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Assessment of geographic distribution and taxonomic anomalies of *Berberis* species found and reported from Karakoram, Hindukush and Western Himalayan Mountain Ranges in Pakistan

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Abstract

Berberis is used for treating more than 100 diseases worldwide. Fourteen (14) different *Berberis* species and subspecies have been reported for more than 31 times by at least 25 researchers from Karakoram, Hindukush and Western Himalayan Mountain Ranges in Pakistan. A serious confusion continues to exist among researchers regarding their taxonomic correct identification and distribution. Present study was aimed at assessment of geographical distribution and contribution towards removing ongoing misunderstanding regarding taxonomic documentation.

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Introduction

Genus *Berberis* exhibits a global distribution and almost all 450 species identified worldwide found across northern Hemisphere (Tiwari *et al.* 2012; Landrum 1999; Rao *et al.* 1998; Ahrendt 1961). It makes almost 70% composition of family Berberidaceae. Being one of the primitive angiosperm (Bruckner, 2000), it has a strong influence among various traditional and modern healthcare systems (Kulkarni & Dhir 2010; Imanshahidi & Hosseinzadeh 2008; Lewis & Ausubel 2006; Srivastava *et al.* 2006a). Asia and South America are considered to be the primary and secondary centres of its diversity respectively (Landrum 1999).

It is assumed that it has most probably originated in Northern Hemisphere during Cenozoic period. However, a complete biogeographical study of all genera of the tribe is still lacking (Emadzade & Hörandl 2011; Raven 1973). According to Li (2010) the genus originated in eastern Asia and has migrated from Eastern Asia to North America in the Oligocene period (33.9 million to 23 million years). Similarly, in view of Chapman (1936), carpellary anatomic features suggest that Berberidaceae and Ranunculaceae arose by parallel evolution from a Proranalian complex.

Berberis shows extremely high morpho-pathological and phytochemical variation making taxonomic identification difficult (Khan *et al.* 2014; Rao *et al.* 1998; Chapman 1936; Ahrendt 1961). Overlapping characters, especially in leaves, stem, and flower and berry size make field identification often challenging. Leaf texture and serrations vary from season to season and with the age of the plant in some of the species (Lucas *et al.* 2012; Tiwari & Adhikari 2011; Rao *et al.* 1998; Chapman 1936; Jafri 1975). Such a variation may be due to environmental and hybridization effects.

Geographically country presents a profound blend of landscapes varying from plains to deserts, forests, hills, and plateaus ranging from the coastal areas of the Arabian Sea in the south to the mountains of the

Karakoram Range in the north (Geo 2014). There are four seasons and climate is varied throughout the country, characterized by hot summers and cool or cold chilling winters (Mehreen & Shahina 2013).

In Pakistan, there are 29 different *Berberis* species (20 species, 6 subspecies, 2 varieties and 1 forma). These species are mostly distributed in the Northern mountainous ranges (Khan *et al.* 2014a; eFlora 2014; Jafri 1975). Stewart and Stewart (1935) were the first to report *Berberis* from Gilgit-Baltistan (Khan *et al.* 2014a).

This study was aimed at assessment of geographic distribution and taxonomic anomalies of *Berberis* species found and reported from Karakoram, Hindukush and Western Himalayan Mountain Ranges in Pakistan. Study will help to remove continuous mistakes made by field surveyors, taxonomists and several other researchers equally. Moreover, study calculates geographic distribution of *Berberis* across these geographical areas for the first time.

Material and methods

Sampling and Data collection

Research is based on the sample collected and literature reviewed from Pakistan (30° 00' N latitude and 70° 00' E longitude). Plant samples have been collected from Karakoram mountain ranges and for Hindukush and Himalaya (Fig.), we have relied on literature resources published or reported since 1935.

Parameters studied

Mature plants of both subspecies have been studied using various morphological characters in the field including plant height, leaf characters, berries, thorns/spines, borer attack infection level, and different analytical tools have been used to assess their basic field based difference viz; maximum, minimum, mean, standard deviation and standard error.

