Differential levels of susceptibility of *Berberis* species to insect attack at various altitudes in Karakoram Ranges

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**Abstract**

Research was aimed to study prevalence of differential borer attack on Berberis spp. across elevation gradient and species diversity, which is found highly significant \( (p<0.001) \). Berberis species are exceptionally medicinal, used for treatment of cancer, diabetes, AIDS, heart, eye, hypertension, jaundice, spleen, cholera, diarrhea, leprosy etc. It plays a vital role for wildlife as wild-herbal-clinic. Various species serve as alternate host of wheat leaf and stem rust. Endemic species of genus Berberis have become critically endangered in the area. 18.73% berries are infected, 35.76% (SD±1.71) in *Berberis brandisiana* and 1.75% (SD±23.12) in *Berberis pseudumbellata* subsp. *gilgitica* (*B. psg*). Maximum number of seeds in *B. psg* is 5 (1%) and 6 (0.14%) in *Berberis brandisiana*. 10.52% berries are seedless, 15.29% (SD± 3.86) in *B. brandisiana* and 5.75% (SD± 6.70) in *B. psg*. In *B. brandisiana* 1, 2, 3 and 4 are frequent seed numbers and 1, 2 and 3 in *B. psg*. Berberis species found in the study area show altitudinal sensitivity, *B. brandisiana* grows only below 2300 m and *B. psg* above 2400 m. In *B. brandisiana* infection prevalence increases with increase in altitude. Study was carried out for the first time in history from the area.

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Introduction


Alkaloids, isoflavonoids, isoquinoline alkaloids, terpenoids, flavanoids, sterols, anthocyanins, vitamins and carotenoids have been characterized from the different parts of Berberis plant. ( Rashmi et al. 2009, Hwang and Jin-Ming et al. 2002). These compounds possess pharmacological activities (Kulkarni et al., 2012, Asif et al. 2007, Bhandari et al. 2000, Stermitz et al. 2000a, Chandra and Purohit 1980). The root and the stem bark are the richest source of alkaloids (5% and 4.2%, respectively) (Kulkarni et al. 2012). Roots, stem and leaves of lowland Berberis species show considerably higher Berberine (major alkaloid extracted from Berberis spp. Janbaza and Gilanib, 2000) contents as compared to plants grow at higher altitude. It is suggested that the concentration of Berberine is probably a result of adaptive response to altitudinal gradient in addition to it being a genetic character of different species of Berberis. (Chandra and Purohit 1980).

There is no information is available about the insect attacks on Berberis spp. and its impact on productive losses in the area. Study of such infections is
important to understand its dynamics, impact on the plant species, other plant and animal populations in the fragile mountainous communities, agriculture and ecosystems. Present investigation brings information on the subject for the first time in history from the area. During the present study severe but differential levels of attacks on berries and seeds were noted on different Berberis species found across altitudinal gradients in Karakoram Mountain Range (Central Karakoram National Park).

Material and method

Study area

Geography

CKNP is part of Karakorum Mountainous Ranges located in the North of Pakistan, area recently renamed as Gilgit-Baltistan (Fig. 1). It extends over 35°N to 36.5°N Latitude and from 74°E to 77°E Longitude. (Hussain et al. 2012, 2010). Elevation ranges from 1200m-6000m above sea level (asl). CKNP is the largest national park in Pakistan covering an area of 10,000 km². It shares international boundaries with India in the east and China in the North-East. In 1993, park was established to protect its unique wildlife and its natural ecosystem reducing undesired impacts on the largest glacial mass outside poles (Hussain et al. 2012). Study area (Fig.1) covers almost 2000 sq.km including Bagrot valley (432 sq.km), Rakaposhi (613 sq.km), Rahimabad-Juglot (450 sq.km) and Naltar (273 sq.km). (WWF Pakistan 2009).

Fig. 1. CKNP and sampling population (red dots).

Climate

Climate is predominantly cold arid and temperate in the lower elevations. Prevalent season is winter, occupying the valleys eight to nine months a year. Areas above 3300 m are very cold with a limiting growing season. (WWF Pakistan 2009). Area lacks significant rainfall, averaging in 120 to 240 millimeters (4.7 to 9.4 in) annually. (Karrar and Iqbal 2011). Most of rainfall occurs during winter and early spring. According to Archer (2004) elevation and temperature show an inverse relation (Fig. 2). An average month wise temperature (°C) and precipitation (cm) for the last 54 years (1955-2009) can be seen in Fig 3.

