracystium* and *Leucophysa* in fruit structure.

6. *Astragalus* L. Sect. *Cytisodes* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 127, 1868.
Lectotype (spec. unic.): *A. cytisodes* Bunge

This section which was originally established by Alexander Bunge (1868) with one species, is now represented by 11 species.

Characteristics. Dwarf shrubs or acaulus. Stipules connate. Leaves imparipinnate. Inflorescence usually short, compact. Bracteoles absent. Calyx cylindrical, not inflated in fruit. Bracts usually oblong to lanceolate. Pods sessile, coriaceous, bilocular, the beak mostly long (1-7 cm long).

Phytogeography. *Astragalus* section *Cytisodes* has its centre of diversity in the Turkestanian floristic province (Takhtajan, 1986), part of the Irano-Turanian region. The species of this section are distributed in Central Asia, East Asia and West Asia.

Distribution in Iran. This section has two endemic species (*A. gigantirostratus* Maassoumi, Ghahr., F.Ghahremani & Matin, *A. neyshaburensis* Podlech) in Iran. This section was formerly an endemic section for Central Asia and a part of China. The presence of the two species of this section in Iran (Maassoumi et al. 1999; Podlech, 1999) is an example of the close relationships of the genus *Astragalus* between Iran and Central Asia. The presence of these species in Iran shows the remarkable distribution range of the section. This section has probably migrated to Iran from Central Asia, i.e. a south-western migration. The distribution area of the section is not a continuous zone, thus it is advisable to search for species of the section in the area between the two reported localities (Iran and Central Asia), so as to define a continuous extension range. These species are distributed at an altitude of between 800 and 1650 m in Iran.

Relationships. The closest relatives of this section are *Cremoceras* and *Ammodendron*. It differs from them in having longer fruit.

7. *Astragalus* L. Sect. *Erioceras* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 109, 1868. -
Lectotype (Podlech, 1990): *A. erioceras* Fisch. & C.A.Mey.

= Sect. *Acantherioceras* Rech.f., Biol. Skr. 9, 3: 147, 1958. Syn.
Nov.

This section, which was originally established by Alexander Bunge (1868) with seven species, is now represented by 36 species.

Characteristics. Herbaceous or woody plants, stems short, rarely subcaulescent. Stipules free. Leaves imparipinnate, rarely with spinous marcescent rachis. Inflorescence short, subumbellate. Bracteoles absent. Calyx cylindric, usually not inflated in fruit, usually with parallel white and black hairy lines. Pods sessile or subsessile, coriaceous, elongated, bilocular or nearly so, more or less curved.

Astragalus section *Acantherioceras* Rech.f. with only one species: *A. acantherioceras* Rech.f. & Koei (M.E. Koei 4450, type, W!) is a candidate as a subsection of section *Erioceras*, the most important difference is the presence of the tragacanthic petiole in the first section.

Phytogeography. The centre of diversity of this section is the Turkestanian floristic province (Takhtajan,

1986) of the Irano-Turanian region. The species of section *Erioceras* are distributed in Central Asia, South Asia, East Asia, West Asia, the Caucasus and Europe.

Distribution in Iran. This section has eight species, of which seven are endemic. *A. acantherioceras* is distributed in Iran and Afghanistan. Recently (Ghahremani et al. 1996) *A. triqueter* Bornm. & Gauba has been moved from section *Xiphidium* to this section. This section has a continuous range in the central, north-western, eastern and western parts of Iran. This species probably penetrated Iran from Central Asia, i.e. a south-western migration. This section is concentrated mainly in the north-eastern parts of Iran. These species are distributed at an altitude of between 180 and 2500 m in Iran.

Relationships. The close relative sections are *Xiphidium*, *Vesicarii* DC. and *Tamias* Bunge. The combination of a shorter stem and fruit indumentum distinguishes it from these.

8. *Astragalus* L. Sect. *Hololeuce* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 104, 1868. -
Lectotype: (Podlech, 1990): *A. hololeucus* Boiss. & Buhse.

= Sect. *Chlorosphaerus* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 106, 1868.

= Sect. *Xerophilus* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 104, 1868.

This section, which was originally established by Alexander Bunge (1868) with 21 species, is now representative with 36 species.

Characteristics. Usually dwarf plants herbaceous, shortly caulescent or acaulescent. Leaves imparipinnate. Inflorescence capitate, long-pedunculate, flowers usually sessile. Bracteoles absent or sometimes present. Calyx campanulate, not inflated in fruit. Pods exceeding the calyx, bilocular or nearly so, few-seeded.

Phytogeography. The centre of diversity of this section is partly the west of the Armeno-Iranian province (Takhtajan, 1986) of the Irano-Turanian region, and partly the Caucasian floristic province of the Circumboreal region. The species of this section are distributed in Central Asia, the Middle East, West Asia, the Caucasus and Europe.

Distribution in Iran. This section has four non-endemic species. *A. bicolor* Lam. is distributed in the west, and *A. alyssoides* Lam. from the west to east of Iran. Iranian species are distributed in Elburz to the Kopet-Dagh Mts., and in the west of Iran (Azarbayjan province). There are probably two migration routes for Iran. The first is from the Caucasus towards the west of Iran; the second route might be from Turkmenistan to the Iranian part of the Kopet-Dagh Mts. These species grow at an altitude of between 800 and 3500 m in Iran.