Taxonomic distinction

Average plant (shrubs) reaches to 2.71 m with a maximum height of 3.37 m (Khan *et al.* 2014d). Leaves petiolate, oblong, obovate or elliptic-acute,

spinere-serrate, sinulose margins. Both the subspecies are thorny; the flowers were deep/light yellow, hermaphrodite, pollinated by insects or self. Flowers were arranged in loose racemose-subumbellate and corymbose panicles. (Khan *et al.* 2014d; Kulkarni, *et al.*, 2012; Alam and Ali 2010; Mehrhoff *et al.* 2003; Agrios 1988; Hooker 1982). Major (visible) features of flowers in both subspecies were similar except berry colour (Khan *et al.* 2014d). Identification was made by Dr. Jan Alam, plant taxonomist, Hazara University, KPK, Pakistan in the field and with the help of the Flora of Pakistan (eFlora 2014; Nasir & Ali 1975; Jafri 1975).

Area distribution calculation

Calculation of overall distribution area has been calculated using Google Earth, Google Earth Pro and GE-Path (v. 1.4.6).

Results and discussion

Distribution of Berberis in Pakistan

So far, 29 different Berberis species (20 species, 6 subspecies, 2 varieties and 1 forma) have been reported from Pakistan. These species are mostly distributed in the Northern mountainous ranges (Khan *et al.* 2014a; eFlora 2014; Jafri 1975). Table 1 gives a detailed account of species, subspecies,

varieties and forma from Pakistan, specifically from Chitral (Chit), Gilgit-Baltistan (GB) and Central Karakoram National Park (CKNP).

Distribution of Berberis across Karakoram, Hindukush and Himalaya

Stewart and Stewart (1935) were the first to report Berberis from Gilgit-Baltistan (Khan *et al.* 2014a). According to available literature, 25 researchers have reported 14 Berberis species (35 times) from Gilgit-Baltistan and Chitral (Fig.1). Similarly 23 researchers have reported (35 times) 11 species from Gilgit-Baltistan (table 1).

Distribution of Berberis pseudumbellata Parker in Pakistan

There are Berberis pseudumbellata Parker (*B. p.*) is found in different parts of Pakistan including Punjab, Ravi Valley, Kashmir, Naran, Swat, Hunza, Nagar, Gilgit, Ghizir, Naltar, Bagrot, Haramosh, Satpara, Burzil, Thale La, and Chitral (Khan, 2014; Awan *et al.* 2014; Khan *et al.* 2013; Alam & Ali, 2010; eFlora, 2014; Abbas *et al.* 213; Khan & Khatoon, 2007; Shaikh 2000; Ghafoor 1974; Ghafoor & Butt, 1974). Most of the concentration of Berberis pseudumbellata shows across great mountainous ranges of Himalaya, Karakoram and Hindukush (table 2).

Table 1. Abbreviations; **1).** B.L (*B. lyceum*), **2).** B.Br (*B. brandisiana*), **3).** B.OOr (*B. orthobotrys orthobotrys*), **4).** B.OrC (*B. orthobotrys capitata*), **5).** B.PP (*B. pseudumbellata* subsp. *pseudumbellata*), **6).** B. PGI (*B. pseudumbellata gilgitica*), **7).** B. Ku (*B. kunwarensis*), **8).** B.Pa (*B. pachyacantha*), **9).** B.Pr (*B. parkeriana*), **10).** B.Ca (*B. calliobotrys*), **11).** B.st (*B. stewartiana*), **12).** B.ul (*B. ulicina*), **13).** B.ait (*B. aitchisonii*), **14).** B.vul (*B. vulgaris*), KNP (Khunjerab National Park).

Year	Researcher/ Author	Species/Subsp. /Reported from	B.L	B. Br	B. OOr	B. OrC	B. PP	B. PGI	B. Ku	B. Pa	B. Pr	B.Ca	B. st	B. ul	B. ait	B.Vul
2014	Khan <i>et al.</i>	Naltar, Bagrot						√								
2014	Khan <i>et al.</i>	Nomal, Rakaposhi, Goro, Rahimabad					√									
2014	Bano <i>et al.</i>	Skaradu														√
2013	Alamgeer <i>et al.</i>	Gilgit				√										
2013	Iqbal <i>et al.</i>	Kunhar River catchment	√						√	√	√					
2013	Abbas <i>et al.</i>	Naltar valley		√		√	√									
2013	Hussain <i>et. al.</i>	Kuwardu, Thally, Arandu, Hoper, Bagrot	√													

