

DISTRIBUTION PATTERN, ECOLOGY AND ENDEMISM OF FAMILY CRASSULACEAE IN PAKISTAN AND KASHMIR

GHULAM RASOOL SARWAR AND MUHAMMAD QAISER

Center for Plant Conservation, University of Karachi, Karachi-75270, Pakistan
Corresponding author e-mail: qaismd@gmail.com

Abstract

Distribution pattern, ecology and endemism of family Crassulaceae have been studied in Pakistan and Kashmir. Out of 31 taxa, 15 are Irano-Turanian elements, 16 are Sino-Japanese elements and only one is Mediterranean element. Twenty nine taxa are classified as uniregional, while one is biregional element. Only one taxon is considered as pluriregional element. *Rhodiola saxifragoides*, *Rosularia adenotricha* subsp. *chitralica* and *Hylotelephium pakistanicum* are endemic taxa. While *Rhodiola pachyclados* and *Rosularia sedoides* are partim endemic. The former species is confined to (Kurrum valley) Pakistan and Afghanistan whereas the latter species distributed in Kashmir and N India. *Rhodiola coccinea* subsp. *scabrida* is subendemic to the peripheral belt of Irano-Turanian and Sino-Japanese regions.

Introduction

The family Crassulaceae is cosmopolitan in distribution except in Polynesia and Australia with a main concentration in South Africa (Takhtajan, 1986; Sarwar, 2002; Mabberley, 2008). With a few exception most of the species are lithophytes and grow among rocks, stones, rock crevices, boulders and moraines. The information on the distribution pattern and the ecology of various genera of the Crassulaceae is available from the various parts of the world. Such as Soo-Young (1985) studied the phytogeography of Crassulaceae from Korea. He studied the distribution pattern of each species and prepared distribution maps. Egli (1988) studied the general distribution pattern of the genus *Rosularia* and presented distribution map of each species. She also indicated center of diversity and center of speciation of this genus. Theide (1995) studied the phytogeography, species richness and evolution of American Crassulaceae. Chazaro-Bosanez & Theide (1995) studied the phytogeography, species richness, distribution pattern of Crassulaceae of Jalisco (Mexico). Jurgens (1995) studied the phytogeography of the genus *Crassula*. He studied the distribution pattern of each species, endemism, prepared distribution maps and species richness. However, no information on the distribution pattern and ecology of various species occurring in Pakistan is available. The present study is carried out to present the information regarding distribution pattern, ecology and endemism of family Crassulaceae from Pakistan and Kashmir.

Hooker (1904) recognized 2 provinces from Pakistan and some of the adjoining areas. Good (1947, 1974) and Takhtajan (1969) recognized 3 phytogeographical regions in Pakistan viz. Saharo-Sindian region, Irano-Turanian region and Indian region. Kitamura (1960), Hara (1966), Zohary (1973) and Ali & Qaiser (1986) recognized the western most territory of one more region i.e., Sino-Japanese region in Pakistan.

Materials and Methods

The distribution pattern of each species has been traced and maps have been drawn with the help of comprehensive literature survey, herbarium material housed in the following herbaria: BM, E, K, KUH, KYO, LINN, RAW and US (abbreviated as a Holmgren *et al.*, 1990). In addition to this number of excursion trips to all parts of the country were undertaken to study the family Crassulaceae in their natural habitat.

Results and Discussion

The genus *Sedum* is distributed mainly in the North Temperate Zone, and Eurassia in the Himalayas, China and Japan. It is the largest genus of Crassulaceae and consists of 470 species. (Willis, 1973; Ohba, 1978; Sarwar, 2002). In Pakistan, it has 5 species, out of only *S. hispanicum* an Irano-Turanian element is distributed. In Pakistan it occurs from 700-2000 m mostly in gravelly soil. The remaining 4 species i.e. *S. trullipetalum*, *S. multicaule*, *S. fischeri* and *S. oreades* are Sino-Japanese elements. *S. multicaule* grows between the altitude 1800-2800m in crevices and rocks in Kashmir and Hazara. *S. trullipetalum* grows at a higher altitude between 3000-3692m in crevices and grasslands in upper Kashmir. *S. oreades* though more or less sympatric in distribution with *S. trullipetalum* but grows on still higher altitude between 3000-4000m in rocks crevices. *S. fischeri* occupies the highest altitude and grows between 4500-5000m along water stream in Ladakh (Figs. 3 & 4).

Hylotelephium is a small genus of 12 species found in Central Asia (Ohba, 1978; Sarwar, 2002). *H. ewersii* is a Central Asian element (Eastern Irano-Turanian) extending from Russia to India through Mongolia, China, and Central Asia (Ohba, 1978; Sarwar, 2002). In Pakistan it grows between the altitudes 2000-4000 m on rocks and crevices. While, *H. pakistanicum* is a narrow endemic and confined to Gilgit (Pakistan) and W. Kashmir. It grows between 2700-4900m on rocks, crevices and glaciers (Fig. 2).

