Distribution patterns of *Convolvulaceae* in Iran: priorities for conservation

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Abstract

Assessing priorities is the most important action in conservation programs. Rudimentary, mapping of diversity, and distribution patterns have been used to set priorities on diverse scales. The distribution patterns of plant taxa, largely reflect an actual ecological niche. *Convolvulaceae* s.str exhibits cosmopolitan dispersal of diverse life forms and includes 50–60 genera comprising 1600–1700 species including valuable ornamental, medicinal and food crops as well as weedy taxa. Little attention has been paid to the patterns and diversity centers of this family in scale of Iran and Asia. The present study, explains in as much detail as possible distribution patterns and the priorities for conservation of *Convolvulaceae* in the context of species and habitats in Iran. Threatened species of Iranian *Convolvulaceae* include 20.4% distributed in the Irano-Turanian phytochorion as a priority region for conservation planning. Moreover, this family represents the highest richness in the Alborz and central Zagros mountains of Iran. A meaningful proportion of priority taxa and habitats are located in protected areas of Iran. Regardless, some face several threatening factors (e.g. land use change, deforestation, and overgrazing) outside protected areas; therefore, emergent conservation actions (*in situ* and *ex situ* methods) appear necessary to protect these taxa.

Keyword: Conservation management, distribution map, phytogeography, rare species, species richness

الگوی پراکنش تیره پیچک در ایران: الویت‌های حفاظتی*

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خلاصه

ارزیابی الویت‌ها مهم‌ترین اقدام در برنامه‌های حفاظتی محسوب می‌شود. تهیه نقشه تنوع و الگوهای انتشار به صورت متداولی در پایه‌ریزی الویت‌ها در مقیاس‌های متنوع به کار گرفته شده است. تیره پیچک در مفهوم محدود شده نمایانگر یک الگوی انتشار جهان‌وطن متشکل از اشکال متنوع زیستی و مشتمل بر ۵۰-۶۰ جنس از ۱۷۰۰-۱۶۰۰ گونه می‌باشند. تا کنون، مراکز تنوع و انتشار این تیره در مقیاس ایران و آسیا کمتر مورد توجه قرار گرفته است. این مطالعه بیانگر دقیق الگوهای انتشار و الویت‌های حفاظتی در قالب زیستگاهی و گونه‌ای در تیره مذکور در کشور می‌باشد. گونه‌های در معرض تهدید این تیره در ایران ۲۰/۴ درصد می‌باشد که غالبا در مناطق ایرانو-تورانی اکوسیستم البرز و زاگرس انتشار یافته‌اند. این در حالی است که بیش‌ترین تنوع تیره مورد نظر نیز در این مناطق استقرار یافته است. به علاوه، تعداد زیادی از آرایه‌ها در محدوده مناطق تحت حفاظت قرار می‌گیرند. علی‌رغم این، در خارج از مناطق حفاظت شده با چالش‌های متعددی چون تغییرات کاربری اراضی، پاک‌تراشی جنگل و چرای بی‌رویه در زیستگاه‌هایشان مواجه هستند. بنابراین، اقدامات حفاظتی سریع (مشتمل بر حفاظت داخل و خارج از زیستگاه) جهت حفاظت از آن‌ها بسیار ضروری به نظر می‌رسد.

واژه‌های کلیدی: جغرافیای گیاهی، غنای گونه‌ای، گونه‌های نادر، مدیریت حفاظتی، نقشه انتشار

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Introduction

Assessing priorities is the most important action in conservation programs (Lovett *et al*. 2000, Bottrill *et al*. 2008). Rudimentary, mapping of diversity, and distribution patterns have been used to set priorities on diverse scales (Wagnetiz 1986, Barthlott *et al*. 1996, Mutke & Barthlott 2005, Olmstead 2013, Mehrabian 2012). The distribution patterns of plant taxa largely reflect an actual ecological niche (MacArthur 1972, Toledo *et al*. 2012), and can be used as a bioindicator of ecosystems (Dieckmann 2003). Accordingly, distribution patterns are considered to be the most important targets of biogeography and ecology (Vetaas & Ferrer-Castán 2008).

The family *Convolvulaceae* s.str, exhibits cosmopolitan dispersal of diverse life forms (Zohary 1973), and includes 50–60 genera comprising 1600–1700 species (Mabberley 1987) that are mainly distributed in tropical and subtropical regions of the world. This huge diversity is the result of a complex interaction between different climatic zones and biogeographical regions in a particular orographic context (Zohary 1973).

