Quercus semecarpifolia Sm. in the Himalayan region: Ecology, exploitation and threats

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Oaks (*Quercus* spp.) are among the dominant vascular plants of the Himalayas, ranging from the subtropical to the sub-alpine zones. They play an important role in maintaining ecosystem stability. Oaks in the Himalayan region are intimately linked with subsistence hill agriculture as they protect soil fertility, watershed and local biodiversity. They also supply fodder, leaf litter, firewood and timber. *Q. semecarpifolia* is a high altitude oak, ranging up to the timberline in the Himalayan region and forming the climax community on the southern aspect; it is considered to be one of the oldest plants of the region. It is also one of the most over-exploited species and fails to regenerate adequately either in disturbed or undisturbed natural habitat. Since plantation has not been successful, it is important to manage natural forest more effectively. This can be done by implementing sustainable methods of lopping the trees for fodder, removing an adequate number of old and dying trees to make the canopy more open, and controlling the population of cattle and wild animals that damage seedlings through browsing and trampling.

Key words: Himalayan region, oak, *Q. semecarpifolia*, khasru, regeneration of *Quercus*

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Oaks in general

Oak (*Quercus*), a genus under the family Fagaceae, is a large group of hardwood trees with about 600 species. Oaks are found in the northern temperate zone, subtropical and tropical Asia, and the Andes of South America. Oaks dominate many forest landscapes and are intimately linked with a large number of other organisms, ranging from fungi to ferns, birds to bears, and wasps to ants. Human beings have always had a strong connection with oak. Throughout history the oak has been a symbol of permanence, strength, and courage (Keator and Bazel 1998).

Himalayan oaks are evergreen, mostly gregarious, medium- to large-sized tree, distributed at elevations of 800 to 3800 m asl throughout the Himalayan region. There are more than 35 species reported from this region (Negi and Naithani 1995), most of which are abundant in temperate forest. Eight species occur in Nepal (DPR 1997): *Q. floribunda* Lindl., *Q. glauca* Thunb., *Q. lamellosa* Sm., *Q. lanata* Sm., *Q. leuchotrichophora* A. Camus, *Q. mespilifolioides* A. Camus, *Q. oxyodon* Miq. and *Q. semecarpifolia* Sm.

The economical and ecological values of oak are generally higher than those of other species associated with oak. It is closely linked with hill agriculture as an important source of fodder for animals, litter for making compost, fire wood and timber. Oaks dominate the canopy in many temperate forests of the Himalayan region. In comparison to other forests such as pine, oak forests are characterized by higher species diversity, stratification, litter production and soil fertility. The bark of mature trees supports a luxurious growth of non-vascular as well as vascular epiphytes. Many oaks are keystone species without which the complex web of the ecosystem would soon unravel. Oaks also promote the recharge of mountain springs (Valdia 1998).

Unfortunately, the regenerative capability of this important forest element is poor not only in the Himalayan region but also in North America (Lorimer et al. 1994) and Europe (Andersson 1991). Some reasons that have been suggested to explain the poor regeneration of oak forest are erratic seed production, defoliation, acorn herbivory, browsing damage to seedlings, forest fire, extensive lopping, accumulation of thick litter with slow decomposition rate, infestation by stem parasites such as mistletoe, and leaf damage by insect pests. These factors, concatenated, interfere with the natural regeneration of oak forest.

Biology of *Q. semecarpifolia*

Distribution

Q. semecarpifolia (local name khasru) is an element of central Himalayan vegetation, which has occurred in this region for millions of years. Steppe formed after the final uplift of the Himalayas was invaded by this species and oak became the dominant element of then sub-alpine and alpine forest (Singh and Singh 1992). At present it is a dominant species in the Himalayas, from southwest China to Afghanistan, at elevations of 2100 to 3800 m asl. It occurs in moist temperate and sub-alpine regions with heavy snowfall and moderate rainfall, and is absent from the dry regions of the inner Himalayas (Negi and Naithani 1995).

Community structure

Khasru is a gregarious species forming pure forest stands. Its forest is one of the oldest vegetation types of the Himalayan region and a climax community, especially on the southern aspect (Negi and Naithani 1995). Disturbances such as lopping, felling, grazing and fire in most cases result in the development of mixed conifer-oak forest, which represents a seral stage of secondary succession. Major species associated with Khasru in mixed forests are *Q. floribunda, Q. lanata, Q. leucotrichophora, Abies pindrew, Rhododendron* *arboreum*, *Picea smithiana*, *Cotoneaster acuminata*, *Viburnum mullaha*, *Betula utilis*, etc.

Morphology

In natural forest, khasru grows up to 35 m; the lower two-thirds are clear bole without branches. Coppicing results in luxuriant growth. Tree trunks and branches are usually densely covered with epiphytic plants, including ferns and orchids. The leaves are coriaceous, elliptical to oblong, with sub-cordate to rounded base, and veins forked near the margin; they are glossy green above, generally with rust coloured hairs beneath, but old leaves are almost hairless. The leaves of saplings and coppice shoots have spines on the margin but those of older branches of trees have smooth margins. Male spikes are pendulous and occur in fascicles. Involucral scales are free and imbricate, and the acorns are globular, developing in clusters of three. Seeds are among the largest in the oak family, weighing 5.0 to 6.5 gm (Jackson 1994).