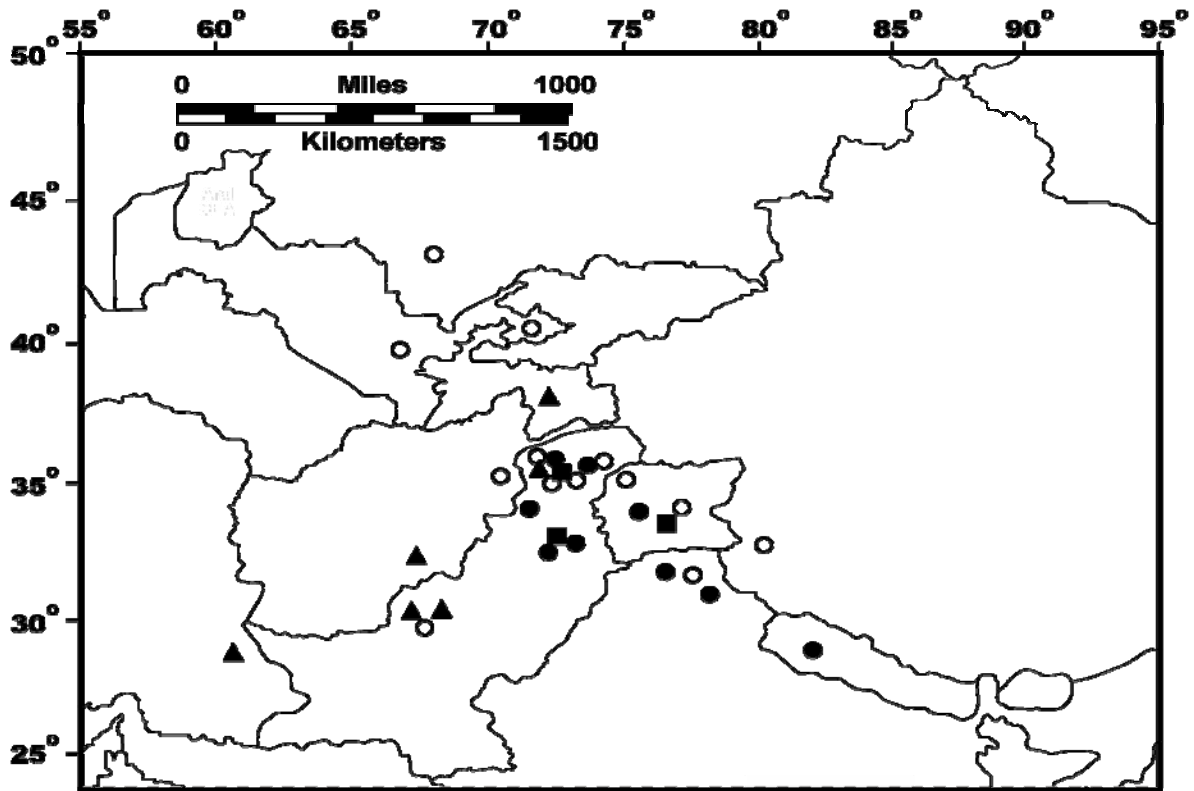


Fig. 1. Distribution pattern of *Rosularia viguieri* (▲); *R. adenotricha* subsp. *adenotricha* (●); *R. adenotricha* subsp. *chitralica* (■) and *R. alpestris* (○).

