Nova Biologica Reperta 6(3): 320-325 (2019)
Print ISSN: 2423-6330/Online ISSN: 2476-7115
https://nbr.khu.ac.ir; Kharazmi University Press; DOI: 10.29252/nbr.6.3.320

یافته‌های نوین در علوم زیستی
جلد ۶، شماره ۳، صفحات ۳۲۰ الی ۳۲۵ (۱۳۹۸)
انتشارات دانشگاه خوارزمی

الگوهای پراکنش گونه‌های بخشه هیپوگلوتیده‌ای از سرده گون (تیره باقلائیان) در ایران

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چکیده. پراکنش گونه‌های گون متعلق به بخشه هیپوگلوتیده‌ای با استفاده از نرم افزار DIVA-GIS مورد بررسی قرار گرفت. در مجموع بر اساس طبقه‌بندی زهری علاوه بر گونه‌های با پراکنش گسترده، پنج الگوی جهانی شامل: ۱. پرونس آسیای شرقی، ۲. پرونس ایرانو-آناتولی، ۳. پرونس پونتیک، ۴. زیرناحیه مدیترانه‌ای شرقی و ۵. زیرناحیه مدیترانه‌ای غربی شناسایی شدند. همچنین گونه‌های ایرانی این بخشه نیز در سه الگوی: ۱. زاگرس مرکزی، ۲. کپه‌داغ-خراسانی و ۳. البرز مرکزی و شرقی طبقه بندی شدند. نقشه ها و الگوهای پراکنش گونه‌ها ارائه شده است.

واژه های کلیدی. بومزادی، جغرافیای گیاهی، دنیای جدید، دنیای قدیم، نیام‌داران

The distribution patterns of *Astragalus* sect. *Hypoglottidei* DC. (Fabaceae) in Iran

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Abstract. The distribution patterns of taxa belonging to the section *Hypoglottidei* DC. were investigated using DIVA-GIS software. Based on Zohary classification, five global patterns, with the exception of widely distributed species, include 1. Centro-Asiatic province, 2. Irano-Anatolian province, 3. Pontic province, 4. East Mediterranean subregion and 5. West Mediterranean subregion, were identified. In addition, the Iranian species of this section were classified in three patterns: 1. Central Zagros 2. Khorasan-Kopet Dagh 3. Central and Eastern Alborz. The maps and distribution patterns of the species were also presented.

Keywords. endemism, legumes, New World, Old World, phytogeography

Received 29.12.2018/ Revised 30.01.2019/ Accepted 13.02.2019/ Published 20.10.2019

دریافت: ۱۳۹۷/۱۰/۰۸/ اصلاح: ۱۳۹۷/۱۱/۱۰/ پذیرش: ۱۳۹۷/۱۱/۲۴/ انتشار: ۱۳۹۸/۰۷/۲۸

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[DOR: 20.1001.1.24236330.1398.6.3.7.6]
[DOI: 10.29252/nbr.6.3.320]

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INTRODUCTION

Astragalus L. (Fabaceae), with more than 3000 species, is the largest genus of vascular plants (Podlech & Zarre, 2013). *Astragalus* is also the largest genus in Iran with around 826 species (Ghahremaninejad, 2015), comprising more than 11% of Iran's flora (Ghahremaninejad *et al.*, 2012). Among 240 sections of this genus, only few sections occur in both the Old World and New World (Barneby, 1964; Podlech & Zarre, 2013). Sect. *Hypoglottidei* DC. is one of the complicated sections of *Astragalus* with a total of 46 species, having members in both the Old and the New Worlds. In fact, the type species of this section is *Astragalus hypoglottis* L., which was selected by De Candolle (1825), and later the species were selected by Podlech (1990) as lectotype. Sect. *Hypoglottidei* is one of the medium-sized sections within the genus (Mahmoodi *et al.*, 2012). Turkey, with 19 species (Podlech & Zarre, 2013), and Iran, with 11 species (Maassoumi, 2018), are the centers of diversity of this section in the Old World. About 82% of the Iranian taxa belonging to this section are endemic to the country (Maassoumi, 2018). The members of this section are herbaceous, characterized by diagnostic morphological features such as tubular calyx and filiform teeth, which are shorter than the tube, long and erect petals, as well as distinctly incised wing apices. This section has been taxonomically revised several times during the last decades (Maassoumi, 1988, 1989, 2018; Chamberlain & Matthews, 1970; Podlech *et al.*, 2010; Xu & Podlech, 2010; Podlech & Zarre, 2013). Based on recent molecular phylogenetic analyses on the genus (Kazempour Osaloo *et al.*, 2003, 2005) sect. *Hypoglottidei* is not a monophyletic group.