Mandaville (1990) has provided valuable data on *Convolvulaceae* in scale of Saudi Arabia besides Sa'ad (1967), and Wood *et al*. (2015) who published well-known monographs on *Convolvulus*. Moreover, phytogeography of some taxa of *Convolvulaceae* (Austin 1998) and distribution of southern *Convolvulaceae* (Austin 2006) are another principal references on this family in the region.

Little attention has been paid to the patterns and diversity centers of scale in Iran and Asia. The present study explains in as much detail as possible distribution patterns and the priorities for conservation in the context of species and habitats. Besides, it aims to determine important plant areas for conservation and phytodiversity of *Convolvulaceae* in Iran.

Materials and Methods

- Study area

The geographical location of the study area is within the borders of Iran. Iran has a total surface area of 1.6 million km^2 located at 24°–40° N longitude and 44°–64° E latitude and include a limited zone in the orogenic belt (Zagros, Alborz and other mountain chains) that spans the Arabian-African unit and the Asian block (Berberian & King 1981).

Iranian habitats are surrounded by several oreographic structures. The Alborz mountain system is composed of an active fold and a segment of the Alpine-Himalayan belt (Stocklin 1974). It appears with a gently sinuous east-west orientation along the northern coastlines of the Caspian Sea (Stöcklin 1974) with an average elevation of over 2000 m containing the highest peak in Iran at Damavand (5670 m). The Zagros is the longest mountain range system of the country and forms a natural massif between the Iranian plateau and the Mesopotamian and Persian Gulf basins at an average elevation of 1305 m (Homke 2007). The Kopet-Dagh in the northeastern (Afshar 1979), Jebal Barez in the central and Makran in southeastern part of Iran are other prominent geomorphological structures (Fischer 1968). Iranian habitats range from 27 m below sea level in the Caspian basin to 5671 m above sea level at Mt. Damavand (Ghorbani 2013), and is categorized into eight zones: Alborz, Zagros, Kopet-Dagh, Sanandaj-Sirjan, southeastern Iran, central Iran, Azerbaijan and eastern Iran (Fig. 1).

Iran receives an annual rainfall of less than one-third of the global average (Shakur *et al*. 2010) and is considered to be an arid region. Because of its topographical diversity, it experiences diverse climatic conditions. Iranian habitats are situated in zonobiom III in the southern zones and zonobiom VII (rIII) in the northern zones (Breckle 2002). Using the new method of world classification by Rivas-Martínez *et al*. (1997); Iranian habitats comprise the macro-bioclimates of the Mediterranean (western, northwestern Iran), temperate (northern Iran) and tropical (southern coast zones of the Persian Gulf and Gulf of Oman) regions.

The distribution zones of the taxa were compiled from 3123 herbarium specimen records from the HSBU, W and WU (herbarium abbreviations according to Thiers 2008), and from scientific studies on Iranian flora. The climate data was based on data from the Iranian Climatological Organization [50-year average (1955–2005)] for precipitation and temperature. The bioclimatic units was based on Rivas-Martínez *et al*. (*l.c.*), and the conservation status was assessed on the basis of the criteria of the IUCN Red List at regional scale (IUCN 2011) calculated by Kew Geocad (http://geocat.kew.org/; Buchman *et al.* 2011).

The distribution points were marked using ArcView (version 3.2) (ESRI 2000) on geo-referenced geological and geomorphological maps ($1/4^6$ to $1/10^6$) of Iran. These points were mapped per 1° × 1° universal transverse Mercator grid cells (100 km^2 with the exception of boundary area) to analysis the pattern of dispersal and the priorities for conservation management. The Flora Iranica (Rechinger 1963), Flora of Iran (Norouzi 2001) as well as Mozaffarian (2010) were the main references for this assessment. Regardless, several literatures on Iranian flora were assessed as the supplementary data.

The criteria for calculation were the index of species rarity (RI) based on Williams *et al*. (1991), the index of species distribution (SDI) by Selvi (1997), and Solymos & Feher (2005). The output data was scored from zero to one (0–1) for each index with the higher numbers showing higher vulnerability. The RI was computed as the inverse of the cell numbers, including the target area, as RI = 1/Ci in which Ci is the number of grid cells and l is the number of taxa present. The SDI is calculated as SDI = l-Ci/C, where C is the total number of grid cells. To calculate the conservation value (CV), the RI and SDI of each species were summed up (the higher scores represent lower CVs). The lowest RI as well as the lowest CV, therefore, showing highest vulnerability and priority to conservation. The biological forms were assessed based on Raunkaier (1934).