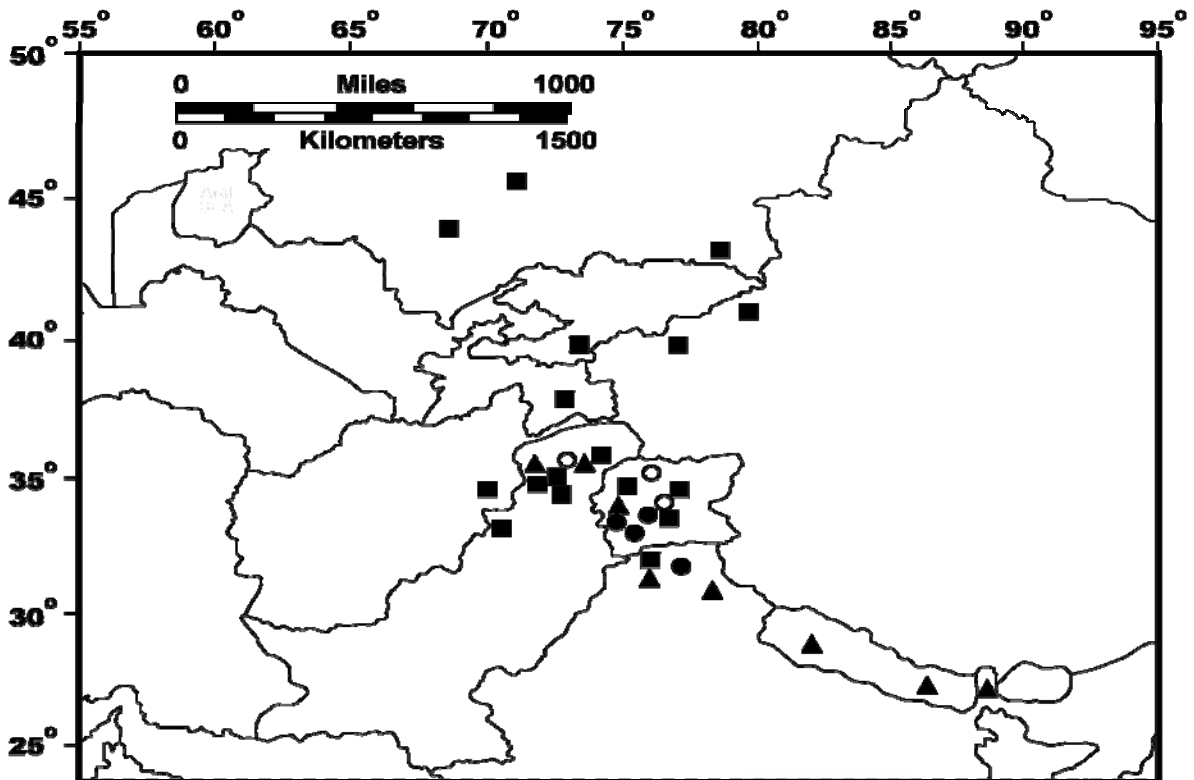


Fig. 2. Distribution pattern of *Rosularia rosulata* (▲); *R. sedoides* (●); *Hylotelephium ewersii* (■) and *H. pakistanicum* (○).

Pseudosedum is also a small genus of 12 species and mainly distributed in Central Asia (Ohba, 1978; Sarwar, 2002). *P. condensatum* and *P. lievenii* are typically Eastern Irano-Turanian element. In Pakistan, both the species are widely distributed in Chitral, Gilgit, Hunza, Baltistan, Karakorum and Kashmir. *P. condensatum* occurs between 3000-3600 m on rocky hilly slopes. While, *P. lievenii* grows between 1500-3600 m on rocky hilly slopes (Fig. 4).

Orostachys consists of 13 species and found only in Asia. *O. thyrsoiflora* is an Eastern Irano-Turanian element. It grows from 2500-4000m on dry rocks and stony grounds in Karakorum mountainous range in Pakistan (Ohba, 1978; Sarwar, 2002). *Tillaea* is a small genus of 16 species, almost worldwide in distribution (Kunjun & Gilbert, 2001; Sarwar, 2002). *T. schimperi* is widely distributed in Asia and Africa. It is a pluriregional element. In Pakistan, it grows between 1300-3000m among rocks and crevices. *T. alata* is a Mediterranean element extending up to Kashmir through Iran and Iraq. It grows between the altitudes 700-1600m in boulders, gravels and crevices (Figs. 3 & 8).

Rosularia is distributed from N. Africa to C and SW Asia through E. Mediterranean region and consists of 36 species (Eggl, 1988; Sarwar, 2002). *R. viguieri* and *R. alpestris* are Eastern Irano-Turanian elements (Central Asian). *Rosularia viguieri* occurs between 1500-2800 m on dry rocks and stones. *R. alpestris* grows between the altitudes 1800-4000m among the rocks and stones. *R. rosulata* and *R. sedoides* are Sino-Japanese elements. *R. rosulata* grows between 3000-3250m in moist shady places while *R. sedoides* occurs between the altitudes 2000-3000m among dry rocks. *R. sedoides* is reported from Kashmir and India and it is considered as partim endemic. *R. adenotricha* subsp. *adenotricha* is a basically W & C Himalayan element but extending to Balochistan through Afghanistan. Whereas *R. adenotricha* subsp. *chitralica* is endemic to Pakistan and occurs in Chitral, Ziarat, Kohat, Hazara and Kashmir (Figs. 1 & 2).

The genus *Rhodiola* is distributed in North Africa to Central Asia through eastern Mediterranean and South Western Asia and consists of 36 species (Ohba, 1978; Sarwar, 2002). It has thirteen taxa, *R. pachyclados* and *R. saxifragoides* have restricted distribution and the former species is endemic to Kurrum Valley, a valley which is extending on both sides of Afghanistan and Pakistan, while *R. saxifragoides* is endemic to (Gilgit and Baltistan) Pakistan and grows between 2500-3200 m on rocks and crevices. *R. coccinea* subsp. *scabrida* is subendemic to the peripheral belt of Irano-Turanian and Sino-Japanese regions, grows between 3000-4000m on rocks, crevices, gravel and grassy slopes (Figs. 6 & 7).

Six taxa viz. *R. wallichiana*, *R. sinuata*, *R. fastigiata*, *R. bupleuroides*, *R. coccinea* subsp. *coccinea* and *R. imbricata* are East Himalayan elements. All the 6 taxa do not extend beyond Pakistan - North West Himalayas the western most limit of these taxa. Four taxa i.e. *R.*

wallichiana, *R. sinuata*, *R. fastigiata* and *R. coccinea* subsp. *coccinea* extend up to Tibet (Eastern Irano-Turanian subregion) whereas *R. imbricata* does not extend beyond Nepal in the east and *R. bupleuroides* extend further up to S W China. *R. tibetica* extend up to Tibet (Eastern Irano-Turanian subregion) it does not extend beyond Afghanistan which is its western most limits. *R. reticulata* and *R. heterodonta* grows between 3000-4600m on rocks, crevices and open slopes whereas *R. quadrifida* grows on lower altitudes between 2500 3050 m and almost occupy the similar habitat. In Pakistan at about 3000-3500 m all the species are sympatric. *R. sinuata* grows at lower altitude between 1800-3000m on rocks and crevices. Whereas, the remaining three species i.e. *R. fastigiata*, *R. wallichiana* and *R. coccinea* subsp. *coccinea* more or less sympatrically distributed. *R. fastigiata*, *R. wallichiana* and *R. coccinea* subsp. *coccinea* grow between 3000-4000 m on rocks crevices, gravels and grassy slopes. *R. wallichiana* grows from 3000-4500m among boulders, on rocks, slopes, moraines and alpine meadows (Sarwar, 2002) (Figs. 5, 6 & 7).