Phenology

New shoots appear in May and June and leaf fall begins during the same period, but most of the new leaves attain full size before the completion of leaf fall. Sometimes, however, leaf fall is completed before the new shoot emerges, and the tree stands leafless for a brief period. Male and female spikes appear at the same time as new shoots, and pollination takes place in June. The period between the pollination and the ripening of the acorn is about thirteen months. The ripening of the acorn takes place from July to August, and germination takes place immediately after the fruit falls. Phenology, however varies with altitude, aspect and micro-climate. Foliar phenology of Khasru in central Nepal (Shivapuri National Park) is different from the pattern mentioned above. Shrestha and Lekhak (2002) reported completely leafless trees during early September.

Seed germination

Mature seeds fall during the rainy season and are viable for a very short period, while stored seeds cannot germinate. More than 95% of fresh seeds can germinate. Some seeds start germination even before they fall on the ground, i.e. partial vivipary (Negi and Naithani 1995). Germination is hypogeous, and a long tube is formed by the cotyledonary petiole which pushes the radicle (tap root) through the thick layer of litter deep into the soil. The plumule lies safely at the base of the petiolar tube. Seedlings are normally leafless in the first year with buds on the axil of the scale leaf, which enables them to withstand autumn drought and winter cold. Food stored in the large seed is sufficient to allow the early growth of the seedling before green leaves are produced. However, under favorable conditions new leaves are produced in the first season. The growth of the tap root is rapid which ensures early establishment in soil with thick litter cover. Dying back of the seedling is common but does not occur under favorable conditions (Negi and Naithani 1995).

Use and level of exploitation

The economic and ecological benefits of khasru oak are substantial. Khasru foliage is a staple dry season fodder from February to April when other green fodder is not available. The leaves are also suitable for feeding the caterpillars of the silk moth *Antheraea perrnyl*. Litter collected from the forest floor is used for making compost. The bark yields tannins. The wood is fine, strong, durable and attractive, and can be easily shaped, making it useful for furniture and agricultural implements. Large branches and trunk wood are in high demand as firewood; the wood is also readily processed into charcoal of superior quality. The acorn is a favored food of many wild animals including bears, monkeys, squirrels and birds. Unfortunately, it has become one of the most over-exploited tree species of the Himalayan region.

The primary reason for the over-exploitation of khasru oak is the demand for dry season fodder, but large branches with foliage are lopped for firewood as well. In privately owned forests, trees are lopped for fodder once every two years, and sometimes even less often (Mathema 1991). In public forests, however, heavy and indiscriminate lopping continues throughout the year (Shrestha and Paudel 1996). Trees are reduced to naked poles. Flower and seed production are impeded to the point that the forest cannot regenerate itself. Leaf production is slashed to the point that the fodder supply is inadequate. And, to maintain the soil fertility of mountain farmland, more and more litter is collected, which prevents seedling establishment and upsets the nutrient balance of the forest.

The ecological benefits of any forest community cannot be expressed in monetary terms. As a dominant tree species of temperate and sub-alpine forest, khasru provides food for a wide range of fauna. The closed canopy allows the growth of shade-loving ground vegetation. Vascular and non-vascular epiphytic plants grow luxuriantly on the trunks and branches of mature trees. The abundant litter production helps to maintain soil fertility. The distribution of many plant and animal species depends on micro-climatic conditions maintained by khasru. In a climax community it is a keystone species, playing a critical role in environmental balance at both the local and also the regional level.

Due to over-exploitation and an inherently slow growth rate, khasru oak forest is degrading and shrinking in Nepal and the adjoining Himalayan region (for e.g., Mathema 1991, Singh and Singh 1992, Shrestha and Paudel 1996, Metz 1997). Degradation of khasru oak forest reduces the supply of dry season fodder, manure, higher quality firewood and durable timber. Reduced supply of fodder forces the farmers to abandon the practice of animal keeping and ultimately reduces the crop production in the region (Shrestha and Paudel 1996), which has already faced the problem of food security. This will present the farmers with two alternatives: either to abandon cultivation and migrate or to adopt agricultural method based on chemical fertilizer (Mathema 1991). However, hill and mountain agriculture based on chemical fertilizer cannot economically be profitable. The ecological cost of oak forest degradation is perhaps more important and damage is irreversible. The intensity of soil erosion and landslide is increasing and mountain spring recharge is decreasing. Many dependants, including epiphytic plants, ground vegetation and animal may be locally extinct.