Relationships. The closest relative section is *Onobrychoidei*. Section *Hololeuce* differs from it in having shorter or no stems, and a different shape of standard.

9. *Astragalus* L. Sect. *Incani* DC.

Prodr. Sys. Nat. Reg. Veg. 2: 304, 1825. - Lectotype (Podlech, 1990): *A. incanus* L.

= Sect. *Proselius* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 116, 1868.

= Sect. *Myobromopsis* Boriss., Fl. URSS 12: 881, 1946.

= Sect. *Holophyllum* Boriss., Bot. Zhurn. SSSR 33: 331, 1948.

This section, which was originally established by De Candolle (1825) with 12 species, is now represented by 123 species. Bunge (1868) introduced this section under *Proselius*.

Characteristics. Herbaceous plants or occasionally lignified at the base, usually acaulescent. Stipules free. Leaves imparipinnate, rarely tri- or unifoliate, marcescent. Inflorescence dense or lax, usually long-pedunculate. Bibracteolate. Calyx cylindrical, not becoming inflated, often splitting later. Pods sessile or stipitate, very variable in form, bilocular, coriaceous to lignified.

Phytogeography. The centre of diversity of this section is the Armeno-Iranian floristic province (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in Central Asia, the Middle East, South Asia, East Asia, West Asia, Caucasus, North Africa and Europe.

Distribution in Iran. This section has 56 species, of which 33 are endemic, in Iran. This section is the largest and most common bifurcate hairy section in Iran. Some of the endemic species of the section are as follows: *A. askius* Bunge, *A. cyclophyllon* G.Beck, *A. fridae* Rech.f., *A. lovensis* Rech.f., *A. xiphidiopsis* Bornm. and *A.*

leucophanus Bornm. Section *Incani* has a vast distribution zone in Iran, and occupies a large part of Iran in the Elburz and Zagros Mts. in North and West Iran. Iran may be a bridge between Central Asia and the Caucasus and Anatolia for the migration of the section. These species grow at an altitude of between 950 and 3000 m in Iran.

Relationships. The closest relatives of this section are *Xiphidium* and *Trachycercis* Bunge. This acaulescent section differs from them in having two bracteoles.

10. *Astragalus* L. Sect. *Laguroopsis* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 137, 1868. Lectotype (Podlech, 1990): *A. laguroides* Pall.

= Sect. *Sphaerocystis* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 138, 1868.

= Sect. *Holargyreus* Vved., Bot. Mater. Gerb. Inst. Bot. Akad. Nauk Uzbeksk. SSR 16: 14, 1961.

This section, which was originally established by Alexander Bunge (1868) with five species, is now represented by 36 species.

Characteristics. Herbaceous, acaulescent or nearly so. Stipules usually free, rarely connate. Leaves imparipinnate. Inflorescence compactly capitate, long-pedunculate, many flowers. Bracteoles absent. Calyx initially cylindrical, becoming bladderly-inflated. Pods sessile or subsessile, remaining within the calyx, few seeded, bilocular.

Phytogeography. The centre of diversity of this section is the Turkestanian and Mongolian floristic provinces (Takhtajan, 1986) of the Irano-Turanian region. This section has the widest range and is distributed from China and Mongolia to Turkey, with one species in Europe, i.e. Central Asia, the Middle East, South Asia, North Asia, West Asia and the Caucasus.

Distribution in Iran. This section has one species in Iran, i.e. *A. subsecundus* Boiss. & Hohen. *Astragalus urgutinus* Lipsky was listed as a species for this section from Iran (Lock & Simpson 1991), but it has been transferred to section *Xiphidium* by Yakovlev et al. (1996). This species grows at an altitude of between 2100 and 3500 m in Iran.

Relationships. The closest relative section is *Chaetodon* Bunge (a Central Asian section); in fact these

are two closely related sections. Unlike *Chaetodon*, it is usually acaulescent.

11. *Astragalus* L. Sect. *Leucocercis* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 132, 1868. - Lectotype (Podlech, 1990): *A. mucronifolius* Boiss.

This section, which was originally established by Alexander Bunge (1868) with three species, is now represented by nine species.

Characteristics. Short-stemmed, woody-shrubby plants. Stipules free. Leaves paripinnate, rachis thick, persistent, spinose, leaflets usually long woody mucronate. Inflorescence short pedunculate, usually lax. Bibracteolate. Calyx campanulate to campanulate-cylindric, not inflated in fruit. Pods unilocular, exceeding the calyx.

Phytogeography. The centre of diversity of this section is the Armeno-Iranian floristic province (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in West Asia (endemic for Iran).

Distribution in Iran. This section has xerophytic species, and is distributed in Iranian deserts, especially in the central, southern, and southeastern parts of Iran. Its nine species are endemic to Iran. These species grow at an altitude of between 300 and 2700 m in Iran.

Relationships. The closest relative section is *Melanocercis* Bunge (nearly a European section), and both of these sections are woody and bibracteolate. It differs from *Melanocercis* in having paripinnate leaves.

12. *Astragalus* L. Sect. *Macrocystodes* Popov

Fl. URSS 12: 882, 1946. - Lectotype (Podlech, 1990): *A. chrysomallus* Bunge

= Sect. *Bucharica* B.Fedtsch.

This section, which was originally established by Popov (Gontscharov et al., 1946) with six species, is now represented by 11 species.