Endemism

Rhodiola saxifragoides is a perennial herb restricted to Gilgit and Kashmir, where it is common. Although it grows in typically Sino-Japanese region. *Rhodiola pachyclados* is a close relative of it. It is a partim endemic and distributed in Pakistan and Afghanistan. It is an Irano-Turanian element and found in (Kurrum valley) border of Pakistan and Afghanistan. *Rhodiola coccinea* subsp. *scabrida* is subendemic to the ecotonic belt of Irano-Turanian and Sino-Japanese regions. It is distributed in Pakistan (Gilgit, Hazara, Swat, and Kashmir) and China (E. Xizang and S W China). *Hylotelephium pakisticum* is a narrow endemic and confined to Gilgit (Pakistan) and W. Kashmir. *Rosularia sedoides* is apartim endemic and distributed from Kashmir to N India. It grows between the altitudes 2000-3000 m among dry rocks. *Rosularia adenotricha* subsp. *chitralica* is endemic to Pakistan and distributed in Chitral, Ziarat, Kohat, Hazara and Kashmir. According to Ali (1978) about 78.22% endemic species of Pakistan are confined to the northern and western mountainous regions. The highest number of endemic species are known from Kashmir which belongs to Sino-Japanese region. Crassulaceae consists of 19.35% endemic taxa. In *Rhodiola* 25% taxa are endemic. While, *Hylotelephium* 50% taxa are endemic. *Rosularia* consists of 33.33% endemic taxa.

Acknowledgement

We are grateful to the Directors and Curators of the following herbaria BM, E, K, KUH, KYO, LINN, RAW, and US for sending the specimens on loan and providing herbarium and library facilities.

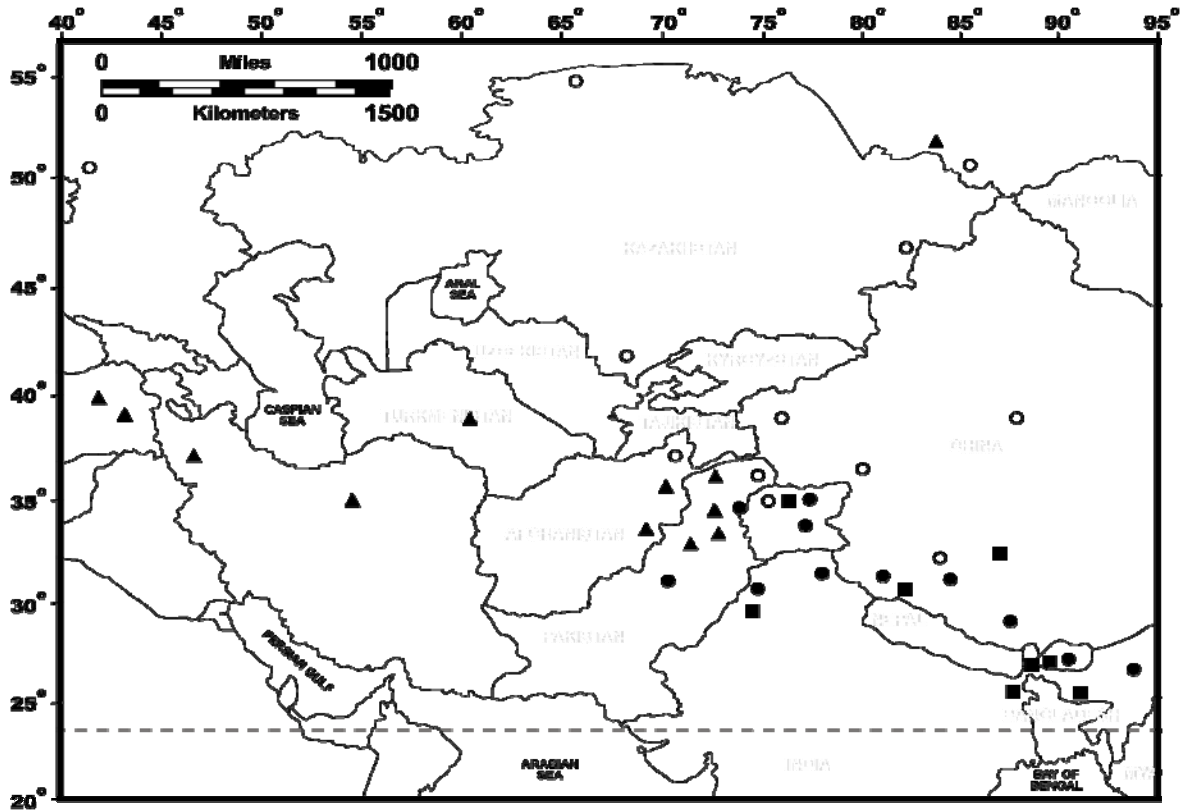


Fig. 3. Distribution pattern of *Sedum hispanicum* (▲); *S. oreades* (●); *S. fischerii* (■) and *Orostachys thyrsoflora* (○).