To understand the origin of a taxon, as well as its migration pattern in space and time, precise information, including fossil records and absence/presence occurrence data, is needed (Luna-Cavazos, & Bye, 2011). However, adequate information to elucidate these evolutionary aspects of sect. *Hypoglottidei* is not available. Yet, we illustrated the geographic distribution pattern of sect. *Hypoglottidei* by presenting the current knowledge of the section's worldwide range and its main diversity centers. We did this by using georeferenced specimen records from natural history collections. Taking into account the distribution of *Astragalus*, a distinct geographical disjunction between the New and Old Worlds species can be observed. In this study, we provided an update of the geographical distribution of sect. *Hypoglottidei*.

MATERIALS AND METHODS

In order to provide a global distribution pattern of sect. *Hypoglottidei*, a dataset was compiled using standard Flora accounts (Podlech *et al.*, 2010; Chamberlain & Matthews, 1970; Xu & Podlech, 2010) and a recent revision of the genus *Astragalus* in the Old World (Podlech & Zarre, 2013). Distribution data for North America was obtained from USDA plant database (USDA, 2018). Also, accounts of species distributions for North America came from Atlas of North American *Astragalus* (Barneby, 1964). Global Biodiversity Information Facility (GBIF) (GBIF, 2018) was consulted in some cases. Locations of all of the species, as reported in the literature, were georeferenced, and the distribution range of the species studied was mapped using DIVA-GIS (Hijmans *et al.*, 2005). Because the analysis in this study follows Zohary's classification (Zohary, 1973), his phytogeographical map was digitized using DIVA-GIS. By overlying the georeferenced records on the digital map, we analyzed the distribution patterns of sect. *Hypoglottidei*.

RESULTS

Distributional pattern of sect. *Hypoglottidei*

Based on Podlech & Zarre (2013), 45 out of 46 species of this section occur exclusively in the Old World, and the only native representative species in the New World is *Astragalus agrestis* Douglas ex G. Don. This species has an additional distribution center in Asia (Fig. 1), which indicates a trans-Beringean colonization of North America. *Astragalus cicer* L. is frequently recorded in the New World, but was introduced there by human beings (Podlech & Zarre, 2013). Among the Old World species belonging to this section, *Astragalus danicus* Retz. is the most widespread species, distributed throughout nearly the entire northern part of the Old World. *Astragalus agrestis*, *A. cicer*, *and A. danicus* can be considered to be widespread species (Fig. 1). Mapping distributional data by DIVA-GIS clearly showed that the remaining species putatively belonging to sect. *Hypoglottidei* fall into five distinct phytogeographical units according to Zohary (1973): 1. Centro-Asiatic province, 2. Irano-Anatolian province, 3. Pontic province, 4. East Mediterranean subregion, and 5. West Mediterranean subregion (Fig. 2). In this pattern, regions 1-5 have considerable numbers of endemics and it can be assumed that the rates of speciation in these areas are high, although, this is only an estimation without the support of comparative analyses.

DISCUSSION

The Irano-Anatolian and Pontic provinces are the most important centres of diversity of section *Hypoglottidei* based on their high endemism and species richness. The base chromosome number for

