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Phytogeography and Distribution Pattern of *Inula* L. (S.Str.) and Its Related Taxa in India

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Abstract

In the present study, phytogeography and distribution pattern of twenty taxa belonging to four different genera viz., *Inula* L. (s.str.), Duhaldea DC., Dittrichia Greuter and Iphiona Cass., has been analyzed from India. Their distribution pattern has also been compared among the different floristic regions of the world. During the present study it was observed that among the 12 species of Inula present in India, 4 species (Inula acuminate, I. falconeri, I. obtusifolia and I. rhizocephala) are typical Irano-Turanian elements, whereas other 4 species (*Inula* hookeri, I. kalapani, I. macrosperma and I. royleana) are typical Sino-Japanese elements. Out of the remaining 4 species of Inula, 3 species (I. clarkei, I. orientalis and I. racemosa) are distributed both in Irano-Turanian and Sino-Japanese regions of the world and only 1 species (Inula britannica) of Inula is the widely distributed species which is present among the boundaries of Irano-Turanian, Indian, Euro-Siberian and Mediterranean regions of the world. Similarly, 3 species (Duhaldea nervosa, D. rubricaulis and D. simonsii) among the 6 species of Duhaldea are typical Sino-Japanese elements. And, remaining 3 species of Duhaldea (D. cappa, D. cuspidata and D. simonsii) are both Sino-Japanese as well as Indian elements. Dittrichia graveolens is a typical Mediterranean element in contrast to Iphiona grantioides which is both Indian as well as Saharo-Sindian element.

Keywords: Distribution pattern, *Inula*, Duhaldea, Dittrchia, Iphiona, India.

Introduction

The genus *Inula* (*s.l.*) belongs to the tribe Inuleae, sub-tribe Inulinae of the family Asteraceae. It includes *c.* 100 species mainly distributed in warm and temperate regions of Africa, Asia and Europe (Anderberg 1991, 2009; Abid & Qaiser 2002; Chen & Anderberg 2011). In India, the genus *Inula* (*s.l.*) is represented by 20 species distributed mainly in Trans Himalaya, Western Himalaya and North East regions (Kumar & Pant 1995). Anderberg (1991) transferred several species of *Inula* (*s.l.*) to other genera *viz*., *Duhaldea*, *Iphiona* and *Dittrichia* etc. Thus, presently in India the genus *Inula* (*s.str.*) comprises only 12 species; whereas, out of the remaining eight species, *Duhaldea* represents six species while both *Iphiona* and *Dittrichia* contain single species (Shekhar *et al.,* 2013).

The genus *Inula* (*s.str.*), *Duhaldea*, *Dittrichia* and *Iphiona* are mainly Eurasian in distribution. The distribution pattern of these taxa has been studied only from some part of the world (Qaiser and Abid, 2005; Shekhar *et al* 2013). Anderberg (1991) studied the taxonomy and phylogeny of the tribe Inuleae in which he also discussed general distribution of these taxa. Similarly, Rao and Dutt (1996) studied the diversity, endemism and phyto-geographical affinities of some Indian Asteraceae along with the biogeographical regions of India. Apart from the above reports on distribution pattern on these taxa, no information is available on the phytogeography and ecology of various species belonging to *Inula*, *Duhaldea*, *Iphiona* and *Dittrichia* occurring in India.

Objective of the Study

To study the Phytogeography and Distribution Pattern of *Inula* L. (s.str.) and its Related Taxa in India.

Materials and Methods

Twenty species belonging to 4 genera viz., *Inula* (*s.str.*), *Duhaldea*, *Dittrichia* and *Iphiona* were studied for their phytogeography and distribution pattern. Both herbaria and fresh collections were taken in consideration. Following Herbaria from India were consulted: DUH, CNH,

DD, BSD, NEHU, KASH, SHILLONG; whereas, the fresh collections were done from Leh-Ladakh, Kargil, Kashmir, Srinagar- Garhwal, Badrinath, Kedarnath, Dehra Dun, North-East (Sikkim, Meghalaya, Manipur and Arunachal Pradesh).

