

## Assessment of diversity, endemism and distribution of the genus *Aconitum* Linnaeus (Ranunculaceae) in India

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### Abstract

Present work is an overview and critical assessment of published data and herbarium records on the diversity, endemism and distribution of the genus *Aconitum* in India. Out of total 32 taxa (27 species and 5 varieties), 16 are confined to the Eastern Himalaya, 12 to the Western Himalaya and 4 taxa are common to both the flanks. Genus forms the group of high altitude flowering plants and maximum diversity has been observed between 3000 – 3500 m asl. Many taxa are of high medicinal value and find key position in IUCN Red List.

**Key words:** *Aconitum*, Ranunculaceae, diversity, India

### INTRODUCTION

The genus *Aconitum* Linnaeus (Ranunculaceae), nested in the tribe Delphineae along with *Delphinium* Linnaeus and *Consolida* (De Candolle) Gray is characterized by hooded zygomorphic flowers with hidden nectaries and characteristic seed-coat ornamentation (Hoot 1991; Johansson & Jansen 1993), comprises of nearly 300 species (Luo *et al.* 2005), distributed in Japan (Nakai 1908; Tamura & Namba 1959; Kadota 1981), central Europe, east Asia (Nakai 1908), and Eastern (Hardin 1964) and north-western America (Brink 1980, 1982) sharing nearly 12 % species of 'Buttercup family'. The centre of diversity for the genus is South-West China and the Eastern Himalaya, where *Aconitum* has 166 species (Liangqian & Kadota 2001). The genus exhibits exceedingly high morphological variability, thus, making taxonomic classification difficult (Luo *et al.* 2005; Sutkowska *et al.* 2013) and even there are numerous reports on the occurrence natural hybrids in *Aconitum* (Gayer 1909; Gotz 1967; Seitz 1969).

The genus *Aconitum*, commonly known as Aconites or Monkshood, is one of the most valuable indigenous drug and has found an important place in ancient Ayurvedic systems of medicine by the name of "Atish/Ativisha" for their efficacious medicinal properties. Aconites are one of the most promising medicinal herbs with high therapeutic properties to cure analgesic and neurological disorders, rheumatism, gastroenteritis, diarrhea, edema, bronchial asthma, leprosy, paralysis, various tumors and some endocrinal disorders like irregular menstruation, etc. and also used as antiviral, antifungal, antihelminthic, appetizer, astringent, carminative, etc. (Jabeen *at al.* 2012; Jaiswal *et al.* 2013; Shyaula 2011). *Aconitum* species are the rich

sources of diterpene alkaloids and flavonoids. Tubers of the plant are the natural source of alkaloid aconitine, a neurotoxin which attributes to the medicinal properties of the plant ((Sharma *et al.* 2009).

Annual demand of botanical raw drugs is quite high in domestic market in India (Ved & Goraya 2007), which has put an immense pressure on the genus making it threatened in different states of Himalayan range as assessed by several workers and these assessments placed *A. heterophyllum*, *A. falconeri*, *A. ferox*, *A. deinorrhizum*, *A. violaceum*, *A. spicatum* into different threat categories of IUCN (Sharma 2012; Chhetri *et al.* 2005; Srivastava *et al.* 2010). *Aconitum*, being one of the most traded species in the indigenous drug industry (Chakrabarti & Varshney 2001) is destructively harvested by tribal, local people, forest contractors, and various drug development agencies of the country causing considerable depletion of their wild populations.

India as a whole possesses a rich floristic diversity (17,000 species of flowering plants) accounting for 10.78% of floral species of the world with 33.5% endemism (Nayar 1996). Out of the total number of endemics reported for India, about 46% are found in the Indian part of the Himalayas and *Aconitum* spp. occur at several position in the list of 3471 endemic species of flowering plants reported in the Himalayas.