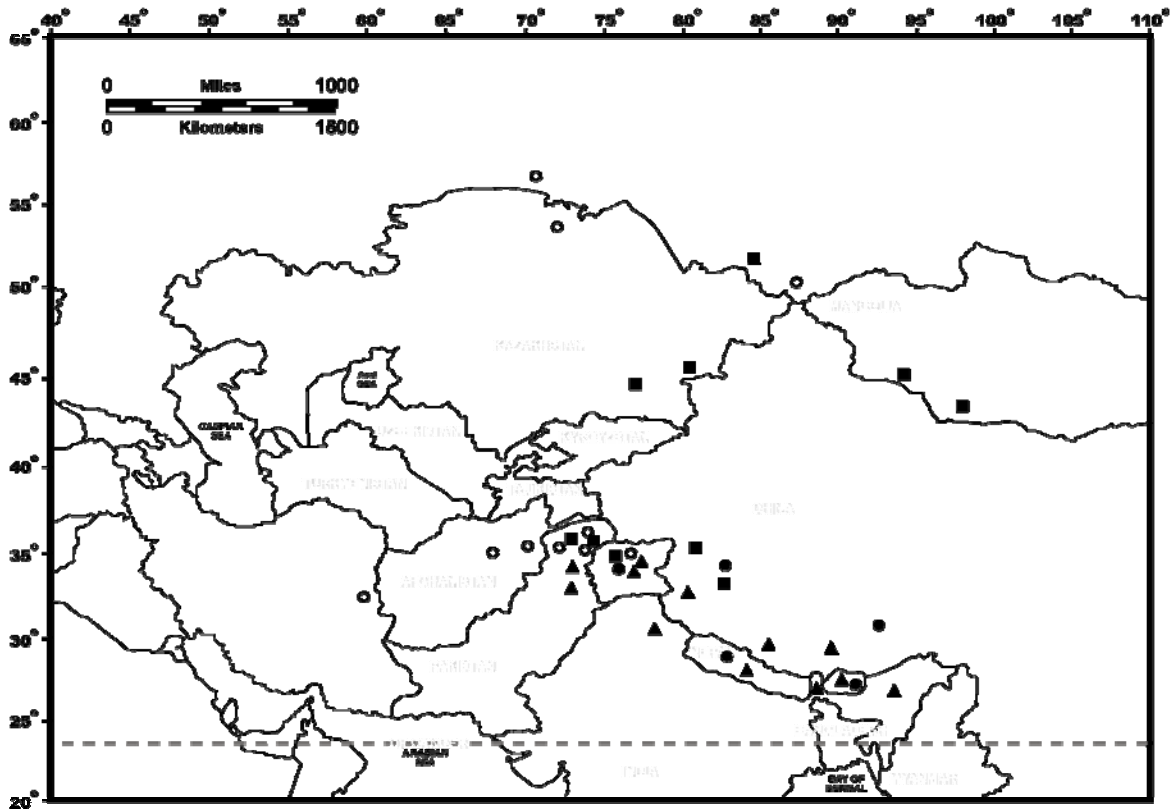


Fig. 4. Distribution pattern of *Sedum multicaule* (▲); *S. trullipetalum* (●); *Pseudosedum lievenii* (■) and *P. condensatum* (○).