Observations ad Discussions

Inula (s.str.) is represented by *c.* 100 species in world. It is widely distributed in Europe, Africa and Asia (Merxmüller *et al*., 1977; Anderberg 1991, 1994; Dawar 1998; Qasir & Abid 2003; Anderberg 2009; Chen & Anderberg 2011 and Shekhar *et al.,* 2013). The Centres of distribution for these genera is considered to be the Eastern Mediterranean region, Tropical African region and the Himalayan region. Among the 100 species of *Inula*, Kumar & Pant (1995) reported 20 species from India, but Anderberg (1991) had transferred many species of *Inula* to *Duhaldea, Dittrichia, Iphiona* and many other genera which also included eight species of *Inula* from India. Thus presently, there are twelve species of *Inula*, six species of *Duhaldea* and only one species each of *Iphiona* and *Dittrichia* in India (Shekhar *et al.,* 2013).

Distribution Pattern of *Inula*

Indian *Inula* covers five major floristic regions of the world i.e. Irano-Turanian, Sino-Japanese, Indian, Euro-Siberian and Mediterranean (Table 1). *Inula acuminata, I. falconeri, I. obtusifolia* and *I. rhizocephala* are typically Irano-Turanian elements. *Inula britannica* is widely distributed in Indian, Irano-Turanian, Euro-Siberian and Mediterranean regions of the world. *I. clarkei, I. orientalis* and *I. racemosa* occurs in Irano-Turanian and Sino-Japanese region. *I. hookeri, I. kalapani, I. macrosperma* and *I. royleana* are typically Sino-Japanese elements. The major distribution of the genus *Inula* in India occurs in Trans-Himalaya (upper parts of Jammu & Kashmir), Western Himalaya (remaining parts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Meghalaya, Assam and Arunachal Pradesh) whereas, only one or two species occur in Semi-arid region (Punjab) of India (Fig. 1; Table 2, 3). *Inula acuminata* is rare in its occurrence, grows in damp places on calcareous rocks between 1600-2700m elevations. It grows in Western Himalaya, covering some parts of Jammu & Kashmir especially Baramulla, Phalgam, Srinagar and rarely present in Himachal Pradesh and also in Karakorum and Hindu Kush ranges in Pakistan, which are western most limits of Sino-Japanese region. *I. britannica* grows in wet places at an elevation of 1800-2500 m. In India it is present only in between Trans Himalayan and Western Himalayan regions of Jammu & Kashmir and also widely distributed in Western Europe (Austria, Berlin France and Paris), Turkey extending eastward to China through Iran and Pakistan.

I. clarkei shows a very narrow range of distribution in Western Himalayan region (Jammu & Kashmir and Himachal Pradesh) at the elevation of 2400-3500m. It is also present in Karakorum ranges in Pakistan. *I. falconeri* is restricted to Tran-Himalayan region (Drass-Kargil) at an elevation of 2300-2500 m. It is also distributed in Baltistan, Karakorum (Pakistan) and Western Tibet which is the type locality. *I. hookeri* occurs at 3000-4100m elevation in the temperate forests of North Eastern region of India which includes Sikkim (Lachen to Chunthang, Lachung to Yanthang) and Arunachal Pradesh (Thunglung to Lum La and Kameng district). It is also present in Nepal, Bhutan, Myanmar and China.

I. kalapani is endemic and restricted to Khasi hills, Meghalaya and Kameng District, Arunachal Pradesh in the North Eastern region at the elevation upto 1300-1500m. *I. macrosperma* is also rare and endemic to the alpine regions of Sikkim Himalaya, in North East region of India. *I. obtusifolia* grows commonly in rock crevices, on clumps, dry cliffs, slopes and stony grounds at 2000-4500 m elevation in Western Himalaya (Jammu & Kashmir, Himachal Pradesh and Uttarakhand), Semi-Arid regions of Punjab and rarely present in North East India (Assam). It is sympatric in N.W.

Himalaya, Karakorum and Hindu Kush range and extend further west to Eastern Afghanistan and eastward to China. *I. orientalis* is common and gregarious, grows on damp places along the steeps, edging the torrents upto 2000-3600m elevation in Western Himalaya (Jammu & Kashmir covering Gulmarg, Sonmarg, Sheshnaag near Pissu Ghati; Himachal Pradesh covering Chamba, Chenab, Kinnaur, Pangi, Jaunsar, Lahul, Keylong and Uttarakhand covering Badrinath and Kedarnath in Garhwal Himalaya) and Semi arid regions of Punjab. The species is also distributed from Nepal to Balkan-Asia minor through Pakistan, Caucasus.