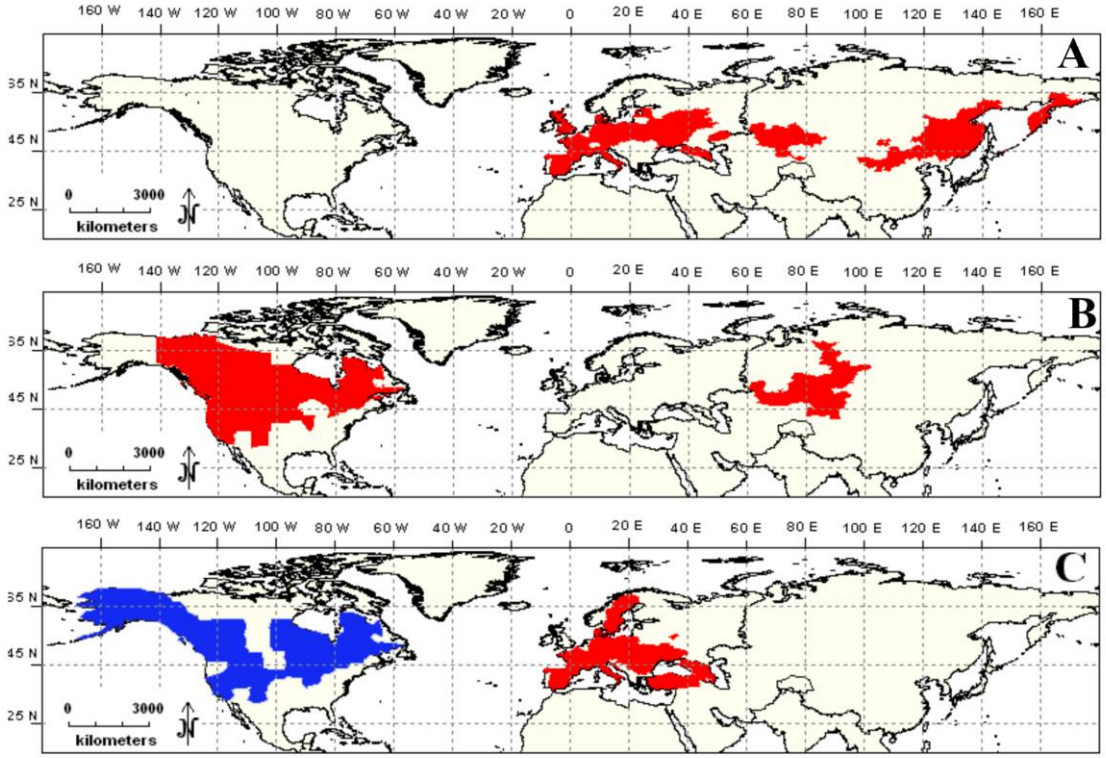

Fig. 1. Distribution of widespread species of sect. *Hypoglottidei*. **A.** *A. danicus*. **B.** *A. agrestis*. **C.** *A. cicer*: native (red), introduced (blue).

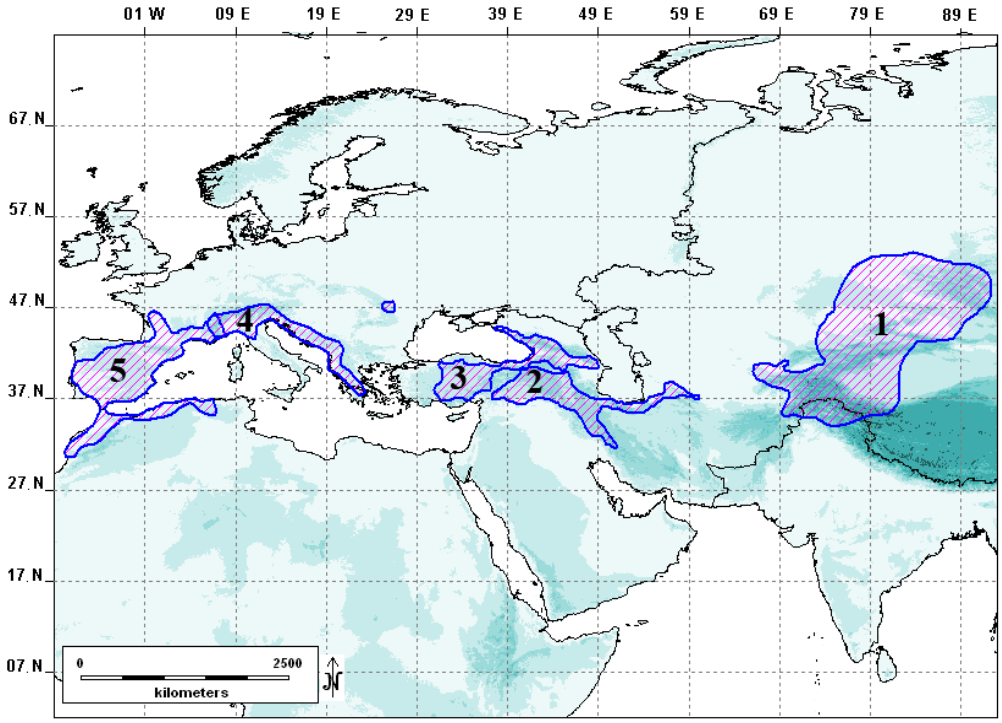

Fig. 2. Distribution of *Astragalus* sect. *Hypoglottidei* (except *A. danicus*, *A. agrestis*, and *A. cicer*) in the Old World. 1: Centro-Asiatic species, 2- Irano-Anatolian species, 3- Pontic species, 4: East Mediterranean species and 5- West Mediterranean species.