Characteristics. Stems usually well developed. Stipules connate or not. Leaves imparipinnate. Inflorescence lax, elongating in fruit. Bracteoles absent. Calyx at first cylindrical, becoming inflated, finally ruptured by the pod. Pod sessile or nearly so, coriaceous, bilocular, few seeded.

Phytogeography. *Astragalus* section *Macrocystodes* has its centre of diversity in the Turkestanian floristic province (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in Central Asia and West Asia (Iran).

Distribution in Iran. This section is represented by *A. pseudorhacodes* Gontsch. (Maassoumi, 1998). This section was previously endemic in Central Asia (based on Yakovlev et al., 1996). The Iranian species is doubtless a product of the south-western migration of the section from Central Asia to North-east Iran. This species grows at an altitude of between 1550 and 1950 m in Iran.

Relationships. The closest relatives of this section are *Macrocystis* Popov and *Cysticalyx* Bunge. It differs from them due to the rupturing of its fruit calyx.

13. *Astragalus* L. Sect. *Onobrychoidei* DC.

Prodr. 2: 285, 1825. - Lectotype: (Barneby, 1964): *A. onobrychis* L.

= Sect. *Onobrychium* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 100, 1868.

= Sect. *Onobrychides* Grey, Proc. Amer. Acad. 6: 197, 1864.

= Sect. *Asciocalyx* Bunge, Mem. Acad. Imp. Sci. 16: 137, 1868.

This section, which was originally established by De Candolle (1825) with 20 species, is now represented by 81 species.

Characteristics. Caulescent herbaceous plants, usually erect with long stems. Stipules connate. Leaves imparipinnate. Inflorescence densely capitate, pedunculate. Bracteoles absent. Calyx campanulate or rarely cylindrical not inflated in fruit. Standard usually long attenuate in upper part. Pod bilocular or nearly so, longer than the calyx.

Phytogeography. The centre of diversity of this section is the west of the Armeno-Iranian province (Takhtajan, 1986) of the Irano-Turanian region, and partly the Caucasian floristic province of the Circumboreal region. The species of this section are distributed in Central Asia, South Asia, the Middle East, East Asia, North Asia, West Asia, the Caucasus, North Africa, Europe and North America.

Distribution in Iran. This section has 20 species, of which eight are endemic. Some of the endemic species for Iran are as follows: *A. lilacinus* Boiss., *A. effusus* Bunge,

A. khorrabadensis Bornm., and *A. teheranicus* Boiss. The Iranian habitats of the section are a part of the very vast distribution range of the section, which probably migrated from the Caucasus. These species are distributed at an altitude of between 880 and 3400 m in Iran.

Relationships. The closest relatives of this section are *Hololeuce* and *Ornithopodium* Bunge, and *Uliginosi* Gray (a bracteolate section). It differs from *Hololeuce* in having a longer stem and an attenuate standard. It differs from section *Ornithopodium* in having shorter fruits. In comparison with section *Ornithopodium*, the species of this section grows in drier habitats.

14. *Astragalus* L. Sect. *Ornithopodium* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 100, 1868. - Lectotype (Podlech, 1990): *A. ornithopodioides* Lam.

This section, which was originally established by Alexander Bunge (1868) with nine species, is now represented by 17 species.

Characteristics. Caulescent herbaceous, with developed erect or prostrate stems. Stipules connate. Leaves imparipinnate. Inflorescence pedunculate, elongate, many-flowered. Bracteoles absent. Calyx not inflated, cylindrical-campanulate, not inflated in fruit. Standard usually long attenuate in upper part. Pod narrowly cylindrical, elongated, many times the length of the calyx, often curved, bilocular.

Phytogeography. The centre of diversity of this section is partly the west of the Armeno-Iranian province (Takhtajan, 1986) of the Irano-Turanian region and partly the Caucasian floristic province of the Circumboreal region. The species of this section are distributed in Central Asia, East Asia, West Asia, the Caucasus and Europe. The extremity of the penetration of this section to the east is Central Iran, if two Chinese species are ignored. Whether these two Chinese species belong to this section is arguable, due to the long distance involved.

Distribution in Iran. This section has 11 species, of which five are endemic: *A. brevipes* Bunge, *A. brachyodontus* Boiss., *A. schistosus* Boiss. & Hohen., *A. trigonelloides* Boiss. and *A. variistipula* Turritt. The Iranian habitats of the section are a part of the distribution range of the section, which is probably migrating from the Caucasus, or alternatively, Iran may

be the ancestral region for this section. These species grow at an altitude of between 790 and 2350 m in Iran.

Relationships. The closest relatives of this section are *Hololeuce* and *Onobrychoidei*, and *Uliginosi* (a bracteolate section). It differs from *Hololeuce* in having a longer stem and an attenuate standard. It differs from *Onobrychoidei* in having longer fruits.

15. *Astragalus* L. Sect. *Synochreati* DC.

Prodr. Syst. Nat. Reg. Veg. 2: 291, 1825. - Lectotype (Podlech, 1990): *A. fragrans* Willd.

= sect. *Acmothrix* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 108, 1868.

This section, which was originally established by De Candolle (1825) with 10 species, is now represented by only six species because some of its species have been transferred to other sections.