Results

- Diversity and distribution

Convolvulaceae is widely distributed in Iran and includes 43 species belonging to the following four genera: *Convolvulus* L. (39), *Calystegia* R.Br. (2), *Ipomoea* L. (1), and *Cressa* L. (1) (Norouzi 2001). Table 1 shows that, 22.2% (10) of *Convolvulaceae* (only *Convolvulus* L.) are confined to the borders of Iran (endemic) (Fig. 3). The greatest abundance occurs on the southern slopes of the central Alborz and Zagros mountains. The greatest abundance belongs to *Convolvulus* L. (up to 20 grid cells) in the central Alborz, Kopet Dagh, and the northern and southern Zagros, *Calystegia* R.Br. (up to 3 grid cells) in the central Alborz, *Ipomoea* L. (up to 3 grid cells) in the central Alborz and central Zagros (Figs 2 & 3), *Cressa* L. (up to 8 grid cells) in the northern and southern Zagros, central Alborz and Taftan. The family (up to 65 grid cells) showed the greatest abundance in the central Alborz, Kopet Dagh, and the northern and southern Zagros (Fig. 1).

The southern slopes of central Alborz, shows the highest richness of species and genera on the scale of Iran (Fig. 2). The peak species richness is at 35°–36° N latitude and the highest genera richness was observed at 27°–32° N latitude (Fig. 3). Altitudinal patterns (Kapos *et al.* 2000) of the studied species can be classified as alpine at above 2500 m, sub-alpine at 1200–2500 m and mountain slopes-to-lowlands at below 1200 m. Species richness severely decreases at above 2000 m. The family distribution is denoted by elevation from 0–4000 m: *Convolvulus* L. at 0–4000 m (Fig. 4), *Cressa* L. to 1500 m, and *Calystegia* R.Br. at 0–2000 m. *Convolvulus persicus*, and *C. commutatus* show the longest and shortest range of distribution, respectively (Fig. 6). *Calystegia* R.Br. is restricted to the northern slopes of the Alborz, but other genera show wider ranges of distribution. *Convolvulaceae* is distributed over 135 of 201 grid cells as follows: *Convolvulus* L. (105), *Calystegia* R.Br. (7), *Ipomoea* L. (3), and *Cressa* L. (47). *Convolvulus* L. and *Calystegia* R.Br. show the highest and lowest abundance in the taxa studied. Sedimentary rock (32.6%), quaternary deposits (29%), igneous rock (19.5%), metamorphic rock (9.5%), ophiolitic rock (5%), and sedimentary-volcanic rock (4.4%) comprise the habitats of this family in the geological context of Iran. Of these, 48.9% occur in zonobiome III, 37.8% in zonobiome VII (rII), and 13.4% in both.

- Phytogeography and conservation

Phytochorions belong mainly to the Sudano-Zambezian (28 taxa; 62.2%), Irano-Turanian (18 taxa; 40%), and Hyrcanian (Euro-Siberian; 17 taxa; 37.7%) areas. Hemicryptophytes (17 taxa; 37.7%), chamaephytes (11 taxa; 24.4%) and therophytes (18 taxa; 40%) comprise the life form spectra of *Convolvulaceae* in Iran.

All endemic taxa of this family (10 species) belong to *Convolvulus* L. situated at 25º to 38º N latitude from 0–3600 m. They are mainly centered in the southern Zagros and include the Irano-Turanian as well as Sudano-Zambezian regions (Fig. 4). *Convolvulus ammocharis* Boiss. & Hausskn., and *C. koieanus* Bornm. ex Koeie. are found in sedimentary rock., *C. cephalopodus* Boiss., *C. stapfii* Rech.f., and *C. gonocladus* Boiss. are found in Quaternary deposits and sedimentary rock. *Convolvulus eremophilus* Boiss. & Buhse, and *C. schirazianus* Boiss. are found in Quaternary deposits, sedimentary and igneous rock. *Convolvulus oxysepalus* Boiss., and *C. urosepalus* Pau. are found in Quaternary deposits, sedimentary, igneous and metamorphic rock. At the end of the endemic taxa is *C. turrillianus* Parsa found in Quaternary deposits, sedimentary and ophiolitic rock.