Ecological Zones

According to Rao and Marwat (2003) there are four main types of forests in the area including Montane Dry Temperate Coniferous, Montane Dry Temperate Broadleaved, Sub Alpine and Northern Dry Scrub forests. Berberis species are found in all these ecological zones.

Data collection and analysis

During 2012-13 quarterly field surveys were made to collect taxonomically important parts (flowers, berries, leaves, bark) and morphological details during flowering (Jun 20-Aug 15), fruiting (Sep-Oct) and harvesting (Sep 10-Oct 20) periods. Global Positioning System (GPS-Garmin) coordinates and elevations were also recorded. Data so gathered was processed and analyzed using SPSS (ver. 16.0), MS Excel and GIS (ver. 10.1) tools.

Data were recorded from 11 natural populations for floral, foliar, seed, spine and berries characters.

For borer (insect) damage, 200 berries were collected randomly from individual plants from 11 populations. Sampling was done from representative valleys of CKNP viz: Bagrot, Rahimabad-Juglot, Rakaposhi and Naltar. Berries were dried in the oven at 40°C (104 °Fahrenheit) for seven days (Bottini et al. 2002). Borer attacked berries were found to have hallow, endoplasm consumed seeds (Fig. 7). Temperature and precipitation records were collected from multiple sources including meteorological department, CKNP directorate, WWF, IUCN and independent researchers (Fig. 2 and 3).
Results and discussion

**Berberis species (Habit and habitat)**

During present study two species of genus Berberis viz; *B. psg* and *B. brandisiana* were found in the study area. Several other researchers have also reported different *Berberis* species from the area including *B. parkeriana, B. orthobotrys, B. lyceum, B. brandisiana, B. psg* (Alamgeer et al. 2013, Abbas et al. 2013, Alam and Ali 2010, Khan and Khatoon 2007, Qureshi et al. 2006, Shinwari and Gilani 2003, Sheikh 2000).

Plants of these two species reach up to 3.3 m (average 2.6 m) height in the study area. There was no significant height difference between the two species was observed, however *B. brandisiana* covers 60% more ground (size) than *B. psg*. *B. pseudumbellata* subsp. *gilgitica* stands alone frequently as compared to *B. brandisiana* which frequently occurs in cluster, though this is not an exclusive feature of both the species. *B. psg* prefers more sandy, gravel and stony habitat as compared to fertile, loamy, gravel and sandy places by *B. brandisiana*.

**Table 1.** Morphological parameters of *B. brandisiana* and *B. psg*.

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<tr>
<th>Species</th>
<th>Average/</th>
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<tr>
<td></td>
<td>Avg. No. of leaves per branch</td>
<td>52.64</td>
<td>8.06</td>
<td>69.28</td>
<td>20.29</td>
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<td></td>
<td>Avg. No. of thorns per branch</td>
<td>46.91</td>
<td>19.48</td>
<td>54.68</td>
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<td>Avg. No. of thorns per branch</td>
<td>3.77</td>
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<td>Leaf Average Size (cm)</td>
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<td>Leaf Average length (cm)</td>
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<td>Avg. No. of berries per branch</td>
<td>0.06</td>
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<td>Avg. length of spine (cm)</td>
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<td>Avg. wt. (g) per berry</td>
<td>2.6</td>
<td>0.7</td>
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<td></td>
<td>Avg. wt. (g) Dry Pulp/ berry</td>
<td>5.49</td>
<td>1.13</td>
<td>8.5</td>
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<td>Avg. No. of Seeds/ berry</td>
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<td><em>B. brandisiana</em></td>
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<td><em>Berberis pseudumbellata</em> subsp. <em>gilgitica</em> (B. psg)</td>
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Plant population and distribution

Individual counting of Berberis species across villages and valleys showed some unique pattern of distribution in the study area. (Fig.4). largest population of *B. psg* was recorded in Bagrot valley followed by Naltar. Similarly, largest population of *B. brandisiana* was found in Juglot (Fig. 4).

**Fig. 2.** Altitudinal temperature gradient time period 1994-1998 (Archer 2004).

*B. psg* was observed only above 2300 m asl and grows up to 3500 m asl. Contrary to *B. psg, B. brandisiana* grows in between 1400 m asl and 2200 m asl.