Characteristics. Dwarf herbaceous plants with a woody base and prostrate year stems. Stipules connate. Leaves imparipinnate, marcescent. Inflorescence, few-flowered. Bibracteolate. Calyx cylindrical to campanulate, not inflated in fruit. Pod coriaceous, nearly bilocular, several-seeded.

Phytogeography. The centre of diversity of this section is the Caucasian floristic province of the Circumboreal region. The species of this section are distributed in the Middle East, West Asia and the Caucasus.

Distribution in Iran. This section has two species in Iran: *A. fragrans* Willd. and *A. levieri* Freyn. Their habitat range in Iran is a small area in north-western parts. The members of this section have probably come to Iran from areas in the Caucasus. These species grow at an altitude of between 1700 and 2900 m in Iran.

Relationships. The closest relative of this section is section *Uliginosi*. It differs from *Uliginosi* only in having a shorter stem growth.

16. *Astragalus* L. Sect. *Trachycercis* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 114, 1868. - Lectotype (Podlech, 1990): *A. humilis* M.Bieb.

= Sect. *Deserta* S.B.Ho, Bull. Bot. Research 3 (1): 59, 1983.

= Sect. *Borodiniana* B.Fedtsch., Beih. Bot. Centralbl. 23, II. Abt.: 366, 1908.

= Sect. *Scabriseta* Kamelin, Flora Asiae Mediae vol. 6, 1981.

= Sect. *Wettsteiniana* Sirj. & Rech.f., Anz. Osterr. Akad. Wiss. Math. Nat. 115, 1955.

This section, which was originally established by Alexander Bunge (1868) with 16 species, is now represented by 57 species.

Characteristics. Caespitose low plants, usually acaulescent. Caudex woody. Stipules free. Inflorescent with 1-4 flowered, or in a very short pedunculate. Bracteoles absent. Calyx cylindrical or campanulate, not becoming inflated. Pod usually sessile, coriaceous, bilocular or rarely subbilocular, usually asymmetrical.

Phytogeography. The centre of diversity of this section is the Turkestanian and Mongolian floristic provinces (Takhtajan, 1986) of the Irano-Turanian region, with a vast distribution across the Central Asiatic subregion and Eastern Asiatic region. The species of this section are distributed in Central Asia, the Middle East, East Asia, North Asia, West Asia, the Caucasus and Europe.

Distribution in Iran. This section has three species, of which one is endemic: *A. dolichophyllus* Pall., *A. humilis* M.Bieb. and *A. poliotrichus* Bornm. (endemic). This section has a very small habitat in Iran, and doubtless migrated from the Caucasus to Iran. These species grow at an altitude of between 1340 and 3500 m in Iran.

Relationships. The closest relative of this section is *Tanythrix* Bunge (a Central Asian monotypic section). It differs from *Tanythrix* by being without stems.

17. *Astragalus* L. Sect. *Uliginosi* Gray

Proc. Amer. Acad. 6: 196, 1864. - Type: *A. uliginosus* L.

= Sect. *Euodmus* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 96, 1868.

This section, which was originally established by Gray (1864) with five species, is now represented by 11 species.

Characteristics. Herbaceous, with long and erect stems. Stipules connate. Leaves imparipinnate, the petiole marcescent. Inflorescence lax or nearly so, many-flowered, long-pedunculate. Bibracteolate. Calyx cylindrical or cylindrical-campanulate, not becoming inflated. Pods sessile, coriaceous, exceeding the calyx, bilocular or nearly so.

Phytogeography. The section *Uliginosi* has a vast distribution in the Circumboreal region (Takhtajan,

1986). The species of this section are distributed in Central Asia, South Asia, the Middle East, East Asia, North Asia, West Asia, the Caucasus, Europe and North America.

Distribution in Iran. This section is representative by *A. odoratus* Lam. in Iran. Iranian species, with a small distribution area (NW Iran), probably penetrated Iran from the Caucasus region. This species grows at an altitude of between 1500 and 2600 m in Iran.

Relationships. The closest relative of this section is *Synochreati*. It differs from *Synochreati* in having a longer and well-developed stem.

18. *Astragalus* L. Sect. *Vesicarii* DC.

Prodr. 2: 288, 1825 - Lectotype (Podlech, 1990): *A. vesicarius* L.

= Sect. *Cystodes* Bunge, Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 133, 1868.

= Sect. *Eriopodus* Popov, Trudy Turkest. Nauchn. obsc. 1: 36, 1923.

This section, which was originally established by De Candolle (1825) with four species, is now representative with 15 species.

Characteristics. Subshrubby plants, with developed stems. Stipules free. Leaves imparipinnate. Inflorescence long-pedunculate. Bracteoles absent. Calyx at first cylindrical, becoming inflated and finally ruptured by the pod. Pods sessile or nearly so, rigidly coriaceous, bilocular, rarely subbilocular, indumentum ascending to spreading.

Phytogeography. The *Astragalus* section *Vesicarii* has most of its centre of diversity in the Eastern European floristic province (Takhtajan, 1986) of the Circumboreal region. The species of this section are distributed in Central Asia, South Asia, the Middle East, West Asia and Europe.

Distribution in Iran. This section has one endemic species, *A. alamliensis* Rech.f., a narrowly endemic species in Khorassan province. This section with only one species in the north-eastern part of Iran probably migrated from Central Asia to Iran. This species grows at an altitude of between 1200 and 1400 m in Iran.