Year	Researcher/ Author	Species/Subsp. /Reported from	B.L	B. Br	B. OOr	B. OrC	B. PP	B. PGI	B. Ku	B. Pa	B. Pr	B.Ca	B. st	B. ul	B. ait	B.Vul
2011	Khan <i>et al.</i>	KNP and Shimshal	√													
2009	Alam and Ali	Naltar, Skoro La-Baltistan						√								
2009	Sher wali Khan	Bagrot, Haramosh		√		√	√	√								
2007	Khan & Khatoon	Bagrot, Haramosh		√		√	√									
2006	Qureshi <i>et al.</i>	Gilgit-Hunza,Astor,Gilgit,Nom al,Naltar, Kargah	√						√							
2003	Shinwari & Gilani	Bulashbar valley, Astore	√													
2000	Kashif Sheikh	Naltar Valley					√				√					
1981	Hussain <i>et al.</i>	Chitral				√										
1975	Jafri, SMH.															
1974	Ghafoor & Butt	Skardu-Satpara;				√		√								
1974	Ghafoor, A.	Naltar						√								
1971	Beg, AR.	Chitral-Brir											√			
1963	Siddiqui, MA.	Baltistan-Sadpara lake			√											
1956	Ali, Shoukat	Karamber, Darkut			√									√		
1956	Beg, AR	Chitral-Bomburait										√				
1956	Stainton, JDA	Chitral-Mastuj													√	
1955	Nisar & Webster	Hushe, Astor; Skardu			√	√										
1954	Stewart, RR.	Naltar			√											
1954	Haq, Saeedul	Chitral-Bomburait										√				
1950	Chaudhri, II.	Chitral-Brum glacier			√											
1946	Stewart, RR.	Astor-Gurikot		√	√											
1940	Stewart, RR.	Skardu- satpara, Burzil; Thale La		√	√		√						√	√		
1939	Stewart & ID.	Gilgit Rd.											√			
1939	Stewart & ID.	Astor, Gurikot, Gilgit			√											
1936	Koelz, W.	Baltistan-Sodpur		√												
1935	Stewart	Gilgit					√									



Fig.1. A GIS based map of study area showing occurrence of Berberis species across Karakoram, Himalaya and Hindukush Mountain Ranges in Pakistan. (Map by Tika Khan).

Geographical area covered by B. p.

Overall geographical reach of *B.p.* shows almost 70,000 km² in Pakistan. Total area covered mentioned here does not reflect extent of occurrence or area of occupancy except geographical area covered which include glaciers and area without under *B.p.*

Discussion

Since the time of Stewart (1935), twenty five (25) researchers have reported *Berberis* species from mighty mountain ranges of Karakorum, Himalaya and Hindukush. However, most of them who report

from Gilgit-Baltistan have remained confused regarding its identification. These researchers have documented 14 *Berberis* species which is not correct at all. Morphological characterization shows that these species found in the area are closely related with minor differences (Khan *et al.* 2014). These differences never support an idea of 14 species or subspecies. This confusion may be due to several reasons; 1) overlapping characters which is an inherent feature of *Berberis* species under the influence of environmental conditions and hybridization, 2) Lack of sound taxonomic investigation, 3) quick field visits, which do not allow enough time to follow identification keys and 4) weak relevance of researchers to taxonomy. Mostly these confusions are with *B. brandisiana* Ahrendt, *B. jaeschkeana* Schneid., *B. orthobotrys* Bien. ex Aitch. and *B. stewartiana* Jafri and *B. pseudumbellata* Parker and *B. umbellata* Wall. ex G. Don (eFlora 2014).

B. pseudumbellata Parker subsp. *gilgitica* Jafri is endemic to Gilgit-Baltistan (Khan *et al.* 2014; Alam and Ali, 2010; Jafri, 1975) and has become critically endangered (Alam and Ali, 2010). Present study contribute towards removing these confusions across field identification with visible features, however, genus specific details investigations including Phytochemistry, protein profile and DNA characterization are important to specify and discriminate species, subspecies, varieties and forma.

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