Similarly different valleys and villages also showed differential composition and distribution of Berberis species viz: Bagrot (*B. psg*), Rahimabad-Juglot (*B. brandisiana*), Rakaposhi (*B. brandisiana*), and Naltar (*B. psg*). (Fig.4). There are only 1140 (± 30) mature individuals of *B. psg* and 1970 (± 50) individuals of *B. brandisiana* in the study area (2000 sq. km). (Fig. 4).

**Fig. 3.** Average monthly temperature and total rainfall (cm) based on data period (1955-2009). Source: Ahmed, M. et al. 2013.
Pant Morphology

Leaves
Leaves petiolate, oblong, obovate or elliptic-acute, spinere-serrate, sinulose margins. In B. brandisiana average leaf size observed relatively bigger (3.77 cm) as compared to B. psg (2.8 cm). However, average frequency of leaf population at B. psg branches was higher (69.29, \(\text{SD±} 20.29\)) than B. brandisiana (52.64, \(\text{SD±} 8.06\)). (See table).

![Fig. 4](image)

**Fig. 4.** Average population of Berberis in sample sites.

Spines

B. psg showed higher frequency of thorns (54.7, \(\text{SD±} 10.78\)) on its branches compare to B. brandisiana with 46.91 (SD ± 19.48). Average thorn size (1.30 cm, SD ± 0.19) difference between two species was not significant. (See table).

Berries

Marking difference was observed between frequency of population of berries on each branch in B. brandisiana (8.6, \(\text{SD±} 6.34\)) and B. psg (1.3, \(\text{SD±} 0.93\)). There was no significant difference between average weights of fresh berries of two species (0.06 g, SD ± 0.03). Average dried pulp quantity in B. brandisiana (0.05 g, SD ± 0.03) was 20% higher than in B. psg (0.04 g, SD ± 0.01) (See table). Berries were 9-12 mm long and 6-3 mm broad, scarcely pruinose, estyllose to very shortly stylose, dark red to dark red brown (B. psg), black to bluish black (B. brandisiana), oblong-ellipsoid berries. (Kulkarni, et al. 2012; Alam, 2009; Mehrhoff et al. 2003; Agrios, 1988; Hooker, 1982).

**Fig. 5.** Frequency of Berberis fruits with different seed number and infection.

Flowers

The flowers were deep/light yellow, hermaphrodite, pollinated by insects or self. Flowers were arranged in loose racemose-subumbellate and corymbose panicles. (Kulkarni, et al., 2012; Alam, 2009; Mehrhoff et al., 2003; Agrios, 1988; Hooker, 1982). Major (visible) features of flowers in both species were similar except inflorescence and other studied morphological features as described above. (See table).

**Fig. 6.** Infection prevalence across elevation and species.
Insect attack prevalence

Larvae of fruit fly attack mainly on mature berries and pierce them to enter into berry. Basically larvae target seed endoplasm and make them hollow (Fig. 7). Strict taxonomy of fruit fly attacking Berberis berries in the study area has not been investigated. Entomologist and technical expert at government agriculture department, Gilgit-Baltistan, Gilgit (personal communication with Mehmood Asghr, director agriculture) identifies borer as larvae of Drosophila species whereas Herrera (1984) reported similar symptoms caused by Tephritid fly larvae on Berberis hispanica Boiss & Reuter.

Fig. 7. Comparative description of berry infection.

Very little information regarding attack of insect pod borer on Berberis is available in literature. During present study it was observe that larvae feed exclusively on, and destroy most or all of, seed content of infested fruit. During the present study severe but differential levels of attacks are noted on different Berberis species found across altitudinal gradients in Karakoram Mountain Ranges (CKNP).

Attack on berries shows presence of larvae at a wider lateral and vertical spectrum ranging from 1400 m asl up to 3500 m asl in the area. However, there was a unique pattern of prevalence across species and elevations (Fig. 6). Within the existence range of B. brandisiana (1400 m – 2200 m asl) borer damage prevalence and elevation increase were found directly proportional. Alternatively it can be concluded that Berberis brandisiana showed higher susceptibility at higher altitudes towards larval attack (Fig.6). Beyond 2300 m asl and below 3500 m asl B. psg showed lowest (1.75%) borer attack as compared to 35.7% attacks on B. brandisiana . (Fig.6). Lowest borer damage percentage in the upper region may be due to unfavorable climatic conditions for larvae or higher degree of resistance of B. psg. At present there is no enough data/information available to rule any of the above described possibility. It is therefore suggested that much work should be conducted to reach on more reliable results.

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