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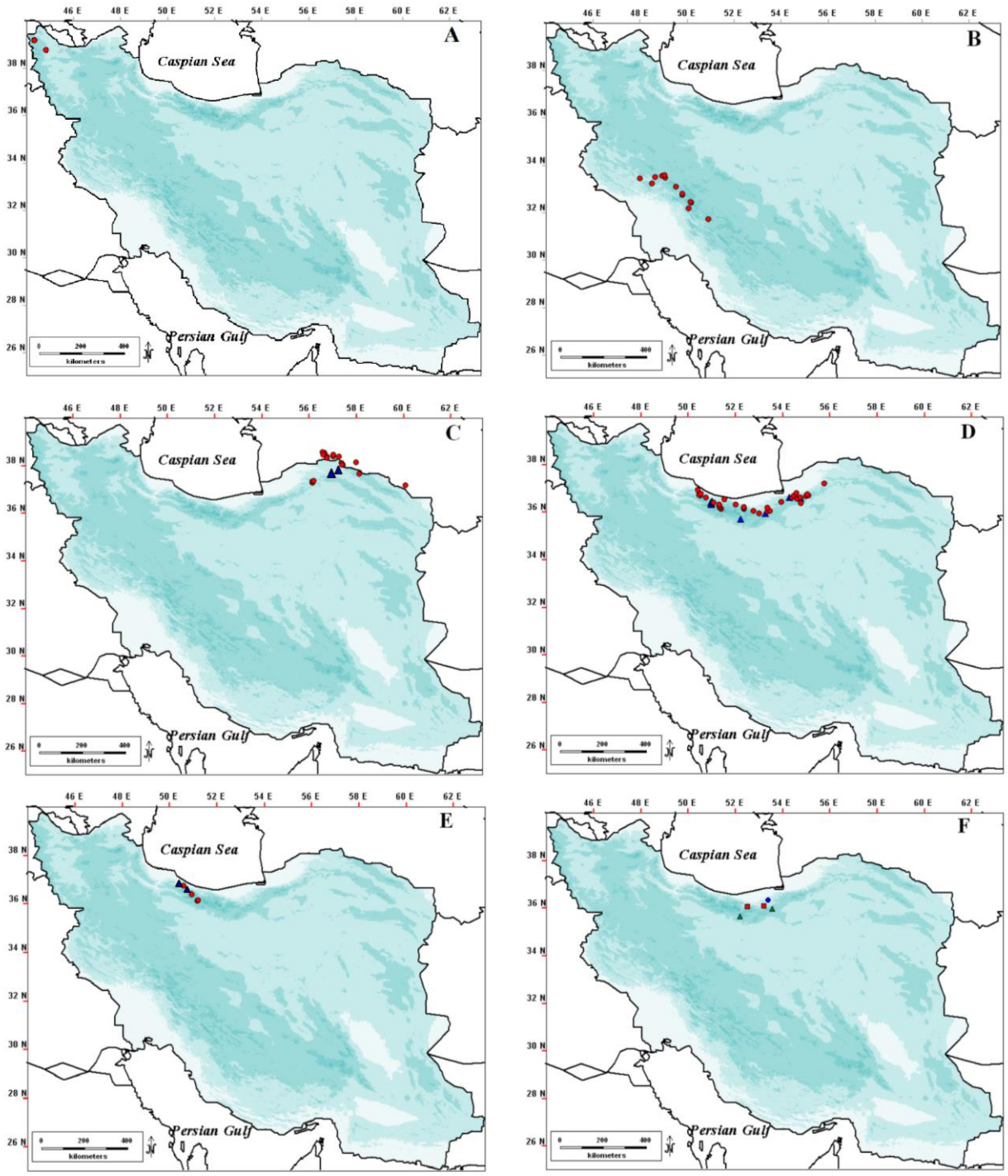

