Review

Phytology and conservation of *Carpinus viminea* Wall ex Lindl: a comprehensive review

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ABSTRACT

The Himalayan hornbeam (*Carpinus viminea* Wall ex Lindl) is a deciduous tree. It is known for its distinctive, hard and dense wood, which is used for various purposes such as construction, tool handles and furniture. However, the rapid destruction of its natural habitats and over-exploitation of its resources have led to a decline in the species' population and distribution. To conserve the Himalayan hornbeam, several strategies have been implemented. Firstly, the protection of existing natural habitats is crucial. Secondly, reforestation and plantation activities are also necessary to restore degraded areas and to increase the species' population. Finally, community involvement and awareness are important factors in the conservation of the Himalayan hornbeam. By educating local communities about the species' ecological, economic and cultural values, they can become involved in conservation efforts and help reduce the pressure on the species. The conservation of the Himalayan hornbeam requires a multi-pronged approach that involves the protection of natural habitats, reforestation and plantation activities and community involvement and awareness. By implementing these strategies, the species can be conserved for future generations to enjoy its ecological, economic and cultural values.

Keywords: *Carpinus viminea*; conservation; Himalayan hornbeam; community involvement

INTRODUCTION

The Himalayan ranges began to form at the beginning of the Cenozoic. Large-scale surface reductions and cyclic climatic changes have impacted the evolution of vegetation across geological time (Singh and Singh 1987). In the northern hemisphere's Cenozoic, *Carpinus* has been abundantly documented (Dai et al 2013).

The genus *Carpinus* has almost 35 monoecious and deciduous species of different size trees. It is native to the northern hemisphere from Europe to eastern Asia, south to the Himalaya and in north and central America (Furlow 1990, Krüssmann 1984, Suszka et al 1996). Furlow (1987) examined its geographic variance through multiple-factor analysis. It is widely distributed in the temperate regions of Europe (*Carpinus betulus* and *C orientalis*), north America (*C caroliniana* and *C tropicalis*) and eastern Asia (ca 30 species) (Rehder 1960, Heywood 1993, Chen 1994).

The Himalayan hornbeam (*C viminea* Wall ex Lindl) (Fig 1) is a native species of the Himalayan region. It is commonly found in the moist temperate forests of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and the northeastern states (Fig 2). It is locally known as Chamkharik, Putli, Katuee in different regions (Verma et al 2010).

It comes under the moist temperate deciduous forest category of lower western Himalayan temperate forest ($12/C_{1e}$). The canopy is sufficiently open to allow the growth of under-canopy trees and a deciduous shrub layer. It is distributed on the elevation of 1,500-2,700 m in the mixed patches with the evergreen forest (Kanjilal and Gupta 1969). It grows in a variety of soil and light conditions, direct sunlight and rich, humid regions with good drainage which are ideal for its growth and development (Dirr 1990, Metzger 1990). It is one of the associated species of oaks (*Quercus* spp) in the Himalayan region. It suffered significant damage up to early 1980s since it was permitted to be

Fig 1. *Carpinus viminea* from Gadaparli, Khokhan and Knawar wild life sanctuaries of Himachal Pradesh

cut from forests. After1980, green felling was prohibited for tree species above 1,000 meters in elevation (Verma et al 2010). The species is still seriously vulnerable nonetheless, because of its extremely low regeneration. It is also coming under the IUCN Red List of threatened species.

Landhausser and Wein (1993) reported that the current colonization of burns by Balsam Poplar and White Birch in Tundra areas indicates that deciduous trees with effective long distance dispersal will become more abundant with global warming. The forest cover decreased at a disturbing rate in the Indian Himalaya region (Pandit et al 2007). The area of Indian Himalaya region of about 59 million ha decreased to 22 million ha (Rao and Saxena 1994).