Because of the high sensitivity to demographic and environmental events, rare species are more threatened with extinction than common species in the same environmental conditions (Johnson 1998, Matthies *et al.* 2004). Rarity is calculated by RI that ranged from 1 (*C. cephaloporus* Boiss., *C. koeieanus* Bornm. ex Koeie., *C. fatmensis* Kunze, and *C. ammocharis*) to 0.031 (*C. pilosellifolius* Desr.). Besides, rare taxa including very rare (4) only present in one grid cell as well as rare (17) which is present up to 10 grid cells including about 48.8% of Iranian *Convolvulaceae* as followings: *Convolvulus* L. (17), *Ipomoea* L. (1), and *Calystegia* R.Br. (2). The CV ranged from 1.60 (*C. cephaloporus*) to 2.871 (*C. arvensis*) in Iran (Fig. 5, Table 2). The family shows highest species richness in the central Alborz and southern Zagros mountains in Iran. Besides, on the basis of Extent of Occurrence (EOO); Area of Occupancy (AOO) 8(18.6) and 5(11.6), it is classified in threatened categories (CR, EN, VU), respectively (Table 2).

Table 1. Comparison of *Convolvulaceae* among some countries of the region

Taxonomic rank	**Iran**	**Iraq**	**Afghanistan**	**Pakistan**	**USSR**	**Turkey**	**Saudi Arabia**
Genus	4	2	4	5	4	4	2
Species	43	13	13	20	39	39	8

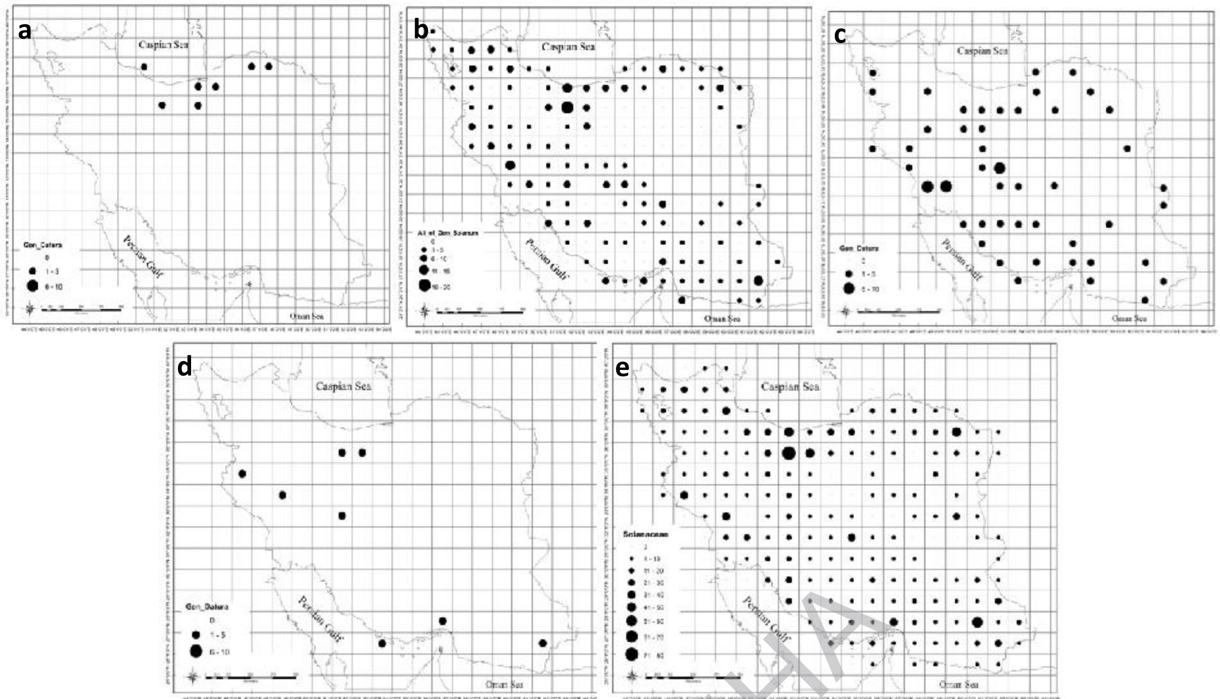

Fig. 1. Abundance pattern of the genera of *Convolvulaceae* in scale of Iran: a. *Calystegia*, b. *Convolvulus*, c. *Cressa*, d. *Ipomoea*, e. family *Convolvulaceae*.

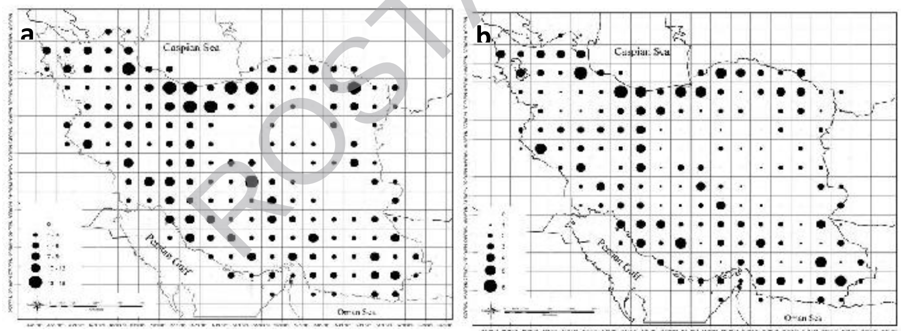

Fig. 2. a. Richness of genera, b. Richness of species inside occupied gird cells.