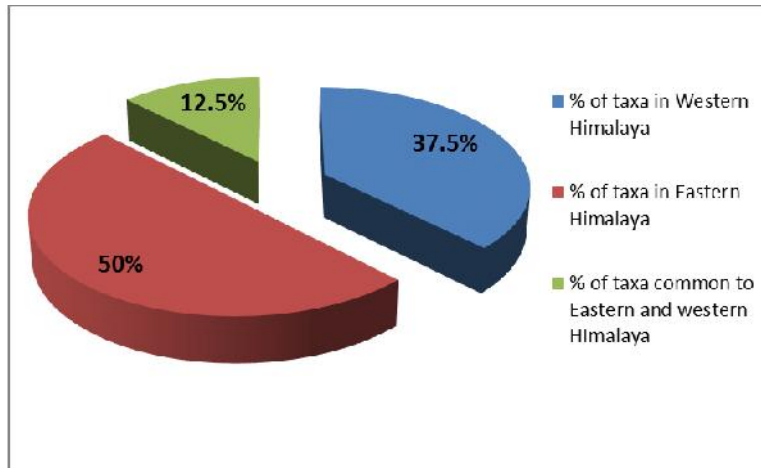
In India, the genus is represented by 27 species and 5 varieties, which are chiefly distributed in the temperate to alpine zones of the Indian Himalayas. These taxa have been inventoried in different Himalayan regions in various floristic studies taken up by several workers (Hooker 1872; Stapf 1905; Bamber 1916; Collett 1921; Hara 1966; Singh and Kachroo 1976; Nair 1977; Blatter 1984; Polunin & Stainton 1984; Chowdhery & Wadhwa 1984; Naithani 1985; Sharma & Jamwal 1988; Rau 1993; Hajra & Balodi 1995; Hajra *et al.* 1996; Uniyal & Thothathari 1997; Chaudhary & Rao 1998; Aswal & Mehrotra 1999; Singh & Rawat 2000; Kaur & Sharma 2004; Pusalkar & Singh 2012; Jabeen *et al.* 2013 Ghosh & Mallick 2014). The present paper deals with the enumeration of *Aconitum* in Indian Himalayan Region (IHR).

Taking into account the medicinal importance of the genus, we present an overview and critical assessment of available literature and published data concerning diversity, distribution range and endemism for the genus *Aconitum* Linnaeus in India.

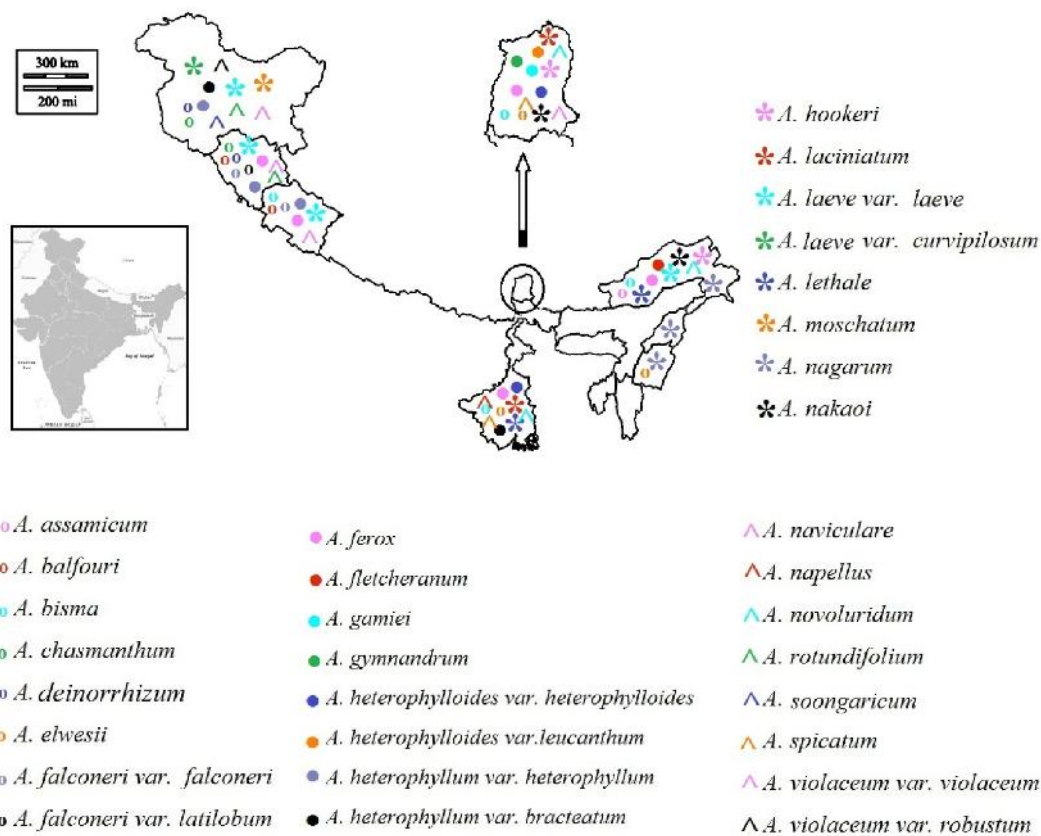
## RESULT AND DISCUSSION

In India, the genus *Aconitum* is represented by 32 taxa (27 species and 5 varieties) confined to Indian Himalayan Region (Table 1). Our data analysis shows that the distribution of *Aconitum* in the Himalaya is mostly concentrated in the Eastern Himalaya where 16 taxa are known to occur as compared to 12 taxa in the Western Himalaya with 4 taxa common to both the flanks. Shankar (2003) stated that the species found in Eastern Himalaya are not known from Western Himalaya and *vice-versa*, whereas our studies revealed that four taxa namely, *A. bisma*, *A. ferox* and *A. leave* and *A. heterophyllum* var. *bracteatum* are common to both Western and Eastern flanks of the Himalayas (Figure 1).

