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CASE STUDY

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Fungal diversity inhabited with trees and their conservation in Bukki Top in upper great Himalaya

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ABSTRACT

This investigation was aimed to explore the biodiversity of upper great Himalayas range with special reference to the flora and its conservation. The natural landscape and high altitude meadows (Bugyal) enhanced the beauty of Uttarakhand. Bukki village and Bukki top one of the gorgeous region locate in Uttarkashi district of Uttrakhand state, fall on the opposite side of the national highway NH-108 and connect the Gangotri Glacier via Harsil. The present article is the description of the flora of the Bukki region and, we tried to mainly focus on different fungus species and disease on trees, observed during the trek. Some important fungus species observed are *Daldinia concentric*, *Trichaptum biforme*, *Fomes fomentarius* and *Daedalea quercina*. We also describe each fungus attributes and *habitat distribution* description.

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INTRODUCTION

Bhukki village locates in the Bhatwari Block of Uttarkashi District of Uttarakhand State, India. It is located 31 km towards the East from district headquarter Uttarkashi. The nearby village location is Bhatwari (16km), Kunjan (3km), Hurri (5km), Kyark (6km), Pala (6km) and Bhangeli (7km). According to ensus 2011, Bhukki village has 36 families, of which a total population is 154, (77 males and 77 females). The village literacy rate is 82.96 % (URL-1). The Bhukki region forest area covers 5b and 6b compartments with Bhukki-I beat and Taknaur Range under the Gangotri Forest Division. Nehru Institute of Mountaineering climbers and trekkers use Bukki village as a starting point for trekking. Villagers also trek with their cattle to grazing in moderate to a dense mixed forest of *Quercus semecarpifolia* and *Taxus wallichiana.* On the trek, villagers made human and cattle shelters near the Bugyal area.

Forest covers density in Bhukki region

Forest Survey of India (FSI) publishes the State of Forest Report (ISFR) in every two-year gap. FSI Classify forest into three forest cover density classes, i.e. very dense forest (VDF), Moderately dense forest (MDF) and Open forest (OF). VDF class cover that area which is coming under 70 % and above tree canopy cover density, similarly MDF (above 40 % but less than 70 % tree canopy cover density), and OF (with above 10 % but less than 40 % above tree canopy cover density), (URL-2). For the current article, we generated a 2 km^2 buffer of the trek for showing the forest cover area under the Bhukki village region. For this, we downloaded Sentinal 2A satellite image from the USGS earth explorer website (URL-3), and did image processing of sentinel 2A in sen2cor 2 (ver.2.8) software.(URL-4) After that, run unsupervised image classification on bhukki region sentinel satellite image using Erdas imagine software (ver.2011) and classified the 2 km^2 bhukki forest region into three forest density classes., for more accuracy, we used Google earth pro (ver. 7.3.4.8248 (64-bit) for post-classification correction. Total 30.44 km^2 area of forest cover calculated in 2 km^2 buffer zone, in which VDF is 14.13 km^2, MDF is 15.53 km^2 and OF is 0.78 km^2 (Figure 1).

Forest types in Nag Bhukki region

According to Forest Survey of India Forest type atlas 2011, the forest type within 2km^2 buffer zone are 9/C1b Upper Or Himalayan Chir Pine Forest (0.03 km^2), 12/C1d Western Mixed