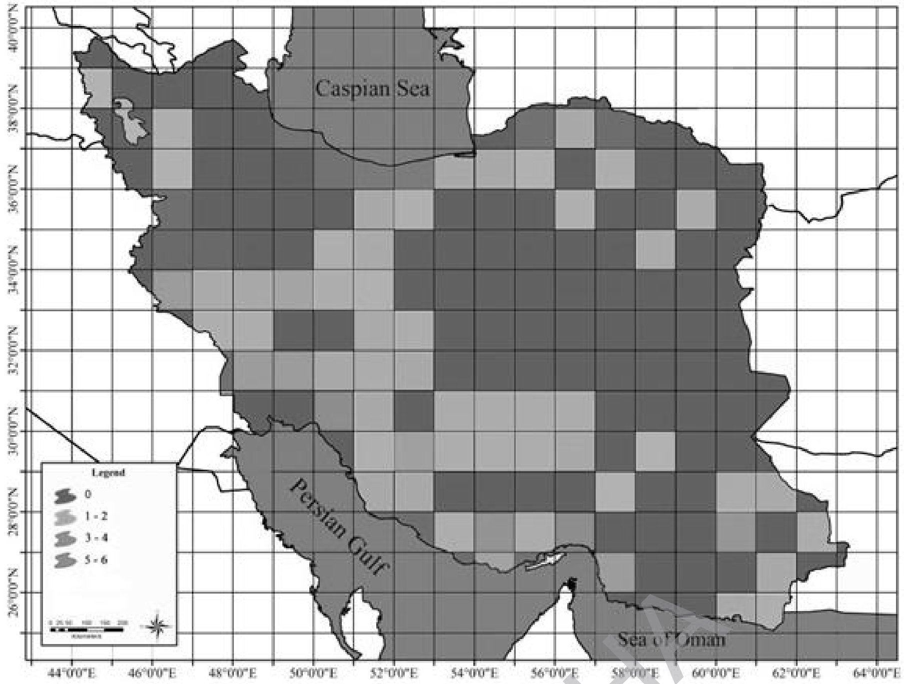

Fig. 3. Richness of endemic taxa in *Convolvulaceae*.

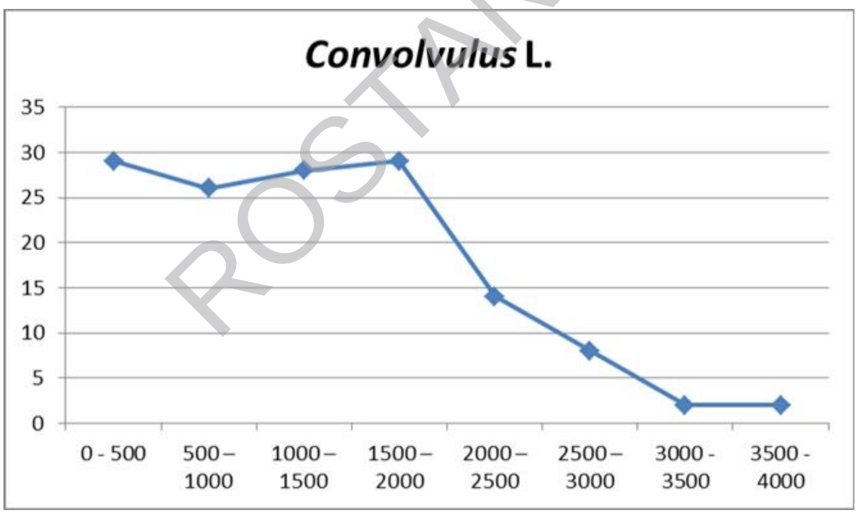

Fig. 4. Richness of *Convolvulus* in altitudinal profile.