I. racemosa is probably one of the most medicinally important species of Indian *Inula* and is mainly cultivated in fields at high altitudes between 1500-2500 m in Western Himalaya covering parts of Jammu & Kashmir and Himachal Pradesh and sometimes grown in North East (Assam). This is the only species which extends from Eastern Afghanistan to Nepal (Eastern Himalayas) through N.W. Himalaya and may be considered as partim endemic in Sino-Japanese region. *I. rhizocephala* grows occasionally in moist meadows between 3500-4000m elevation in Trans Himalayan region covering West Ladakh especially in Nun-Kun basin, Kargil and Suru valley. Over exploitation and habitat degradation are the major causes of the population decline. This is another Irano-Turanian (Central Asian) element distributed in Eastern Iran, Afghanistan, Uzbekistan and Eastern China, extends further east to India through Pakistan. *I. royleana* is sporadic among shrubs, especially Junipers, grows in alpine meadows between 2000-3500m, and on exposed dry alpine slopes upto about 3500-4000m, also present in forest. It is a Western Himalayan element covering parts of Jammu & Kashmir (Above Gaurikot, Kishanganga valley, near Jhelum river, Sonmarg, Gulmarg and Leh-Ladakh) and Himachal Pradesh (Pangi, Lahul) extending in the moist parts of Karakorum Range.

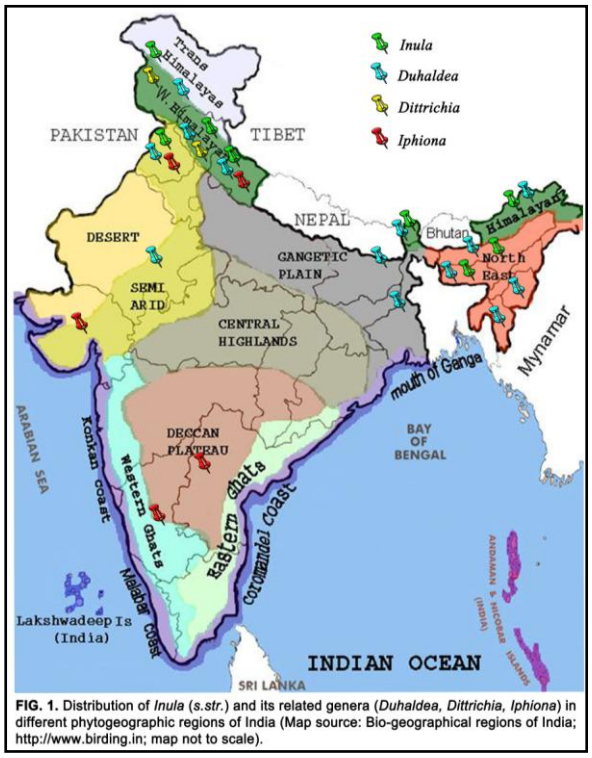

FIG. 1. Distribution of *Inula* (*s.str.*) and its related genera (*Duhaldea, Dittrichia, Iphiona*) in different phytogeographic regions of India (Map source: Bio-geographical regions of India; http://www.birding.in; map not to scale).

Distribution Pattern of *Duhaldea*

Duhaldea is mainly distributed in Africa and Central to East Asia (Qaiser & Abid 2003; Anderberg 2009; Chen & Anderberg 2011 and Shekhar *et al.,* 2013). *Duhaldea* is represented by *c.* 14 species in world. In India, it is represented by 6 species. It primarily covers Sino-Japanese region and some of the Indian floristic region of the world. *Duhaldea nervosa, D. rubricaulis* and *D. simonsii* are typically Sino-Japanese elements whereas *D. cappa, D. cuspidata* and *D. eupatorioides* are both Sino-Japanese as well as Indian element (Table 1). In India 3 species of *Duhaldea viz., D. nervosa, D. rubricaulis* and *D. simonsii* are mainly distributed in North Eastern region and Western Himalayan region (Sikkim, Meghalaya, Assam, Arunachal Pradesh, Manipur, Nagaland, some parts of Jammu & Kashmir, Himachal Pradesh and Uttarakhand) whereas the remaining 3 species *viz., D. cappa, D. cuspidata* and *D. eupatorioides* show a very wide distribution which includes the North East region, Western Himalayan region whereas narrowly distributed in Semi arid region (Punjab and Rajasthan) and Gangetic plains (Bihar and West Bengal) of India (Table 2, 3).