Relationships. The closest relative of this section is *Xiphidium*; in fact they are two very related sections. It differs from *Xiphidium* in its inflated calyx and non-appressed fruit indumentum.

19. *Astragalus* L. Sect. *Xiphidium* Bunge

Mem. Acad. Imp. Sci. Saint Petersburg 11, 16: 123, 1868. -
Lectotype (Podlech, 1990): *A. xiphidium* Bunge.

= Sect. *Drepanolobus* Nabiev & Vved., Bot. Mater. Gerb. Inst. Bot.
Akad. Nauk Uzbeksk. SSR 14: 18, 1954.

= Sect. *Dissitiflora* DC., Prodr. 2: 284, 1825.

= Sect. *Paraxiphidium* Kamelin, Consp. Fl. Asiae Med., vol. 6, 1981.

= Sect. *Pseudohelminia* Kamelin, Consp. Fl. Asiae Med., vol. 6, 1981.

= Sect. *Leptopi* Kamelin, Consp. Fl. Asiae Med., vol. 6, 1981.

= Sect. *Paracraccina* Kamelin, Consp. Fl. Asiae Med., vol. 6, 1981.

This section, which was originally established by Alexander Bunge (1868) with 34 species, is now represented by 169 species.

Characteristics. Herbaceous to frutescent plants, long-stemmed. Stipules free. Leaves imparipinnate, the petiole marcescent. Inflorescence lax or sometimes compact, long-pedunculate. Bracteoles absent. Calyx cylindric, not becoming inflated. Pod stipitate or sessile, many-seeded, bilocular, coriaceous, longer than the calyx, usually covered with appressed hairs.

Phytogeography. The centre of diversity of this section is the Turkestanian and Armeno-Iranian floristic provinces (Takhtajan, 1986) of the Irano-Turanian region. The species of this section are distributed in Central Asia, South Asia, the Middle East, East Asia, North Asia, West Asia, the Caucasus and Europe.

Distribution in Iran. Section *Xiphidium* is the largest bifurcate section in the world. After section *Incani*, it is also the largest section in Iran. In comparison with section *Incani*, this section is distributed in the drier parts of Iran. This section has 21 species, of which 14 are endemic, in Iran. *A. moussavii* Maassoumi, F.Gahremani. & Ghahr., *A. ruscifolius* Boiss., *A. tolgorensis* Sirj. & Rech.f., *A. melanocalyx* Boiss. & Buhse and *A. sitiens* Bunge are some of its endemic species. This section has a vast continuous area in the Old World. Iran is the lowest latitude for it. Iranian species probably partly came from Central Asia and partly from the Caucasus, and maybe were partly an ancestral pool. These species grow at an altitude of between 220 and 4000 m in Iran.

Relationships. The closest relative of this section is section *Vesicarii*, from which it differs in having a non-inflated calyx and appressed fruit indumentum.

Discussion

Asia is the centre of diversity of *Astragalus*. There are more than 40 bifurcated sections of *Astragalus* in Asia, of which nearly 40% are endemic (based on Yakovlev et al., 1996; Lock & Simpson, 1991).

Central Asia is the largest centre of diversity for bifurcating *Astragalus*. This area with nearly 310 bifurcate species has the most concentrated habitat for the subgenus. Central Asia with 201 endemic species,

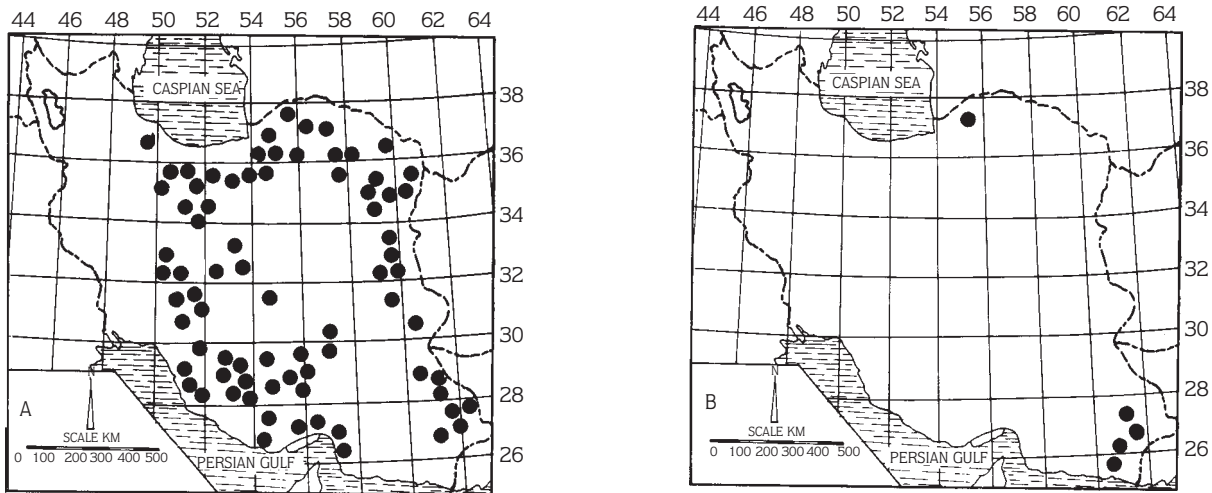


Figure 3. Distribution maps. A: sect. *Ammodendron*, B: sect. *Caraganella*, C: sect. *Craccina*, D: sect. *Cremoceras*, F: sect. *Cytisodes*, E: sect. *Cystium*, G: sect. *Erioceras*, H: sect. *Hololeuce*, I: sect. *Incani*, J: sect. *Laguropsis*, K: sect. *Leucocercis*, L: sect. *Macrocystodes*, M: sect. *Onobrychoidei*, N: sect. *Ornithopodium*, O: sect. *Synochreati*, P: sect. *Trachycercis*, Q: sect. *Uliginosi*, R: sect. *Vesicarii*, S: sect. *Xiphidium*, T: subg. *Cercidothrix*.