During the course of our study we have found lots of confusion and variations within the genus, as it is polymorphic taxa. We do not agree with the workers who have merged several taxa as given on 'The Plant List' or 'IPNI', as we have critically analyzed few taxa, which are persisting but have been merged or synonymized by workers as shown on the web or *vice-versa*. There might be a different picture of the status of several taxa in this genus after completion of monographic studies. Therefore, at this moment we have tried to synthesize the best possible information about the diversity in the genus *Aconitum*.



**Figure 1.** Distribution of taxa of *Aconitum* in Indian Himalayan Region



**Figure 2.** Distribution of the taxa of *Aconitum* in different states in India

Out of the total taxa under the genus *Aconitum*, five taxa (15.6 %) are found to be endemic at global level and 12 taxa were assessed to be endemic at local/Indian level. Interestingly, Sikkim in Eastern Himalaya, being the smallest state in the IHR harbors the highest diversity (13 taxa) of aconites with four taxa endemic at local level followed by Kashmir where 11 aconites have been recorded with two local endemic

**Table 1.** Distribution of the taxa of *Aconitum* L. in India and adjacent countries [Abbreviations used: AP = Arunachal Pradesh; HP = Himachal Pradesh; J&K = Jammu & Kashmir; Mn = Manipur; Ng = Nagaland; SK = Sikkim; UK = Uttarakhand; WB = West Bengal]

Sr No.	Name of Taxa	Altitude (Metres)	Distribution	
			India	Neighboring countries
1.	<i>A. assamicum</i> Lauener	3900-4300	AP	
2.	<i>A. balfourii</i> Stapf	2800-3400	HP, UK	Nepal
3.	<i>A. bisma</i> (Buchanan-Hamilton) Rapaics	1500-3700	UK, WB, SK, AP	Nepal, Bhutan, China
4.	<i>A. chasmanthum</i> Stapf ex Holmes	2100-3700	J&K, HP	Pakistan
5.	<i>A. deinorrhizum</i> Stapf	3000-3500	J&K, HP	Pakistan
6.	<i>A. elwesii</i> Stapf	2400-3200	WB, SK, Mn	Nepal, Bhutan China
7.	<i>A. falconeri</i> Stapf var. <i>falconeri</i> Stapf	3000-4000	HP, UK	
8.	<i>A. falconeri</i> Stapf var. <i>latilobum</i> Stapf	3000-3400	HP	
9.	<i>A. ferox</i> Wallich	2100-3800	HP, UK, WB, SK, AP	Nepal, Bhutan
10.	<i>A. fletcheranum</i> Taylor	4000-4600	AP	Bhutan
11.	<i>A. gamiei</i> Stapf	3300-4800	SK	Nepal, China
12.	<i>A. gymnandrum</i> Maximowicz	4200-4800	SK	Bhutan, China
13.	<i>A. heterophylloides</i> (Bruehl) Stapf var. <i>heterophylloides</i>	3600-4500	WB, SK	Nepal, Bhutan, China
14.	<i>A. heterophylloides</i> (Bruehl) Stapf var. <i>leucanthum</i> (Bruehl) Lauener	4000-4500	SK	Nepal, Bhutan, China
15.	<i>A. heterophyllum</i> Wallich ex Royle var. <i>heterophyllum</i>	2300-4500	J&K, HP, UK	Pakistan, Nepal,
16.	<i>A. heterophyllum</i> Wallich ex Royle var. <i>bracteatum</i> Stapf	3000-3500	J&K, WB	Pakistan
17.	<i>A. hookeri</i> Stapf	3600-4800	SK, AP	Nepal Bhutan China
18.	<i>A. laciniatum</i> (Bruehl) Stapf	3500-4570	WB, SK	Nepal, Bhutan, China
19.	<i>A. laeve</i> Royle var. <i>laeve</i>	2000-3300	J&K, HP, UK, AP	Pakistan, Nepal
20.	<i>A. laeve</i> Royle var. <i>curvipilosum</i> Tamura & Launer	2950-3500	J&K	