Regeneration

Natural regeneration of khasru oak is poor both in disturbed and undisturbed forests. It is failing to regenerate under its own canopy. Lack of regeneration is sometimes attributed to the effect of climate change (Upreti et al. 1984), however there is no long-term data on population dynamics to support this. Healthy and regenerating forests owe their vitality to a continuing sequence of young, mature and old individuals of dominant species. In many undisturbed and little disturbed khasru oak forests, unfortunately, there are large old trees and seedling, but saplings and recruits are absent (Metz 1997); this indicates large-scale death of saplings and small trees before they reach the canopy. Annual, heavy and indiscriminate lopping precludes flowering and seed production for regeneration. Loss of photosynthetic surface as a consequence of repeated lopping not only leads to early senescence but also impairs the ability to coppice (Singh and Singh 1992). A comparative study has shown that trees lopped every year and at the interval of two years did not produce seeds, while trees lopped at the interval of three years or more do produce seeds (Shrestha and Paudel 1996). Litter collection, overgrazing and forest fire indiscriminately damage the seedling and sapling recruits.

Seed germination depends strongly on the quality and ➔

thickness of litter and quality of light. Litter is an important general factor determining the spatial variation in seedling recruitment. Thick litter generally reduces the rates of germination and of seedling establishment. However, herbaceous cover, rather than litter, has an even more adverse effect on seedling emergence, survival and growth (Tripathi and Khan 1990, Dzwonko and Gawronski 2002). Kharsru has an unusual mode of germination, with rapid elongation of a cotyledonary petiolar tube pushing the radicle deep into the soil penetrating the thick layer of litter. Dense growth of weeds such as *Pteracanthus alatus* (Wallich ex Nees) Bremek and *P. urticifolius* (Kuntze) Bremek inhibit the survival of seedlings and saplings; their removal has resulted in the establishment of many khasru oak seedlings at previously unproductive sites (Negi and Naithani 1995). On the other hand, there is no clear relationship between seedling survival and soil variables, indicating that above-ground factors are more important for seedling survival (Vetaas 2000). Khasru is a light demander; seedlings and saplings respond positively to high intensity solar radiation. As a result, saplings form a thicket along the edges of khasru oak forest, but in the interior of dense forest no young plants beyond seedling stage are found (Negi and Naithani 1995).

The problem of inadequate natural regeneration of khasru oak has long been reported (e.g., Singh and Singh 1992, Negi and Naithani 1995, Metz 1997 and Vetaas 2000). Some management attempts, including artificial plantation, have been undertaken in order to induce natural regeneration. The direct sowing of seeds and planting nursery-raised seedlings are both practiced, however the former is widely preferred. Direct sowing has been successfully adopted in various parts of India (Negi and Naithani 1995). Survival of nursery-raised seedlings in plantation is very low, less than 4% in Solukhumbu, Nepal (Stewart 1984). Due to lack of detailed information on seedling establishment and growth behavior of khasru, the problems of poor survival of planted seedlings have remained unsolved (Jackson 1994, Shrestha and Paudel 1996). Metz (1997) hypothesized that khasru is not able to reproduce in individual tree fall gaps, but needs more severe disturbance. Management practices in natural forest, involving thinning of old trees, so as to open the canopy and allow more light to reach the ground, have produced promising results in India (Negi and Naithani 1995, and references therein). However, even the community forestry programmes in Nepal have not developed any management strategies that might induce natural regeneration of khasru and other oaks (Shrestha and Paudel 1996). In some districts of western Nepal (Parbat and Myagdi), facilitated by Lumle Agricultural Research Center (Kaski), local people have adopted sustainable lopping practices. The accessible forest was divided into several blocks and a few blocks were opened each year for fodder lopping on a three-year rotational cycle. Protection of a few mother trees without lopping was recommended (Shrestha and Paudel 1996) to ensure seed production and natural regeneration. These management practices can increase the total fodder production and ensure regeneration.

Khasru in Shivapuri National Park (SNP)

The temperate forest of Shivapuri National Park (1366 to 2732 m asl), lying on the northern hills of Kathmandu valley, is a major source of water supply to the capital. It is dominated by *Q. lanata* at lower elevations and *Q. semecarpifolia* (khasru oak) at higher elevations. Regeneration of khasru is very poor in comparison to *Q. lanata*. A preliminary study showed that khasru forest had only old dying trees and seedlings but no individuals between these two size classes (Shrestha and Lekhak 2002), a clear indication of inadequate regeneration. The forest is mature, with above-ground biomass and basal area cover of 462.14 t/ha and 0.73% respectively at 2600 m (Subedi and Shakya 1988), which is remarkably high for this altitude (Singh and Singh 1992). Khasru density was 217 trees/ha, although it is the most exploited among the oak trees (Siluwal et al. 2001). The forest has been protected for nearly three decades (since 1975) but khasru oak fails to regenerate under its own canopy; mitigation or removal of human induced pressure alone is not sufficient to ensure regeneration of khasru oak forest in Shivapuri National Park. The regeneration is continuous in the nearly undisturbed forest of khasru in Langtang National Park, central Nepal (Vetaas 2000) but such a situation was not observed in SNP (Shrestha and Lekhak 2002) indicating that absolute conservation does not ensure continuous regeneration of this species. The forest shows prominent signs of decline. Abnormal growth and branching (i.e., clusters of thin, profusely branched and slender branches with shorter internodes), increased defoliation and dying back of leader and branch tips, which are frequently observed in the forest, are sure signs of decline (Larcher 1995). ■

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