Table 2. Conservation status and rarity of studied taxa

Taxon	RI	SDI	CV	EOO	CS	AOO	CS
Calystegia sepium (L.) R.Br.	0.166	0.970	1.966	83,153.388	LC	15,000.000	LC
C. silvatica (Kit.) Griseb.	0.5	0.990	1.87	2,108.413	EN	646.566	VU
Convolvulus acanthocladus Boiss.	0.038	0.870	1.958	506,135.063	LC	77,500.000	LC
C. ammocharis Boiss. & Hausskn.	1	0.995	2.265	0.000	CR	0.000	CR
C. arvensis L.	0.015	0.686	2.471	1,671,558.095	LC	217,500.000	LC
C. betonicifolius Mill.	0.333	0.985	1.928	19,356.778	VU	3,529.961	NT
C. buschiricus Bornm.	0.25	0.980	1.89	85,316.515	LC	15,000.000	LC
C. calverti Boiss.	0.2	0.975	1.725	23,449.273	NT	20,000.000	LC
C. cantabricus L.	0.052	0.905	2.227	784,353.565	LC	67,500.000	LC
C. cephalophorus Boiss.	1	0.995	2.435	0.000	CR	0.000	CR
C. cephalopodus Boiss.	0.1	0.950	1.6	317,266.876	LC	42,500.000	LC
C. chondrilloides Boiss.	0.055	0.910	2.125	225,054.195	LC	75,000.000	LC
C. commutatus Boiss.	0.031	0.840	2.311	809,148.126	LC	120,000.000	LC
C. dorycnium L.	0.076	0.935	1.951	324,156.082	LC	47,500.000	LC
C. elymaiticus Mozaff.	1	0.995	2.255	0.000	CR	0.000	CR
C. eremophilus Boiss. & Buhse	0.066	0.925	1.821	633,853.144	LC	45,000.000	LC
C. erinaceus Ledeb.	0.066	0.925	1.871	228,647.779	LC	55,000.000	LC
C. fatmensis Kunze	1	0.995	2.265	0.000	CR	0.000	CR
C. fruticosus Pallas	0.045	0.890	2.035	457,342.894	LC	75,000.000	LC
C. glomeratus Hochst ex Choisy	0.25	0.980	1.67	36,964.983	NT	15,000.000	LC
C. gonocladus Boiss.	0.062	0.920	1.752	213,042.980	LC	60,000.000	LC
C. koeieanus Bornm. ex Koeie.	1	0.995	2.265	0.000	CR	0.000	CR
C. kotschyanus Boiss.	0.2	0.975	1.835	104,592.306	LC	20,000.000	LC
C. leiocalycinus Boiss.	0.033	0.850	1.983	643,944.747	LC	122,500.000	LC
C. leptocladus Boiss.	0.071	0.930	1.831	545,561.149	LC	50,000.000	LC
C. lineatus L.	0.045	0.890	2.485	777,192.446	LC	72,500.000	LC
C. oxyphyllus Boiss.	0.066	0.925	1.761	425,971.192	LC	70,000.000	LC
C. oxysepalus Boiss.	0.071	0.930	1.991	204,431.560	LC	40,000.000	LC
C. pentapetaloides L.	0.5	0.990	1.93	14,087.951	VU	6,413.481	LC
C. persicus L.	0.2	0.975	2.055	333,987.713	LC	22,500.000	LC
C. pilosellifolius Desr.	0.031	0.840	1.921	1,371,612.443	LC	107,500.000	LC
C. prostrates Forssk.	0.166	0.970	1.686	211,644.850	LC	47,500.000	LC
C. pseudocantabrica Schrenk	0.090	0.945	1.975	187,080.193	LC	32,500.000	LC
C. reticulatus Choisy	0.090	0.945	1.975	211,644.850	LC	47,500.000	LC
C. schirazianus Boiss.	0.2	0.975	2.115	56,140.251	LC	15,000.000	LC
C. siculus L.	0.333	0.985	1.758	39,449.943	NT	4,654.443	LC
C. spinosus Burm. f.	0.071	0.930	1.831	449,006.399	LC	40,000.000	LC
C. stachydifolius Choisy	0.052	0.905	2.117	906,342.241	LC	75,000.000	LC
C. stapfii Rech.f.	0.2	0.975	1.835	19,158.059	VU	5,948.096	LC
C. urosepalus Pau	0.1	0.950	2.04	565,612.419	LC	30,000.000	LC
C. virgatus Boiss.	0.062	0.920	1.922	262,232.822	LC	55,000.000	LC
C. turrillianus Parsa	0.142	0.965	1.827	181,690.759	LC	22,500.000	LC
Cressa cretica Linn.	0.019	0.741	2.31	1,441,915.359	LC	160,000.000	LC
Ipomoea crassicaulis (Benth.) B.L. Rob.	0.333	0.985	1.758	5,525.909	LC	2,742.676	LC

RI (Rarity Index), SDI (Species Distribution Index), CV (Conservation Value), EOO (Extend of Occurrence), CS (Conservation Status), AOO (Area of Occupancy), and CS (Conservation Status).