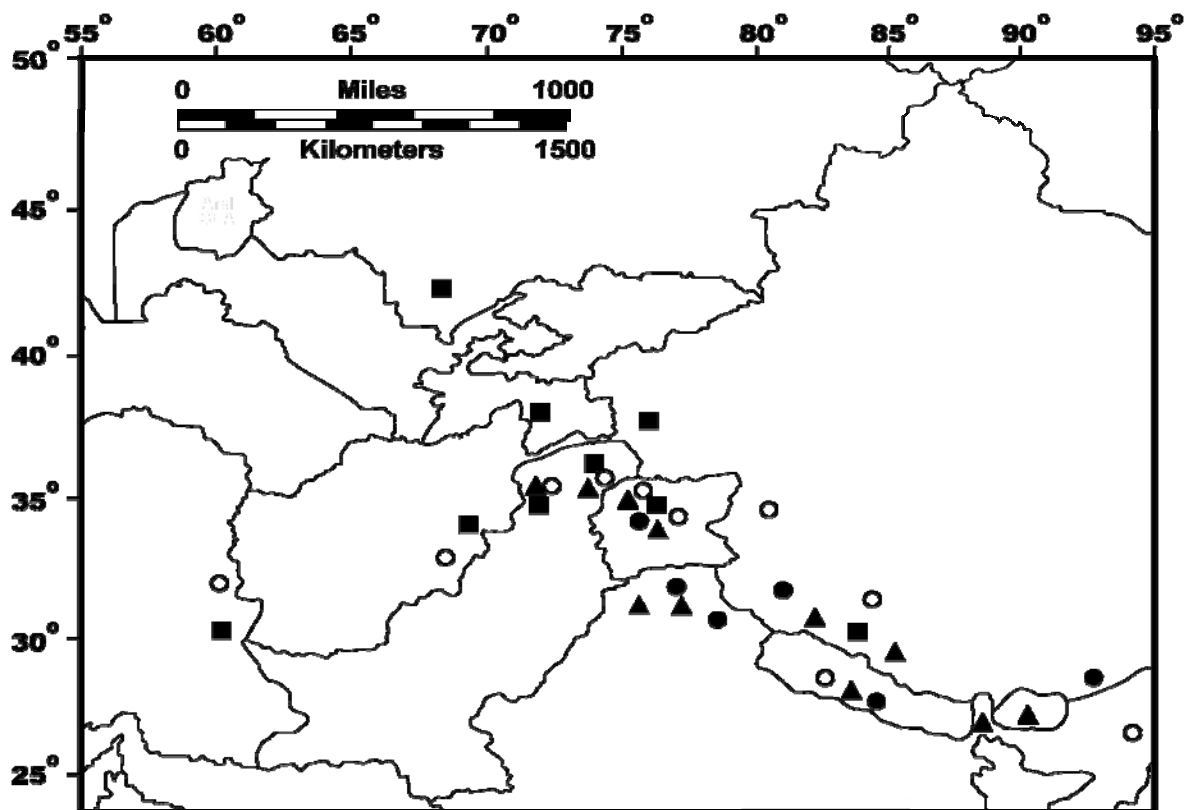


Fig. 5. Distribution pattern of *Rhodiola wallichiana* (▲); *R. sinuate* (●); *R. reticulata* (■) and *R. heterodonta* (○).

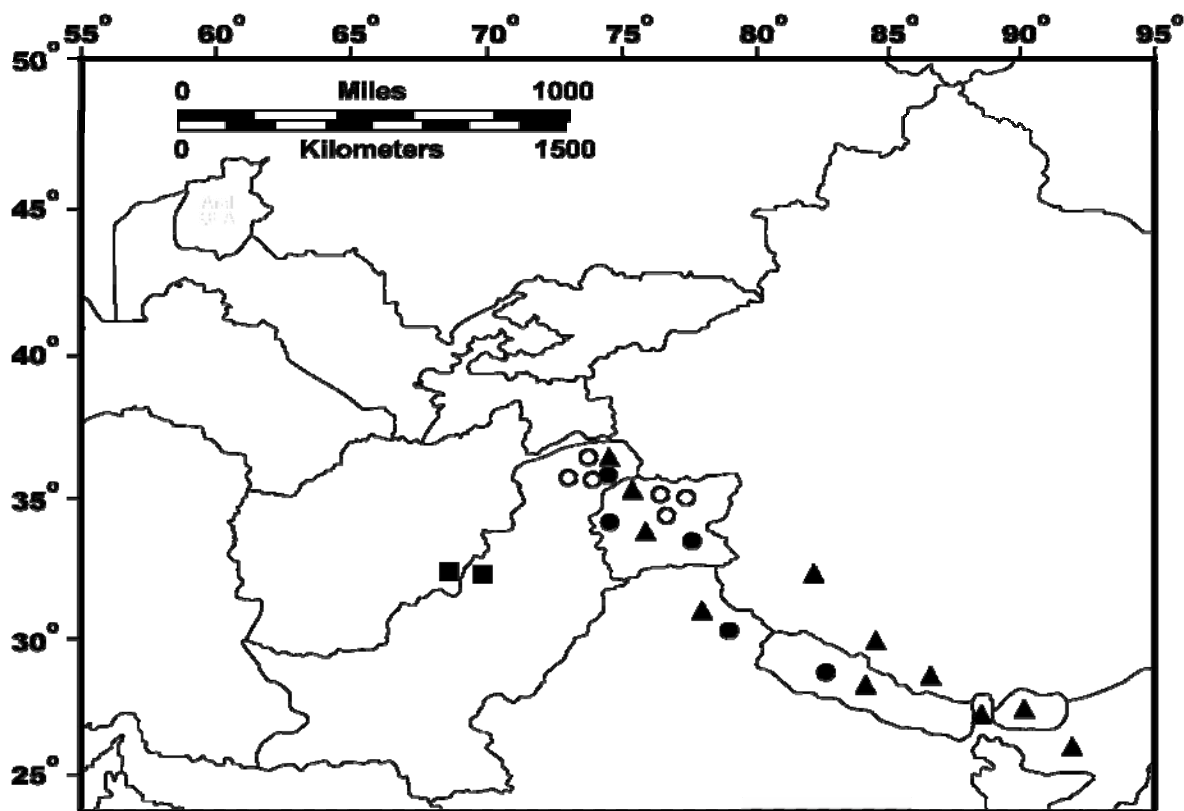


Fig. 6. Distribution pattern of *Rhodiola bupleuroides* (▲); *R. imbricate* (●); *R. pachyclados* (■) and *R. saxifragoides* (○).