Taxonomy

Kingdom:	Plantae
Phylum:	Tracheophyta
Class:	Magnoliopsida
Order:	Fagales
Family:	Betulaceae
Genus:	*Carpinus*
Species:	*viminea*
Common name:	Himalayan hornbeam

Morphology: *C viminea* comes under mid-montane winter deciduous forest (Champion and Seth 1968). The sub-category of moist temperate deciduous forest category of lower western Himalayan temperate forest is $12/C_{1e}$. It generally inhabits the humid places of small regions along the rivers or streams. It is the region which attributes to needle-leaf evergreen forests and mid-montane hemi-sclerophyllous forests.

These species are subtropical elements that extend into the Himalaya during the geological past (Puri 1960). Tree height can vary from 20 to 30 m and the canopy is adequate for the development of a shrub layer and under-canopy trees. The diversity of species is moderately high but lower than that of submontane deciduous forests. Older trees have smooth, slate-grey bark with irregular flutes (Dirr 1990).

It can be found in isolated patches of 1-2 ha or combined with other evergreen and deciduous tree species (Bhatt and Ram 2007). It is most common as an understory in moist, temperate forests in the Himalayas which are dominated by oaks and during the early stages of succession (Bhatt and Ram 2009). The medium-hard wood is primarily used to make musical instruments, bobbins, shuttles for the textile industry, tool handles and occasionally small timber. Numerous birds, particularly parakeets consume its buds, seeds and leaves as food (Bhatt 2005).

On the same tree, the female and male catkins (staminate and pistillate aments) emerge in the spring along with the new leaves. Pollination takes place between March and April. Fruits are ovoid, ribbed and have a single seed. They develop in clusters of 12-25 at the top of young shoots, each at the base of a distinctive, three-lobed involucre (bract) (Bhatt and Ram 2005).

Phenology: Phenology refers to the study of the timing of recurring biological events such as the flowering, fruiting and leaf fall of plants. Plant phenology is one of the most commonly utilized traits and has acquired new significance due to its association with climate change (Chapman et al 2005). Environmental factors including temperature, moisture and photoperiod have an impact on phenology (Rathacke and Lacey 1985). The phenology of *C viminea* can vary depending on specific location and climate. However, in general, this species is known to have the following phenological events:

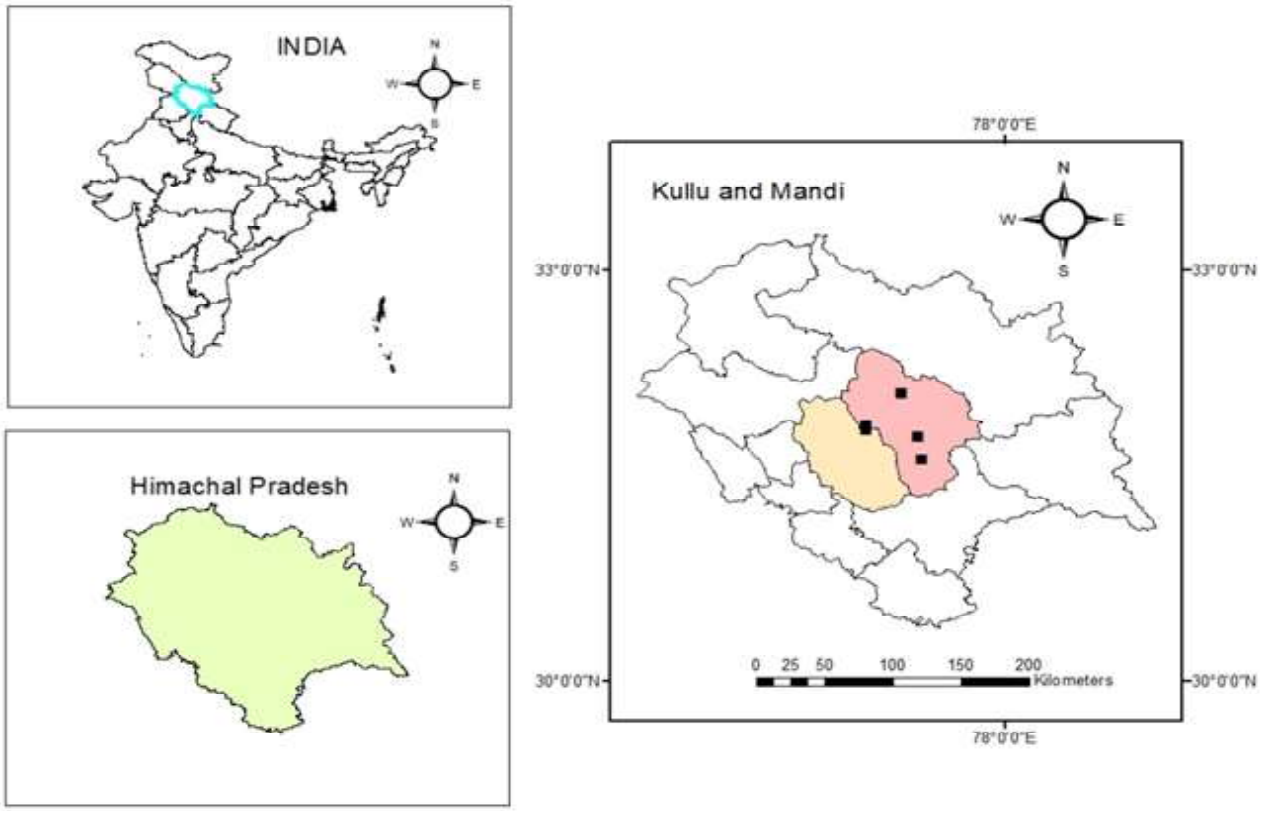

Fig 2. Distribution of *Carpinus viminea* in Himachal Pradesh

Leaf emergence: This species typically leaves out in early spring, between late March and early April.

Flowering: It is monoecious, meaning that both male and female flowers are produced on the same individual. Flowers typically appear in early May with male flowers in pendulous catkins and female flowers in short spikes.

Fruiting: This species produces nut-like fruits that are enclosed in a woody cup-like structure. Fruits typically mature in the late summer or early fall around August or September.

Leaf fall: It is deciduous, meaning it sheds its leaves in the fall. Leaf fall usually occurs between late October and early November.

Seed characteristics: The length, width and thickness of seeds were measured using electronic vernier calliper and the weight was measured based on ISTA rules. The maturation of *C viminea* seeds occurs in late October and early November. The collected seeds were dried at room temperature for a week. Damaged seeds and extra material were removed and stored at 4°C in a refrigerator. Using chemical pre-sowing treatments like GA_3 (Cirak et al 2004, Airi et al 1998), IAA (Chauhan et al 1998) and KNO_3 (Bhatt et al 2005, Butola et al 2007) is advised to achieve high plant germination. *Carpinus* seeds have good viability. The mean germination percentage increased when seeds were treated with 35µ MGA_3 and 130 mM KNO_3 (Paul and Samant 2018). At high elevations, *C viminea* develops in pure patches with greater tree density, favouring high pollination success and increasing the number of sound seeds, resulting in high germination percentage and survival of seedlings (Bhatt and Ram 2007).

Nursery practices and seedling care: The ideal seedbed should have rich loamy soil, moist and protected from drastic atmospheric changes (Rudolf and Phipps 1974, Suszka et al 1966). Naturally dispersed seeds take two springs to germinate once they are dispersed (Rudolf and Phipps 1974). To maximize the chance of germination in the first spring, seeds should be harvested while still green (with yellowing wings but remaining soft and malleable) and sown in the autumn or they can be stratified right away and sown the following spring (Dirr 1990, Hartmann et al 1990,

Rudolf and Phipps 1974). Rudolf and Phipps (1974) suggested that beds should be moderately shaded during the first year and the soil surface should be kept moist till after germination. Placing cuttings at a temperature of 0°C during the winter months satisfies the dormancy requirements (Dirr 1990). Stock plant etiolation and stem banding have been shown to improve the rooting of hornbeam (Bassuk et al 1985, Maynard and Bassuk 1987, 1991, 1992, 1996).