Duhaldea cappa grows between 900-3500m among rocks crevices and steep grassy banks, frequent along road-sides and mainly distributed in Western Himalaya and North Eastern regions, Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Srinagar-Garhwal, Mussoorie, Badrinath, Kedarnath), Sikkim (Mendong, Richingpong-Gassing), Assam, Nagaland, Manipur and Meghalaya; in Semi arid regions of Punjab and Rajasthan (Ajmer). *D. cuspidata* is common in open places, on steep hill slopes, along the edges of the forests, along river banks and among rock crevices from 900-2000m. It is mainly distributed in Western Himalaya viz. Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Pauri, Khirsu, Nainital, Mussoorie, on the way to Haridwar and Rishikesh) and restricted to Sikkim in North East region. Also present in Nepal, Bhutan, Pakistan and China. *D. eupatorioides* is found at the altitude between 700-1500m on rocky slopes. It covers a wide range in North Eastern region (Sikkim, Meghalaya, Assam, Arunachal Pradesh, Manipur and Nagaland), but restricted upto Uttarakhand in the Western Himalaya and West Bengal and Bihar in Gangetic plains. It stretches from Nepal, Bhutan, China, upto Myanmar. *D. nervosa* is common along the roadsides and often in forests upto 1500-2500m. *D. rubricaulis* grows on the shady ravines or rocky slopes, rare in sheltered places, ascending upto 1500-3500 m. Both (*D. nervosa* and *D. rubricaulis*) show a wide range of distribution in North Eastern regions (Sikkim, Meghalaya, Assam, Arunachal Pradesh, and Nagaland), whereas restricted in a very narrow range in Uttarakhand state of Western Himalayan region. *Duhaldea nervosa* and *D. rubricaulis* are also distributed in Nepal, Bhutan, Myanmar, Thailand, China, and Vietnam. *Duhaldea simonsii* is very rare and has been reported only from Arunachal Pradesh and Bhutan.

Distribution Pattern of *Dittrichia*

Dittrichia is represented by six species in world and single species (*D. graveolens*) in India. It grows on waste grounds Baluchistan (Qaiser & Abid 2005; Anderberg 2009 and Shekhar *et al.,* 2013). It is a typical Mediterranean element (Table 1). In India, it is confined to some parts of Western Himalayan region (Jammu & Kashmir and Himachal Pradesh) (Table 2 & 3). It is widespread in all Mediterranean territory marginally penetrating in the Atlantic European coast and Middle East (Iran, Iraq, Afghanistan and Pakistan).

Distribution Pattern of *Iphiona*

Iphiona shows a wide distribution covering Mediterranean-Tropical regions, South Africa, Mascrene Islands, Arabia expanding to Central Asia, Pakistan, arid plains of Sindh and Baluchistan (Qaiser & Abid 2005; Anderberg 2009 and Shekhar *et al.,* 2013). *Iphiona* is represented by 15 species worldwide and one species (*Iphiona grantioides*) in India. It occupies mainly Saharo-Sindian and Indian floristic region of the world (Table 1). It is mainly distributed in between the semi-arid region (Punjab and Gujarat) and in between the Deccan Plateau and Western Ghats (Karnataka and Andhra Pradesh) of India (Table 2 & 3). It is also present in Western Himalaya (Uttarakhand). It grows on the hilly slopes, stony grounds, among rocks, dry river beds, in arid plains at an altitude of 650-800 m.

Conclusion

Thus by the present study it can be concluded that among the 12 species of *Inula* present in India, 4 species (*Inula acuminate, I. falconeri, I. obtusifolia* and *I. rhizocephala*) are typical Irano-Turanian elements, whereas other 4 species (*Inula hookeri, I. kalapani, I. macrosperma* and *I. royleana*)

are typical Sino-Japanese elements. Out of the remaining 4 species of Inula, 3 species (*I. clarkei, I. orientalis* and *I. racemosa*) are distributed both in Irano-Turanian and Sino-Japanese regions of the world and only 1 species (*Inula britannica*) of Inula is the widely distributed species which is present among the boundaries of Irano-Turanian, Indian, Euro-Siberian and Mediterranean regions of the world. Similarly, 3 species (*Duhaldea nervosa, D. rubricaulis* and *D. simonsii*) among the 6 species of *Duhaldea* are typical Sino-Japanese elements. And, remaining 3 species of *Duhaldea* (*D. cappa, D. cuspidata* and *D. simonsii*) are both Sino-Japanese as well as Indian elements. *Dittrichiagraveolens* is a typical Mediterranean element in contrast to *Iphionagrantioides* which is both Indian as well as Saharo-Sindian element.