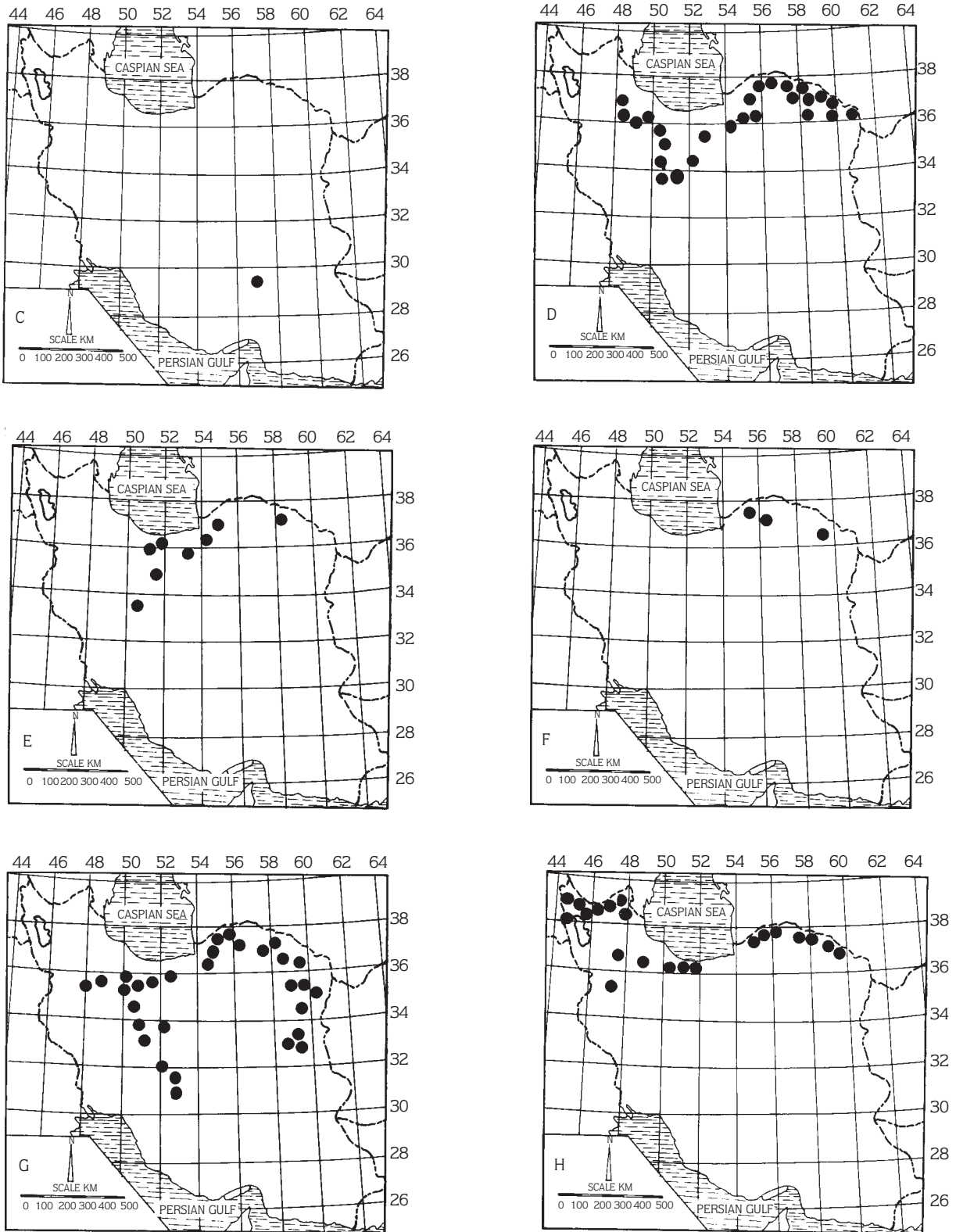


Figure 3. (Continued)