Discussion

This recent study represents the first phytogeograpical conservation assessment of *Convolvulaceae* based on the geographical information system at Iranian scale. The results revealed a higher rate of diversity and endemism than other countries in SW Asia. Several rare taxa in the family (Austin 1992) have been confirmed by the efforts of the current study. The endemic taxa are mainly distributed across a range of geology and this diversity has been reported as an essential factor of plant endemism in Iranian habitats (Hedge & Wendelbo 1978). Moreover, the centers of endemism of this family correspond to Iranian centers of endemism (Hedge & Wendelbo 1978, Davis *et al.* 1994). Diversity gently decreases toward NW Asia and sharply decreases towards the western zones of Asia. Iran, Turkey, and USSR are the most important centers of diversity in western and central Asia (Table 1). The family represents a greater rate of diversification than other flowering plants and colonization in a temperate bioclimate across three southern continents four million years ago (Ushimaru & Kikuzawa 1999).

The life forms showing adaptation to ecological factors, therefore, their analysis can help identify ecological properties of the habitats (Diaz & Cabido 1997). The highest diversity of life forms ranges between 1000–1500 m and abruptly falls over 2000 m. Moreover, it shows a peak between 26° to 31° latitude and with an irregularity decrease at the higher and lower latitudes (Fig. 6).

Central Asia especially Iran, shows the highest diversity of *Convolvulus* in Irano-Turanian territory (Wood *et al*. 2015). Several species (e.g. *C. oxyphyllus*, and *C. pilosellifolius*) have been reported as importance and grazing feedstock under desert conditions. *Convulvulus* species are known as important structures to shaping the vegetation especially shrubby species in Middle East (Zohary 1973).

Convolvulecta iranica subtropica comprises several communities in the in border zones of the Persian Gulf to the central lands of Iran and include *C. acanthocladus* Boiss. and *C. leocalycinus* Boiss, *C. acanthoclada* Boiss., *C. turrillianus* Parsa, *C. cephalopdus* Boiss., *C. spinosus* Burm., and *C. virgatus* Boiss. (*l.c.*). They are prominent elements of the Sudano-Zambzian region and are mainly distributed along coastlines and zones adjacent to the Persian Gulf (*l.c.*). Moreover, these elements (spiny habit and tomentose leaves) compose a different group of Eurasian clade of *Convolvulus* (Wood *et al*. 2015).

Besides, the endemics of *Convolvulaceae* cover Mediterranean (e.g. xeric-continental, desertic-continental) to tropical desertic climes that affected by arid and tropical bio-climatic conditions, respectively. Our results confirmed the Austin (1998) who believes that, endemism zones in *Convolvulaceae* centered mainly in tropical zones. *Convolvulus betonicifolius* Mil., *C. staechadifolium* Choisy., and *C. arvensis* L. are known as the segetal plant communities and synanthropic flora in the Middle East, including Iran (Zohary 1973). *Convolvulus arvensis* by a widely ecological distribution is the most spared taxa in Iran. This species is known as a biological disaster in pastures of Iran as well as throughout the world (Ditomaso 2000), so management actions seems to be necessary to its ecological control in Iran.

Calystegia R.Br. comprises about 26 species, two of which are distributed in Iran. *Calystegia sepium* (L.) R.Br. distributed throughout Europe, Turkey, Caucasia, the northern slopes of the Alborz mountains (N. Iran), and in confined zones of the SW and central Zagros mountain in Iran. Besides, Iran is the far eastern border of the distribution of the mentioned taxa worldwide. *Calystegia silvatica* (Kit) Griseb, similar to other species of genus (Ushimaru & Kikuzawa 1999) is distributed in the Hyrcanian forests. However, other drier Mediterranean bio-climes are the largest barriers to penetration of these taxa into the Iranian plateau.