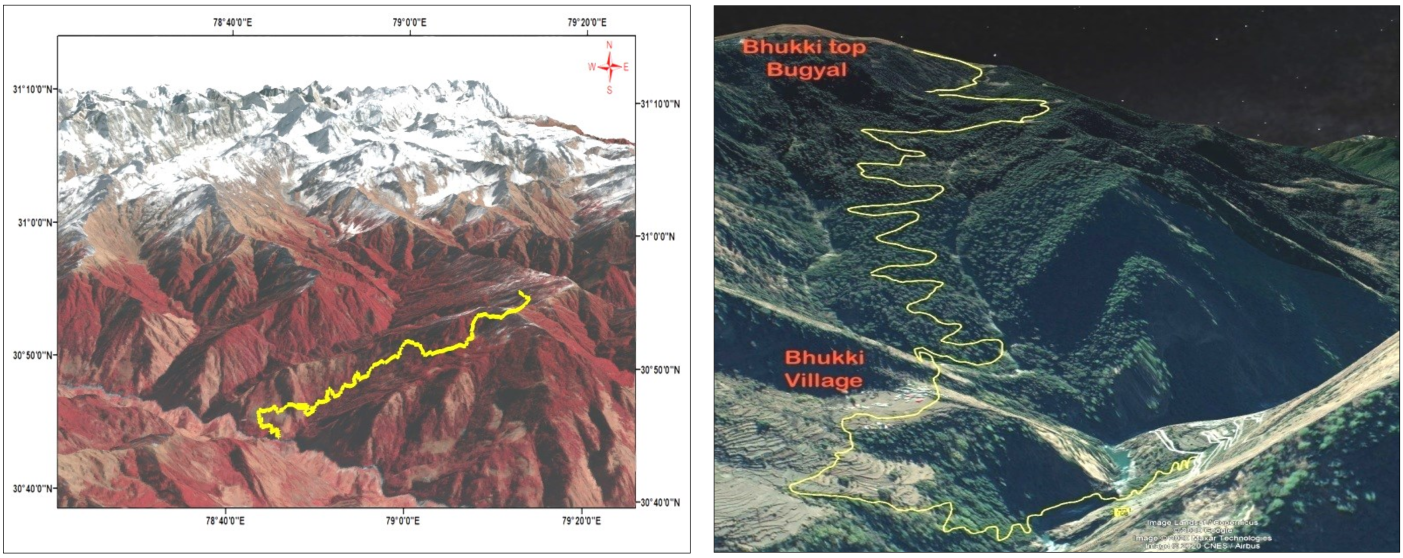

Figure 1 (a). *3D view of the study area with the associate region, (b) 11.2 km incline trekking from NH-108 to Bhukki Bugyal via Bhukki village.*

Figure 2. *Elevation profile and 3D view of trekking area with the associate region.*

Figure 3 (a, b). *Team members during exploring the forest trek.*

Coniferous Forest (Spruce, Blue Pine, Silver Fir (8.85 km^2), 12/C2a Kharsu Oak Forest (*Q. semecarpifolia*) (20.14 km^2), 13/C2b Dry Deodar Forest (0.69 km^2), 14/C1a West Himalayan Sub-Alpine Birch (0.67 km^2) (Figure 2).

Observed local species during the trekking

To trek toward the Bhukki village, we left NH-108 road and moved toward the Bhukki village, situated at a 1963 m altitude. During the Trek, we crossed the Bhagirathi River (1749 m) and moved to Bhukki village and almost covered 214 m height from starting point to reached Bhukki village (Figure 3 a, b). The village was situated in the Bhagirathi river valley and surrounded by paramount mountains. After the Bhukki village, we crossed gad or gadera (seasonal stream) and trek toward the mixed moderate forest. At the elevation of 2050 m, *Pinus roxburghii* species tree population became low, and it seemed that a *P. roxburghii* species altitude boundary was only up to this altitude. As elevation was increasing, the dense tree patch of *Quercus leucotrichophora* began with few other associate trees. We also recognized a small patch of *Arundinaria falcate* hill bamboo species, locally known as Rignal, spread between *P. roxburghii* and *Q. leucotrichophora* tree patches seem like a barrier between both tree species. As we went up on the route, the forest of *Q. leucotrichophora* becomes denser. At the altitude of 2400-2500 m, We noticed that due to the open area between *Q. leucotrichophora* and *Q. semecarpifolia* with *T. wallichiana* mixed forest created a wide gap, and this not done by nature because the humans made the structure for cattle as well himself also, for the night stay. As we moved up, we got to see the dominant forest patch of *Q. semecarpifolia* and *T. wallichiana*, spread between 2589 m to 2986 m amsl. We also scrutinize the whole patch and found that the distribution pattern was uniform, but as far as population status considers the entire patch looked pristine but also looked well disturbed and affected by the disease. We measured the height and diameter of 30 trees of *Q. semecarpifolia* and *T. wallichiana* randomly with a distance of at least a hundred meters. The height of *T. wallichiana* recorded