Uses: *C viminea* is a commonly available fuelwood species in the Himalayan region. Some species are utilized as fodder in addition to fuelwood. Its bark is also used as traditional herbal medicine for fractured bones of animals in villages of Uttarakhand (Shah et al 2008). According to Bhatt and Badoni (1995), several fodder taxa are under threat. Therefore, species with low nutritional and high calorific values must be employed exclusively as fuelwood species. It is also employed in producing shuttles, sporting goods, musical instruments, agricultural tools, particularly turners and carved items for ordinary carpentry work. The pulp made from wood has good mechanical qualities and can be used to make paper.

Traditional veterinary herbal treatment for setting animal shattered bones uses the bark of this plant. It burns well and produces great charcoal for cooking and is also used in gun-power manufacturing (Furlow 1990). For the locals, this is a perfect replacement for oak species because it has all these qualities.

Threats: The lack of sufficient saplings for most of the species was attributed to poor regeneration. The central Himalayan forest ecosystems have recently experienced significant biotic and environmental changes. These disruptions prevent the ecosystem from recovering and prevent the regrowth of forest species (Singh 1998). Continuous regeneration failure of the species is due to the effect of climatic factors. The growth of these forests will be a cumulative effect of both ecological factors as well as institutional ones (Pala et al 2013).

C viminea is generally considered a hardy and low-maintenance tree that is not prone to many significant threats. The main threat to the hornbeam is habitat loss, which is primarily caused by deforestation, urbanization and expansion of agriculture. Over-exploitation is another major threat to the species as the tree is heavily harvested for its wood, leaving the remaining trees vulnerable to diseases and pests.

Climate change is also affecting the species as changes in temperature and rainfall patterns alter the tree's growth and distribution. Hornbeams are particularly vulnerable to significant variations in temperature and precipitation because they are northern hemisphere trees (Holstein and Weigend 2017). Rising temperatures and adequate rainfall can cause harm and even death. The mean temperature of the wettest quarter and the annual temperature range for *C viminea* are the second most significant climatic parameters influencing its distribution. In respect of altitudinal distribution, it was observed that *C viminea* grows within an elevation range of between 700 and 2,600 m (Li and Zheng 1979).

Conservation strategies: Despite its importance, the Himalayan hornbeam is facing significant threats due to deforestation, overgrazing, human activities and competition with associated species (Paul and Samant 2018). The tree is also affected by climate change which is causing its distribution to shrink. In addition to creating long-term research on climate change response, these baseline data would be useful for exploring deciduous species regeneration and adaptations to disturbance and global climate change (Bhatt and Ram 2007).

In some areas, the species has already been extirpated due to excessive deforestation and in other areas, its population has declined significantly. With the high viability, *Carpinus* is not able to germinate and escalate in wild habitats. Its conservation is crucial to ensure its survival and the preservation of its ecological and economic benefits. It requires a multi-disciplinary approach that includes measures such as habitat protection, management and restoration. The creation of protected areas and the implementation of strict laws to prevent deforestation and illegal logging are important steps in ensuring its survival. In addition, the involvement of local communities in the conservation of the species can help to reduce the pressure on the tree and improve its management. The promotion of alternative livelihoods, such as ecotourism, can also help to reduce the dependence on the trees and provide incentives for their conservation.

CONCLUSION

The preservation of the ecological balance and the earth's history under changing climatic conditions is a concern shared by the entire world today. The Himalayan hornbeam is a valuable species that is facing

serious threats from habitat loss, over-exploitation and climate change. To conserve this species, a multi-faceted approach is needed including the establishment of protected areas, reforestation programmes and community-based conservation efforts. The conservation of the Himalayan hornbeam is important not only for the species itself but also for the ecosystem services it provides and the benefits it brings to local communities. It is a valuable species with a range of ecological and economic uses. Further research is needed to fully understand the biology and ecology of this species and to explore its potential for wider use and cultivation.

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