Sr No.	Name of Taxa	Altitude (Metres)	Distribution	
			India	Neighboring countries
21.	<i>A. lethale</i> Griffith	3900-4600	WB, AP	Nepal, Bhutan, China
22.	<i>A. moschatum</i> (Bruehl) Stapf	3650-4270	J&K	
23.	<i>A. nagarum</i> Stapf	2400-3400	AP, Ng, Mn	Myanmar
24.	<i>A. nakaoui</i> Tamura	3800-4400	SK, AP	Bhutan China
25.	<i>A. naviculare</i> (Bruehl) Stapf	3000-4900	SK	Nepal, Bhutan, China
26.	<i>A. napellus</i> Linnaeus	3400-5000	WB	Europe
27.	<i>A. novoluridum</i> Munz	3600-5000	WB, SK, AP	Bhutan, China
28.	<i>A. rotundifolium</i> Karelin & Kiriloff	3000-4500	J&K, HP	Afghanistan, Nepal, Pakistan, Turkestan
29.	<i>A. soongaricum</i> Stapf	2900-3400	J&K	Pakistan, China, Turkestan
30.	<i>A. spicatum</i> (Bruehl) Stapf	3300-4500	WB, SK	Nepal, Bhutan, China
31.	<i>A. violaceum</i> Jacquem var. <i>violaceum</i>	3000-4800	J&K, HP, UK	Nepal, Pakistan
32.	<i>A. violaceum</i> Jacquem var. <i>robustum</i> Stapf.	2750-4480	J&K	Pakistan

taxa (Figure 2). The three states namely, Himachal Pradesh, Arunachal Pradesh and West Bengal hold equal number of taxa (10), whereas Himachal Pradesh and Uttarakhand has 2 globally endemic taxa, Arunachal Pradesh and West Bengal each with one local endemic taxon and Uttarakhand holds 7 taxa but not endemics. Hooker & Thomson (1872) included 7 species of *Aconitum* in the *Flora of British India* but the detailed taxonomy of Indian *Aconitum* was carried out by Stapf (1905) who recognized 24 species. Rau (1993) reported 27 species and 4 varieties of *Aconitum* for *Flora of India*, whereas Sinam & Devi (2011) mentioned the number of species of *Aconitum* to be 28. Uniyal & Thothatri (1996) recorded 7 *Aconitum* species from West Bengal but recently Ghosh & Mallick (2014) have added 3 more to the region, the first one is *A. lethale* which was earlier known as endemic to Arunachal Pradesh (Hajra *et al.* 1996), the second taxa, *A. heterophyllum* var. *bracteatum*, reported from Kashmir and Pakistan (Chaudhary & Rao 1998; Jabeen *et al.* 2013) and the third species, *A. napellus* which was earlier reported from Europe. *Aconitum gymnantrum* was considered as endemic to Qinghai in Tibetan Plateau, China by several workers (Liu 2002; Duan *et al.* 2009; Wang 2009) is now also known to occur in Sikkim (Rau 1993; Srivastava 1998). Singh *et al.* (2002) reported two species namely *A. nagarum* and *A. elwesii* from Manipur and only one species, *A. nagarum*, has been collected from the Dzoku Valley in Nagaland by A.A. Mao at an altitude of 2200 m, and the specimen is lodged in ASSAM. As evident from

Figure 1, the humid forests of the Eastern Himalaya provided very suitable habitat for the occurrence and growth of *Aconitum* species. Phytogeographically, Sikkim forms the junction of migratory elements from the neighbouring countries like Nepal, China and Bhutan. The altitudinal distribution and growth of *Aconitum* is directly related to the specific climate and geography of the ecological niche.

The distribution of *Aconitum* plotted against the altitudinal gradient reveal a hump-shaped curve (Figure 3). Maximum concentration of taxa of *Aconitum* are found between 3000 – 3500 m amsl (Figure 3). Most of the Aconites have been more frequently collected from the sub-alpine and alpine zones of the Himalayas than from lower or higher altitudes. Species richness was found to be affected by increasing altitude and was highest in the mid-altitudinal ranges viz. 2500 – 3000 (11 taxa), 3000 – 3500 (21 taxa), 3500 – 4000 m (20 taxa), 4000 – 4500 m (19 taxa), 4500 – 5000 (9 taxa) suggesting a unimodal relationship between species richness and altitude. The reduction in species in higher altitudinal gradient could be attributed to eco-physiological constraints, such as extremely low temperature, short growing season and geographical barriers. Further, the lower altitudes were in a regime of frequent anthropogenic disturbances, such as road construction, habitation and agricultural practices, which resulted in replacement of natural vegetation with man-made ecosystems consisting of plantations and agriculture. The aconites prefer moist, open grassy, stony slopes, shrubberies, cliff edges, which are sensitive and susceptible to disappearance because of natural perturbations like rock falls, landslides and avalanches.

Owing to the high medicinal value, Aconite is one of the most traded plants in the indigenous drug industry and ruthless overexploitation results speedy decline in their population and inclusion in Red List. Earlier, the Aconites were used to prepare traditional medicine by ethnic communities in small quantities but commercialization of plant based drugs in recent years has increased the demand and consequent exploitation of different species of *Aconitum*. Due to increased demand for pharmaceutical industries, uncontrolled collection and lack of organized cultivation, plants are depleted in natural habitat. Therefore, it is imperative to study remaining population trends and research be conducted to determine optimal conditions for survival of these highly medicinal species.

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