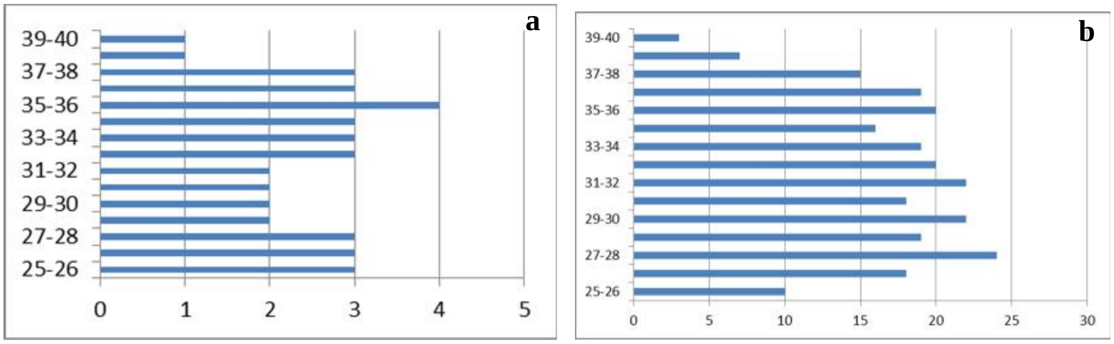

Fig. 5. a. Species profile along latitude, b. Genera profile along latitude.

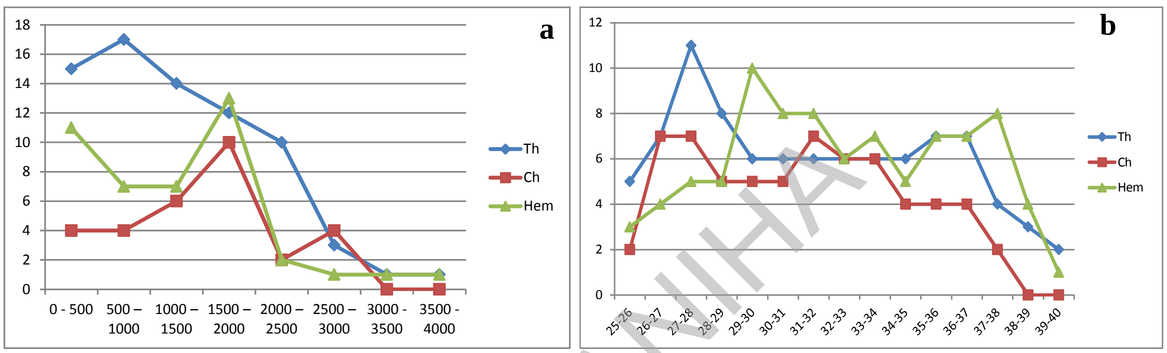

Fig. 6. Comparative life form diversity in: Altitudinal profile (a), Latitudinal profile (b).
(Th=Therophyte, Ch=Chamaephyte, Hem=Hemicryptophyte).

Ipomoea crassicaulis (Benth.) Robinson is distributed in coastal areas of the Persian Gulf, Saudi Arabia, and Central America. Zohary (1973) classified them as the Mesogeion relict elements of heterogeneous origin of Mediterranean flora during Arcto-Tertiary migrations and Neogene geological events.

The current results show that, *Convolvulaceae* undergoes minor changes at 2000 m but sharply decreases above 2000 m (Fig. 5), so can be classified as mainly lowland to mountainous elements in Iranian habitats as a prominent zone to conservation plans.

A prominent percentage of Iranian *Convolvulaceae* appear to have very rare to rare distributions, out of which them *Convolvulus* mainly cover the threaded categories on the basis of IUCN criteria distributed in the Irano-Turanian phytochorion as a priority region for conservation planning. Moreover, this family represents the highest richness in the Alborz, and central Zagros mountains. Moreover, Conservation value as a cumulative index appear a more comprehensive perspective to determine the priorities for conservation, so the *C. cephalopodus* and *C. arvensis* show the highest and lowest degree in context of priority for conservation. The presence of spine habit as well as leaves in some taxa (e.g. *C. spinosus*, and *C. acanthocladus*), it can reflect the ecological feasters of habitats as well as protecting habit against herbivory attacks (Hanley *et al*. 2007).

A meaningful proportion of priority taxa and habitats (Figs 2–3 & 5) are located in protected areas of Iran. Regardless, some of them experiment several threatening factors (e.g. land use change, deforestation, and overgrazing) outside protected areas. Emergent conservation actions (*in situ* and *ex situ* methods) appear necessary to protect these priorities for conservation of taxa. Habitat loss is the most important threatened factor to rare and endangered species (Foin *et al*. 1998). In addition, availability of suitable habitats are considered as a prominent limited factor to rare plants (Aitken *et al*. 2007), mainly those taxa by narrowly geographic distribution. The ecological modelling methods provide a proper strategy to predict the habitat suitability as well as alternative habitats to *ex situ* conservation of these endangered taxa. However, *in situ* conservation of near threatened taxa and priority habitats (e.g. endemism and diversity zones, threatened habitats), can be an effective strategy to ensure their survival.

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