Figure 4. *Q. semecarpifolia anthracnose disease leafs.*

Figure 5. *Daldinia concentrica fungus on decay wood.*

between 8-18 m, and the diameter recorded 70-150 cm, the average height and diameter were 14 m and 104.03 cm recorded. Similarly, the height and diameter of *Q. semecarpifolia* 9-22 m and 30-200 cm recorded, and the average height and diameter recorded 16.89 m and 107.07 cm respectively. We also observed that mostly *Q. semecarpifolia tree leaves have* anthracnose symptoms *(*Figure 4). Oak anthracnose is a term used to describe diseases caused by fungi that produce dark, pinpoint-sized asexual fruiting bodies and cause localized necrotic spots or lesions on leaves and young shoots. Some of these fungi may completely kill young leaves and twigs under certain conditions. Dead leaves may remain attached to killed twigs. It may cause defoliation if disease levels are severe**)**. The brown oak not only makes an essential biome but its also considerable for humans use for fuelwood, dry season fodder and leaves for Tasar culture. It is a keystone species that plays an essential role in maintaining the ecological balance of the area. Across the world, human activities have caused many changes in ecosystems. Different anthropogenic disturbances such as a collection of fuelwood and biomass exceedingly affect the diversity of forest communities (Sayer and Whitmore, 1991), change in forest structure and species composition (Kouki, 1994), (Gairola *et al.*, 2015). Uncontrolled grazing by domestic animals also directly impacts the recruitment of species (Kelt and Valone, 1995). Anthropogenic disturbances in the upper montane zones of many mountains of the world have been reported to alter the regeneration dynamics of both forest and alpine vegetation communities (Young, 1994). The irregularities have been widespread in the upper montane zones across the Indian Himalayan region, thereby impacting both composition and functioning of high elevation natural ecosystems (Gairola *et al.*, 2015), (Gairola *et al.*, 2019), (Rawal *et al.*, 2012). Himalayan oaks are slow-growing in nature and experience severe anthropogenic pressure. These are the leading reasons why the area under brown oak is declining in the Himalayan region (Metz, 1994), (Shrestha and Paudel, 1996), (Mathema, 1991). The presence of seedlings and old trees is conspicuous in the brown oak forests, but saplings are rarely present (Metz, 1994). Natural regeneration of *Q. semecarpifolia* is more or less absent need to be supplemented with artificial regeneration of the species. For this, it is essential to have reliable scientific information on the time of acorn maturity for large scale acorn collection, as fully mature seeds retain viability for a longer time than immature ones (Phartyal, 2002).

Observed some important fungus

Daldinia concentrica: Several generic names are recognised for the inedible fungus *D. concentraica,* like King Alfred's sandwich, cramp balls and coal fungus. The light spores are dispersed worldwide, as with other fungi, and the fungi grow anywhere conditions are acceptable-it grows on dead and rotting Wood and is a normal, widespread saprotroph. The fungus is ball-shaped, with a 2 to 7 cm wide, firm, friable, shiny black fruiting body. It resembles a chunk of coal, known its several common names, including carbon fungus and balls (Figure 5). According to legend, after it was over, King Alfred once hid in a country house during the war and was tasked with extracting baking from the oven. He fell asleep and burnt the cakes. It's said *D. concentraica* looks like a cake left to this fate. The fungus flesh within is purple, orange, or silvery-black, and is arranged in thin layers. Most studies accept that some layers are related to seasonal growth as are tree rings (First Generation, 2020). The asci are cylindrical and arranged within the perithecium in flask form. When each ascus is engorged with fluid, it spreads and releases spores beyond the perithecium. *D. Concentrica* contains many special compounds, including a polycyclic violet dye and a concentraicol metabolite, which is oxidised squalene. Within this genus of fungus, several forms of insects and other small animals make their home.

Uses: The fungus is a valuable source of fire-lighting tinder. Typically the brown variety is too thick and compact to be good; the black variety is thinner and nicer. It does need to be fully dry, after which conventional flint and steel can take a light. It burns painfully, almost like a briquet of charcoal, with especially pungent smoke. Usually, once burned, it takes a steady oxygen supply to maintain burning, such as spinning the champignon or blowing on it. Exposing more embers, fragments can be broken off and transferred to a tinder bundle to create an open flame.

Ecological uses: This fungus has been found to consume caterpillars of the concealer moth *Harpella forficella*. This fungus plays a crucial role in speeding the decomposition of ash trees' fallen branches which are dropped very often, naturally (Figure 6).