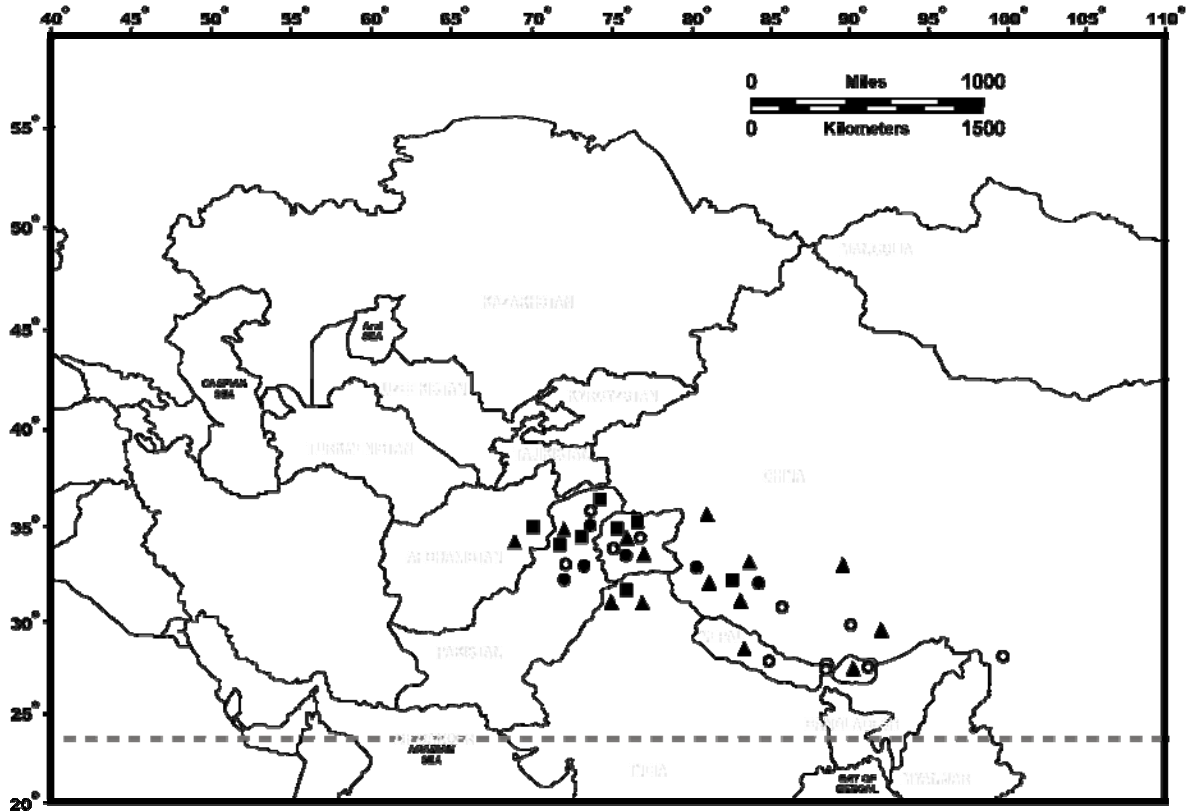


Fig. 7. Distribution pattern of *Rhodiola coccinea* subsp. *coccinea* (▲); *R. coccinea* subsp. *scabrada* (●); *R. tibetica* (■) and *R. fastigiata* (○).