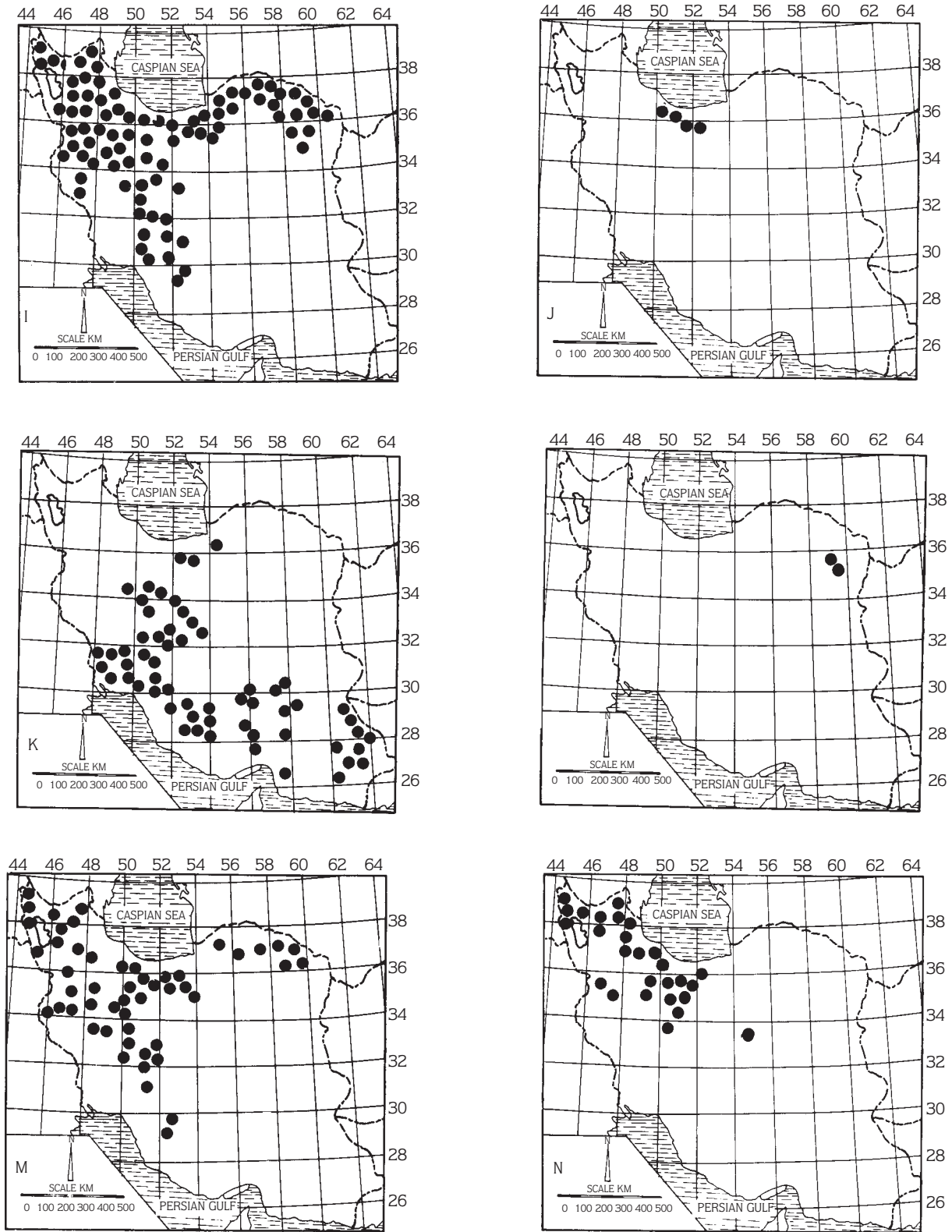


Figure 3. (Continued)