Trichaptum biforme: *T. biforme* in the order Hymenochaetales is a genus of poroid fungus. It is a saprobe that breaks down stumps and logs in hardwood. They are inedible (Phillips, 2010). It grows on the side of different tree.

Fomes fomentarius: *F. fomentarius* (commonly referred to as the tinder fungus, false tinder fungus, hoof fungus, tinder conk, tinder polypore or ice man fungus) is a fungal plant pathogen species occurring in Europe, Asia, Africa and North America (Phillips, 1981). The species grows very large polypore fruit bodies that are shaped like the hoof of a horse and range in colour from a silvery grey to nearly black, while usually brown (Figure 7).
Species which it infects with broken bark, causing root. Typically the genus continues to live on trees even after they have aged, converting from a fungus to a decomposer. And if it is inedible, Traditionally, *F. fomentarius* has been seen used as the main ingredient of amadou, a substance mainly uses as tinder but often used in producing clothes and other products. The Iceman's 5,000 year-old Ötzi carried four bits of *F. fomentarius*, concluded to be used as a Tinder. It has therapeutic effects, as well as some. The species is both a pest and valuable for processing timber.

Habitat and distribution

F. fomentarius has a circumboreal distribution and is generally observed in northern and southern Africa., in Asia and eastern North America (Schmidt, 2006) and Europe (Schwarze *et al.*, 2000; Kibby, 2003). The ideal temperature for the growth of the plant is between 27 and 30 ° C (81 and 86 ° F), and the mean temperature is between 34 and 38 ° C (93 and 100 ° F) respectively (Schmidt, 2006). Usually, *F. fomentarius* grows alone, but many fruit bodies can be found occasionally on the same host trunk (Phillips, 1981). The species grows more commonly on hardwoods. It is *most* widespread in northern areas on birch, while in the south it is more characteristic of beech. (Schmidt, 2006) In the Mediterranean, oak is the usual host (Schwarze *et al.*, 2000). The species has also been known to grow upon maple, (Schwarze *et al.*, 2000) cherry, hickory (Stamets, 2005) lime-tree, poplar, willow, alder, hornbeam, (Schmidt, 2006) sycamore (Phillips, 1981) and even, exceptionally, softwoods, (Schmidt, 2006) such as conifers (Schwarze *et al.*, 2000).

F. fomentarius is a plant pathogen with stem decay. Myceliums of the genus enters the wood of trees by infected bark or broken roots, causing host rot (Schwarze *et al.*, 2000). It can grow on the wound of the bark, or even directly on the bark of aged or dead trees. (Butin and Lonsdale, 1995). The decayed wood reveals black lines in decayed areas with a light colour; these are known as pseudosclerotic layers or demarcation lines (Schwarze *et al.*, 2000). Lines are caused by enzymes called phenoloxidases, which convert melanin into either fungus or plant matter. The lines are not an absolute marker, as they can also appear in plants contaminated with *Kretzschmaria deusta* and certain types of *Armillaria* (Schwarze *et al.*, 2000). Despite beginning as a parasite, the species can survive for a time (hastening decomposition) on fallen or felled trees as a saprotrophic feeder (Schmidt, 2006) and typically lives there for years, until the log is destroyed (Schwarze *et al.*, 2000). It is also capable of colonising and breaking down pollen grains, giving it a second food source which is exceptionally high in nitrogen (Schwarze *et al.*, 2000). Infected trees become very brittle, (Schwarze *et al.*, 2000) and cracks may occur due to wind in the affected tree. In specific *F. fomentarius* is inclined to pass through tree cracks without interference (Schwarze *et al.*, 2000). On top of infected trees, though, *F. Förderungarius* is considered to be an endophyte, meaning good trees that don't sport F. Infection of the *fomentarius* fruit bodies may proceed (Stamets, 2005).

Figure 6. *Trichaptum biforme fungus* on decay wood.