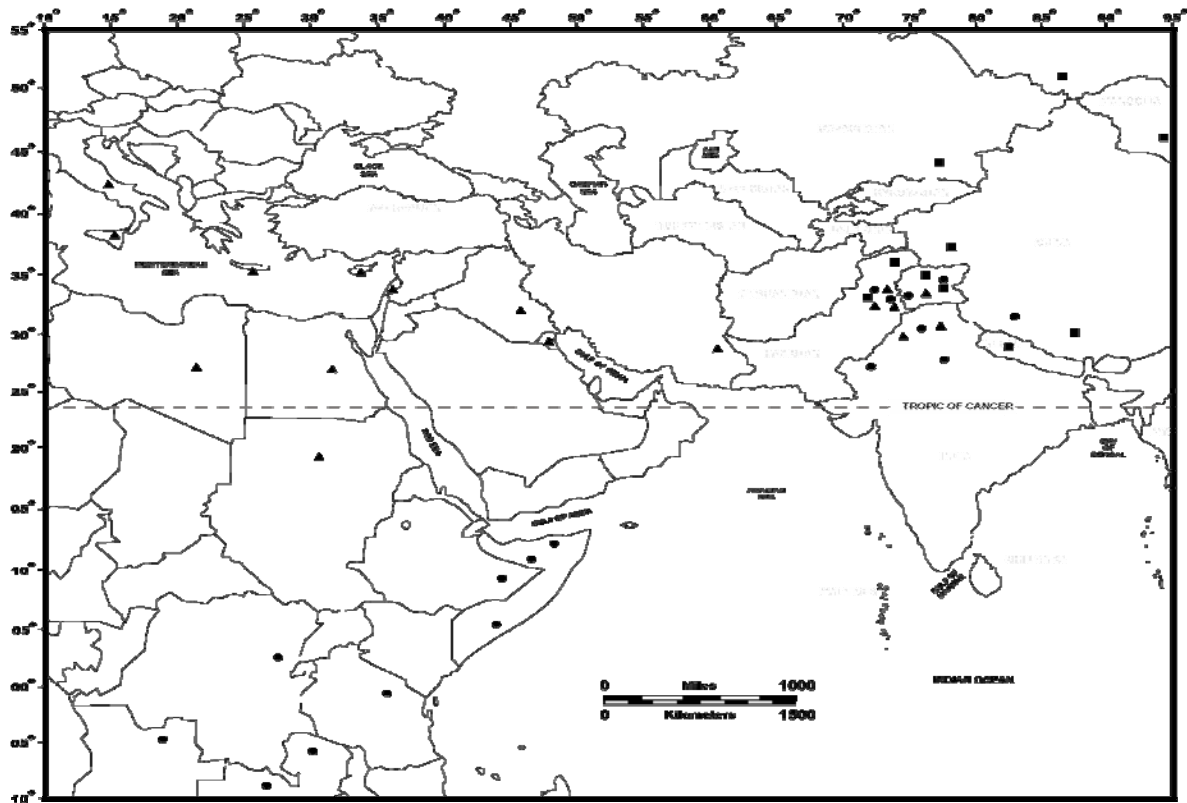


Fig. 8. Distribution pattern of *Tillaea schimperi* (●); *T. alata* (▲) and *R. quadrifida* (■).

References

- Ali, S.I. 1978. The flora of Pakistan: Some general and analytical remarks. *Notes from the Royal Botanic Garden Edinburgh*, 36: 427-439.
- Ali, S.I. and M. Qaiser. 1986. A phytogeographical analysis of the phenoragams of Pakistan and Kashmir. *Proceeding of the Royal Society of Edinburgh*, 89B, 89-101.
- Chazaro-Basanez, M.J. and J. Theide. 1995. *Floristic and phytogeographical studies on the Crassulaceae of Jalisco (Mexico)*. In: *Evolution and Systematics of the Crassulaceae*, (Ed.) Hart & Egli, Leiden. 124-135.
- Eggl, U. 1988. A monographic study of the genus *Rosularia* (Crassulaceae). *Bradleya*, 6: 1-119.
- Good, R. 1947. *The Geography of the Flowering Plants*. 1st ed. Longman, London.
- Good, R. 1974. *The Geography of the Flowering Plants*. 4th ed. Longman, London.
- Hara, H. 1966. *The Flora of Eastern Himalaya*, Tokyo: University of Tokyo Press.
- Hooker, J.D. 1904. *A Sketch of the flora of British India*. London.
- Holmgren, P.K., N.H. Holmgren and L.C. Barnell. 1990. *Index Herbariorum* Part I: The Herbaria of the World. 8th ed. Regnum Veg. New York.
- Jurgens, N. 1995. *Contributions to the phytogeography of Crassula*. In: *Evolution and systematics of the crassulaceae*. (Eds.): Hart & Egli. Buchuys Publishers Leiden. Netherland. 136-152.
- Kitamura, S. 1960. *Flora of Afghanistan*. Results of the Koyoto University Scientific expedition to the Karakorum and Hindukush 1955, Vol. II. Japan: Koyoto University.
- Kunjun, F and M.G. Gilbert. 2001. *Flora of China. Crassulaceae*. Vol. 8. (Eds.) Zheng-yi and Raven. Missouri Botanical Garden Press.
- Mabberley, D.J. 2008. *Plant Book* 3rd ed. Cambridge University Press.
- Ohba, H. 1978. Generic and infrageneric classification of the Old World Sedoideae (Crassulaceae). *J. Fac. Sci. Univ. Tokyo*, sect. iii, 12(4): 139-198.
- Sarwar, G.R. 2002. *Flora of Pakistan. Crassulaceae*, (Eds.): S.I. Ali & M. Qaiser. No. 209: 1-65. Department of Botany, University of Karachi and Missouri Botanical Garden St. Louis, Missouri, USA.
- Soo-Young, O. 1985. The phytogeographical studies of family Crassulaceae in Korea. *Resh. Rev. Kyungpork Nat. Uni.* 39: 123-159.
- Takhtajan, A. 1969. *Flowering plants. Origin and Dispersal*. Edinburgh : Oliver & Boyd.
- Takhtajan, A. 1986. *Floristic regions of the world*. University of California Press, Berkeley.
- Theide, J. 1995. *Quantitative phytogeography, species richness and evolution of American Crassulaceae*. In: *Evolution and systematics of the crassulaceae*. (Eds.): Hart & Egli. Backhuys Publishers. Leiden. Netherland. 89-123.
- Willis, J.C. 1973. *A dictionary of flowering plants and ferns*. Revised by Airy-Shaw, H.K. Cambridge.
- Zohary, M. 1973. *Geobotanical Foundations of the Middle East* Vols. 1 & 2. Stuttgart: Gustav Fischer Verlag.

(Received for publication 25 August 2011)