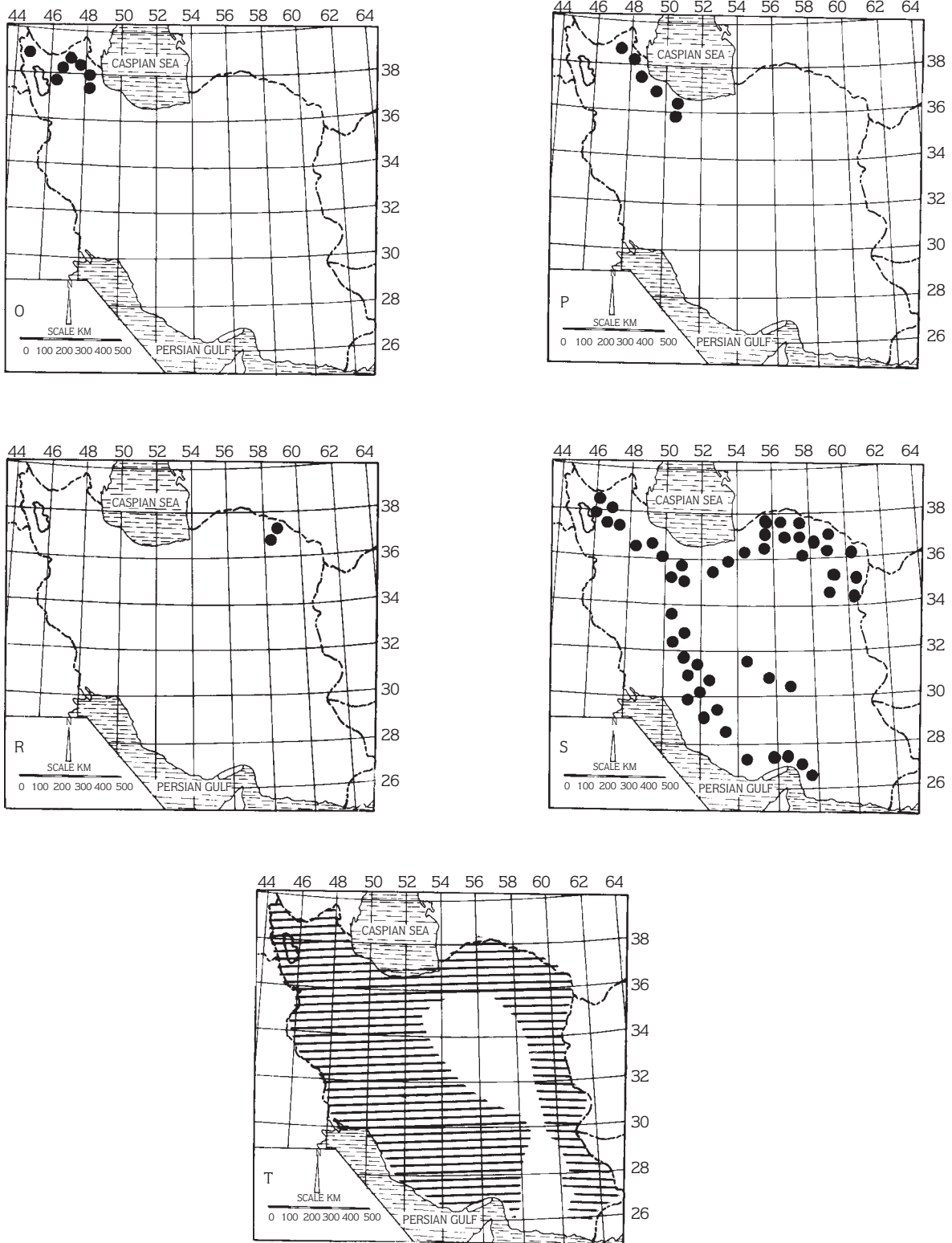


Figure 3. (Continued)

25% of bifurcating *Astragalus* species, is the most important and the largest centre of endemism for the subgenus (based on Yakovlev et al., 1996).

Turkey and Iran are two other important areas for the taxon. They have 160 (92 endemic) and 158 (89 endemic) species, respectively. Another centre is the Caucasus with 95 species, of which 42 are endemic. China, with 92 species (33 endemic) and Mongolia, with 67 species (22 endemic), are two other important centres. These areas are in fact an expansion of Central Asia's *Astragalus* species to the east. The importance of the taxon (number of species and their concentrations) decreases toward the east. Section *Trachycercis* is the section with high diversity in the east (based on Yakovlev et al., 1996; Kuntsun et al., 1993).

There are 19 sections, with 158 species (of which 89 are endemic), of *Cercidothrix* in Iran. Iran and Turkey, after Kazakhstan, occupy the second position for the subgenus. However in respect of the number of endemic species, Iran, with 89 endemic species, occupies second place after Turkey with 92 endemic species, and Kazakhstan with 47 endemic species occupies third place.

The largest section in Iran is *Incani*. After Iran, Turkey (with 37 species) and Azerbaijan (with 21 species), occupy second and third positions respectively for this section. In addition, *Xiphidium*, *Onobrychoidei*, *Ornithopodium*, and *Ammodendron*, with 21, 20, 11 and 11 species respectively, are larger sections in Iran.

With regard to endemism, *Incani* (with 33 endemic species), *Xiphidium* (with 14 endemic species), *Leucocercis* (with nine endemic species), *Onobrychoidei* (with eight endemic species), *Erioceras* and *Ammodendron* (with seven endemic species each), and *Ornithopodium* (with five endemic species) are the most important sections in Iran for the subgenus. The remaining five sections have no endemic species, and seven sections have one or rarely two endemic species.

The woody species belong to the sections *Ammodendron*, *Caraganella*, *Leucocercis*, *Cytisodes* and *Xiphidium*. The habitats of the majority of these kinds of species are the arid and desert areas of Iran. The species of sections *Onobrychoidei*, *Ornithopodium* and the majority of species of *Incani* are herbaceous and are concentrated in mountainous and more humid zones (based on the author's observations in the field).

The presence of the two species of *A. section Cytisodes* in Iran (Maassoumi et al., 1999; Podlech, 1999) shows the close relationship between sections of *Astragalus* in Iran and Central Asia. Another example is the Central Asian *A. section Macrocystodes*, of which *A. pseudorhacodes* has been recorded recently from Khorassan province, Iran, by Maassoumi (1998). In the case of *A. section Cytisodes* further investigation will have to answer whether *A. gigantirostratus* testifies to a south-western migration of *A. section Cytisodes* into the Hyrcanian floristic province, or, conversely, whether the Hyrcanian province is perhaps the ancestral region of this section.

Throughout Iran, many *Astragalus* taxa possess narrow geographic and ecological ranges e.g. *A. fridae* (section *Incani*), *A. alamlensis* (section *Vesicarii*), *A. talimansurensis* Sirj. & Rech.f. (section *Leucocercis*), *A. gigantirostratus* (section *Cytisodes*), *A. moussavii* (section *Xiphidium*), *A. xiphidiopsis* (section *Incani*) and *A. anacamptus* Bunge (section *Erioceras*).

The number and the distribution range of Iranian species are not stable due to the discovery of new species or new localities. Each new species or record of a new area in Iran may constitute a remarkable range extension of each section, and this may provide new information about migration routes and ancestral regions of the sections. With the discovery of every new species, the richness of the endemism of the Iranian *Astragalus* increases. However, due to synonymies of each species with other species, and the discovery of endemic Iranian species in other countries, the richness of the endemism decreases.

In the future, systematic molecular work will be necessary to help achieve a better understanding of the migration routes and sectional placements of the selected Old World *Astragalus*.

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