Figure 7. *Fomes fomentarius.*

Figure 8. *Daedalea quercina fungus grow on dead wood.*

The bodies of the fruits are perennial and grow for up to 30 years. The time of highest development is between early summer and autumn (Schmidt, 2006). Annual growth typically happens at the bottom of the mushroom, which means the youngest is the lowest layer. This happens even if the host tree has been laid on the forest floor (Schmidt, 2006), which can occur because of the white-rot induced by the fungus. This is a process known as positive gravitropism (Schmidt, 2006). Very large quantities of spores are produced, particularly in spring, with some fruit bodies producing up to 887 million basidiospores an hour. Even spore development takes place in the fall, but not just as strongly. (Brown *et al*., 2000). At comparatively low temperatures the spores are released (Brown *et al*., 2000). The spores are visible as a white powder in dry conditions (Butin and Lonsdale, 1995). The plant is not edible (Phillips, 1981; Sterry and Hughes, 2009). The meat tastes acrid, with a distinctly fruity scent (Phillips, 1981). The disease has economic significance; it depreciates the value of wood as the parasite infection progresses. *F. fomentarius* infects trees through damaged bark (Butin and Lonsdale, 1995). It will often infect trees already weakened from beech bark disease and thus has a substantial and useful role in decomposing unusable timber.

Daedalea quercina**:** *D. quercina* is a mushroom species in the Polyporales order and the Daedalea genus type species. Commonly known as the oak mazegill or maze-gill fungus, the particular epithet refers to the *Quercus* species of tree, on which it sometimes spreads, producing a brown rot (Figure 8).

It is found in Europe, Asia, Australasia, Northern Africa and. It can be used as a natural comb through inedible and has been the focus of chemical studies. Although *D. quercina* For the tree species *Fagus grandifolia*, *Fraxinus americana*, *Juglans nigra*, *and Ulmus americana*, *quercina* tends to grow on the genus *Quercus* (Overholts, 1939). Following the trend of oak distribution, it has been recorded from almost all European countries. It has also been recorded from the Caucasus to India and also Australia in Northern Africa (Tunisia), Asia. Fruit bodies of *D. quercina* have been used as a natural comb, employed for brushing down horses with tender skin (Rolfe, 1974) Gilbertson notes that in England, smoldering fruit bodies were used for anaesthetizing bees (Gilbertson, 1980). This species has been investigated for application in bioremediation (Asgher *et al*., 2008). The laccase, isolated, and purified lignin-degrading enzyme from *D. Quercina*, has been shown to use a number of poisonous dyes and pigments to biodegrade (Baldrian, 2004). Isolated from the oak mazegill, the drug quercinol (a chromene derivative) has anti-inflammatory activity and inhibits the enzymes cyclooxygenase 2, xanthine oxidase, and horseradish peroxidase (Rawat, 2018).

Conclusion

The topography of this terrain is very complex and provide habitats for diverse fauna and flora. The population of this region live in small villages according to their resources and grow crops using terracing farming, which dependents on rainfall., Uneven precipitation and lack of irrigation leads to a poor economic atmosphere, in that case, the forest plays a significant role to survey in extreme condition for the villagers. In a remote area, usually, a village locates within or near a forest area, which results in the forest becoming shrinking or disturbed due to dependence on cattle grazing, fodder and fuelwood. Gradually all factors create pressure on the forest, results in consequences changes appearing in the forest such as composition, density and structure and contribute to global warming. The villagers and shepherd bring their cattle (cow, buffalos, goat and sheep) into the forest area for grazing, which causes two adverse effects on the forest., the first is the hoof of cattle erode the forest surface as well as ruin the seeds and newborn tree. Due to overgrazing, forest density converted into dense to moderate and moderate to open forest. All these factors badly affect the wildlife also, such as Himalayan black bear eats *Quercus* tree species seeds, but due to lack of food then bear and other herbivorous animals migrate to find alternate food and habitats. It is like a chain reaction, carnivorous (leopard) depends on herbivorous prey, and if herbivorous migrate then leopard has only a few options, either leopard has to move from that place or prey nearby village for cattle and dogs and sometimes leopard kills the villagers as easy prey. Once the leopard kills the villagers' leopard consider a man-eater. Then unwillingly forester has to kill that man-eater leopard, which against nature. But this reaction does not end yet and leads to another adverse effect, this breaks the food chain and forest without a top big carnivorous (leopard) become safer for the villagers and villagers take the advantage of this situation Without any fear and exploit the forest, which leads to change the microclimate of the region.

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