Fig. 3. Distribution maps of species of sect. *Hypoglottidei* in Iran. **A.** *A. saganlugensis*. **B.** *A. longirostratus*. **C.** *A. brachypetalus* (●) and *A. bojnurdensis* (▲). **D.** *A. atricapillus* (▲) and *A. nurensis* (●). **E.** *A. rimarum* (●) and *A. pishchakensis* (▲). **F.** *A. herbertii* (■), *A. damghanensis* (●) and *A. parvarensis* (▲).

the genus is x=8. The majority of New World species are aneuploid but 13-15 species in North America have euploid or polyploid chromosome numbers based on x = 8. *Astragalus agrestis* and *A. cicer* have not been considered or treated as aneuploids (Wojciechowski *et al*., 1993). According to Podlech & Zarre (2013) *A. cicer* was introduced to and naturalized in America while *A. agrestis* is a native species in North America. We suggest that it can be a recent colonization (not an introduction) from the Old World to the New World, for which many examples are reported (e.g., Blattner & Kadereit, 1995; Blattner, 2006; Friesen & Blattner, 2000). The general distribution patterns of sect. *Hypoglottidei* (Fig. 2) can be interpreted as having arisen through a process of vicariance, whereby four assemblages were formed. These

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vicariant assemblages were formed by adaptation to the highlands and semi-desert areas of the northeast of Iran, the highlands and mountains of Azarbayejan and the disjunction between Asia and Europe across the Black Sea and the Aegean Sea. At the moment, there is no sufficient evidence to explain the evolutionary mechanism(s) shaping the above-mentioned distribution patterns of sect. *Hypoglottidei* and it is hard to imagine the kind of event(s) which may have caused these patterns.

Distribution of section *Hypoglottidei* in Iran

All the Iranian species belonging to sect. *Hypoglottidei* should be considered Irano-Anatolian elements, except *A. longirostratus*, which is clearly a Kurdo-Zagrosian species. Nearly all other species fall into the Armeno-Iranian Sector (Zohary, 1973). Without following traditional phytogeographical classification, and only on the basis of their geographical distribution, Iranian species can be subdivided into three groups:

1. Species distributed across Central Zagros Mountains:

A. longirostratus Pau is the only species in this area (Fig. 3B) and is the southernmost species in the distribution range of sect. *Hypoglottidei*. It is distributed in Chaharmahal va Bakhtiari, Isfahan and Lorestan Provinces.

2. Species distributed across Khorasan-Kopet Dagh Mountains:

A. brachypetalus Trautv. and *A. bojnurdensis* Podlech are two members of this group (Fig. 3C). *A. brachypetalus* is presented in many collections on both sides of the border of Iran (north-eastern part of the country mainly from North Khorasan Province) and Turkmenistan, but especially on the Turkmenistan side, whereas *A. bojnurdensis* is a local endemic species in the area.

3. Species distributed across central and eastern Alborz Mountains:

The species in this group can be subdivided into three subgroups: **a.** *A. atricapillus* Bornm. and *A. nurensis* Boiss. & Buhse (Fig. 3D), which have a rather wide distribution in Golestan, Mazandaran, Semnan and Tehran Provinces, the latter being the most widespread of the Iranian species in the section. **b.** *A. rimarum* Bornm. and *A. pish-chakensis* Maassoumi (Fig. 3E) are the westernmost central species of the Alborz subgroup. Both species are local endemic and represented by limited records in Mazandaran and Tehran Provinces. **c.** *A. herbertii* Maassoumi (occurs only in Mazandaran Province) and *A. parvarensis* Podlech & Sytin and *A. damghanensis* Podlech (occur only in Semnan Province) (Fig. 3F), which comprise the easternmost central Alborz subgroup. The other species found in Iran is *A. saganlugensis* Trautv. (Fig. 3A). This species mainly occurs in East Anatolia and Southern Caucasus. The first record of this species for the flora of Iran is that of Szovits in 1828 (Lamond, 1973) and the second and most recent one rediscovered by Bagheri *et al.* (2018).

ACKNOWLEDGEMENT

This study was carried out with the financial support of the University of Isfahan and the Research Institute of Forests and Rangelands of Iran.

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How to cite this article:

Bagheri, A., Mahmoodi, M. and Maassoumi, A.A. 2019. The distribution patterns of *Astragalus* sect. *Hypoglottidei* DC. (Fabaceae) in Iran. – Nova Biol. Reperta 6: 320-325.

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