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Table 1
Phytogeographical Distribution of Indian *Inula* (*s.str.*) and Related Genera in Different Floristic Regions of the World

Name of Taxa	Irano-Tur.	Sino-Jap.	Ind.	Saharo-Sind.	Eur. Sib.	Med.
Inula acuminata	+	-	-	-	-	-
I. britannica	+	-	+	-	+	+
I. clarkei	+	+	-	-	-	-
I. falconeri	+	-	-	-	-	-
I. hookeri	-	+	-	-	-	-
I. kalapani	-	+	-	-	-	-
I. macrosperma	-	+	-	-	-	-
I. obtusifolia	+	-	-	-	-	-
I. orientalis	+	+	-	-	-	-
I. racemosa	+	+	-	-	-	-
I. rhizocephala	+	-	-	-	-	-
I. royleana	-	+	-	-	-	-
Duhaldea cappa	-	+	+	-	-	-
D. cuspidata	-	+	+	-	-	-
D. eupatorioides	-	+	+	-	-	-
D. nervosa	-	+	-	-	-	-
D. rubricaulis	-	+	-	-	-	-
D. simonsii	-	+	-	-	-	-
Dittrichia graveolens	-	-	-	-	-	+
Iphiona grantioides	-	-	+	+	-	-

Abbreviations: Irano-Tur.= Irano-Turanian, Sino-Jap.= Sino-Japanese, Ind.= Indian, Saharo-Sind.= Saharo-Sindian, Eur.-Sib.=Euro-Siberian, Med.= Mediterranean, + = Present, **-** = Absent.

Table 2
Phytogeographical Distribution of *Inula* (s.*str.*) and Related Genera in Different Phytogeographical Regions in India

Name of Taxa	Trans-Him.	West. Him.	Semi-Arid	N.E.	Gang. Plain	Dec. Plat.	West. Ghats
Inula acuminata	-	+	-	-	-	-	-
I. britannica	+	+	-	-	-	-	-
I. clarkei	-	+	-	-	-	-	-
I. falconeri	+	-	-	-	-	-	-
I. hookeri	-	-	-	+	-	-	-
I. kalapani	-	-	-	+	-	-	-
I. macrosperma	-	-	-	+	-	-	-
I. obtusifolia	-	+	+	+	-	-	-
I. orientalis	-	+	+	-	-	-	-
I. racemosa	-	+	-	+	-	-	-
I. rhizocephala	+	-	-	-	-	-	-
I. royleana	-	+	-	-	-	-	-
Duhaldea cappa	-	+	+	+	+	-	-
D. cuspidata	-	+	+	+	+	-	-
D. eupatorioides	-	+	+	+	+	-	-
D. nervosa	-	+	-	+	+	-	-
D. rubricaulis	-	+	-	+	+	-	-
D. simonsii	-	+	-	+	+	-	-
Dittrichia graveolens	-	+	-	-	-	-	-
Iphiona grantioides	-	-	+	-	-	+	+

Abbreviations: Trans-Him.= Trans Himalaya, West. Him.= Western Himalaya, N.E.= North East, Gang. Plain= Gangetic Plain, Dec. Plat. = Deccan Plateau, West. Ghats= Western Ghats. + = Present, - = Absent.

Table 3
Distribution of *Inula* and Related Genera (*Duhaldea, Dittrichia* and *Iphiona*) in Different States of India

Name of Taxa	Jammu Kashmir	Himachal Pradesh	Uttarakhand	Sikkim	Meghalaya	Assam	Arunachal Pradesh	Manipur	Nagaland	Gujarat	Rajasthan	Punjab	West Bengal	Bihar	Karnataka	Andhra Pradesh
Inula acuminata[*]	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I. britannica	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I. clarkei	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I. falconeri	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I. hookeri	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
I. kalapani[*,**]	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
I. macrosperma[*,**]	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
I. obtusifolia	+	+	+	-	-	+	-	-	-	-	-	+	-	-	-	-
I. orientalis	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	-
I. racemosa	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
I. rhizocephala[*]	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I. royleana	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Duhaldea cappa	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-
D. cuspidata	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	-
D. eupatorioides	-	-	+	+	+	+	+	+	+	-	-	-	+	+	-	-
D. nervosa	-	+	+	+	+	+	+	-	+	-	-	-	-	-	-	-
D. rubricaulis	-	+[*]	+	+	+	+	+	-	+	-	-	-	-	-	-	-
D. simonsii[*]	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Dittrichia graveolens	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iphiona grantioides	-	-	+[*]	-	-	-	-	-	-	+	-	+	-	-	+	+

+ve sign indicates the distribution of the species in the mentioned State,
-ve sign indicates absence of the species in the mentioned state, [*]Endemic, [*]Rare