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Coal mining and its leachate are potential threats to *Nepenthes khasiana* Hook. f. (Nepenthaceae) that preys on insects - an endemic plant in North Eastern India

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Abstract

The present study was conducted in the coal mining areas of Jaintia Hills Meghalaya to access the impact of acid mine drainage on *Nepenthes khasiana* Hk. f. an endemic and threatened species of Meghalaya, which occur mostly in isolated pockets of region. Mine drainage originating from coal spoils, leaching of heavy metals and intuitive collection of the pitcher of this species, create a severe threat to the survival of this hunter plant in its environs.

Key words: North-Eastern India, Meghalaya, Mining, Acid mine drainage, endemism, Insectivorus pitcher plant

1. Introduction

Plants that prey on insects is an ecological enigma. Ecology and modelling for plant carnivory is necessary since insectivorous plants are widespread but are extremely rare. These plants absorb a wide variety of elements from their prey than what was believed previously (Adlassnig et al 2009). Genus *Nepenthes is* distributed in North East India, Madagascar, Sri Lanka, North Australia and South East Asia. (Anonymous 1985).

2. Study Site

Jaintia hills district occupies the eastern part of the state of Meghalaya in India (Figure 2). It covers an area of 3819 Km^2, which is 17.03% of the total geographical area of the state and forms a contiguous part of the Khasi Hills consisting of northern undulating hills. The region is predominantly composed of sandstone with clay, coal seams and fossiliferous limestone and is also formed of various rock types with varying lithological characters. Different agents of denudation like rainfall, surface water and temperate conditions have played an important role on the rock types in moulding the landforms of the area.

The study site is located near Sutnga Elaka of Jaintia Hills, at a distance of ca. 120 km away from Shillong, the capital of Meghalaya. Hillocks and undulating topography characterize the landscape of the area. Coal mining and limestone extraction are the major problem resulting in soil erosion, water pollution and environmental degradation of the area. The physiography of the study site is mentioned in table 1.

Table 1. Physiography of the study site

Study site	Physiography		
	Latitude	Longitude	Altitude (m)
Unmined Area (Control)	$25^0$20.313'N	$092^0$28.777'E	973
Coal Mining Area	$25^0$21.128'N	$092^0$28.606'E	933
Limestone Mining Area	$25^0$20.552'N	$092^0$29.453'E	995

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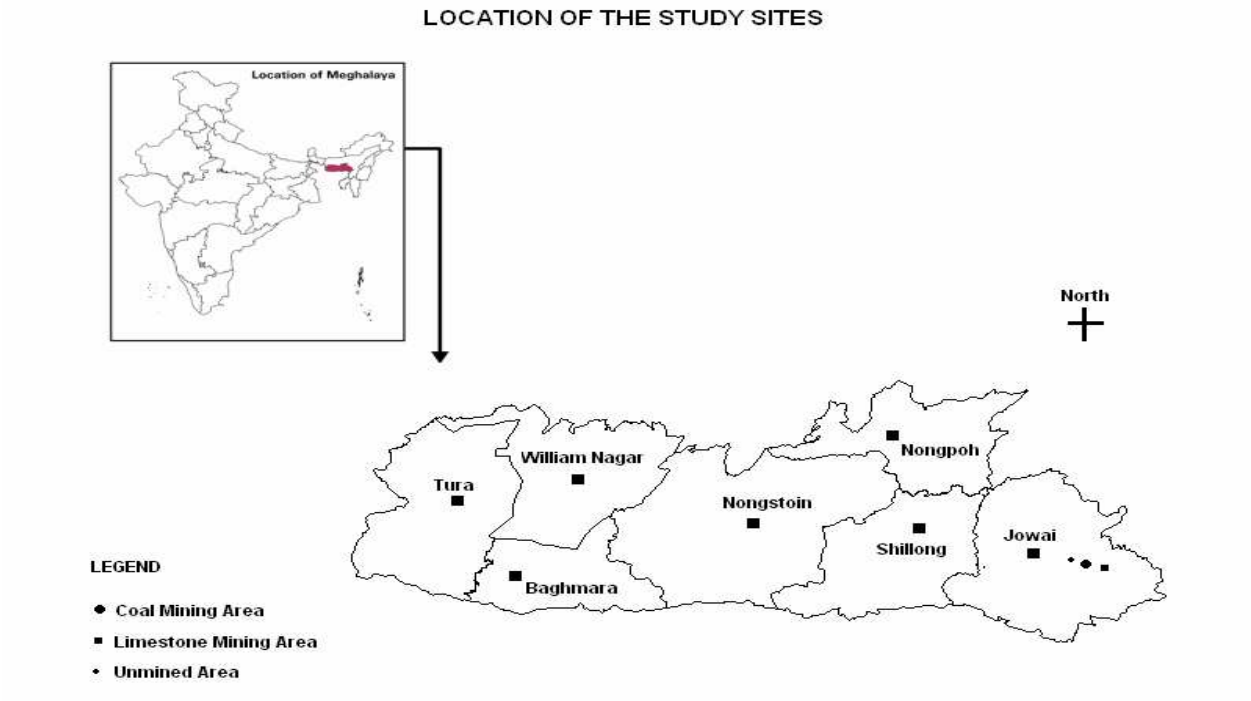

Figure 1. Location of study site in north-eastern India

2.1. Soil

The soil is mostly sandy, reddish brown to yellow brown in colour, acidic, rich in mineral content and organic matter, but deficient in phosphate and potash. Such soils are good for the cultivation of banana, potatoes, arecanut, betel vines and hill rice in hill slopes and terraces. Coal and limestone are the major deposits of the soil in the area, which are important raw material for the manufacture of Portland cement.

2.2. Climate

The climate of Jaintia Hills is subtropical monsoonic with distinct alternate wet and dry seasons. The wet season extends from April to October, followed by a dry period from November to March. During the wet season the monthly rainfall ranges from 152 to 756 mm, while in the dry period it is usually < 50 mm per month. The mean annual rainfall was 3276 mm during the study period. Relative humidity also exhibited marked seasonal variation and is closely related to precipitation. The mean monthly temperature varied from a maximum of 27^0C in the month of April to a minimum of 3.4^0C in December.

2.3. Mining activities

Mining operations in Meghalaya is being done mainly with the most traditional and unscientific methods and have led to massive environmental degradation. It affects the land, water and community health, particularly when the ecological and occupational considerations are not given due importance. Extraction of coal in Jaintia hills is done by primitive mining method commonly known as 'rat-hole' mining. In this method, the land is initially cleared by cutting and removing the ground vegetation, and then pits ranging from 5 – 100 m^2 are dug vertically in the ground to reach the coal seam. Thereafter, horizontal tunnels are made into the seam for extraction of coal, which is brought back to the pit by using a conical basket or a wheelbarrow. The entire process of mining is done manually employing small implements. While digging the pits, the pieces of soil and rocks above the coal seams are thrown haphazardly outside the pit creating coal mine spoils that cause large-scale destruction to the surrounding agricultural cropland and vegetation, often beyond replenishment.

Acid mine drainage caused by the weathering of pyretic materials associate with coal that are exposed to air and water during mining process are the primary cause of threat to the habitat of *Nepenthes*. The chemical reactions that result in the formation of AMD can be represented as follows:

$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2Fe^{2+} + 4SO^{2-}_4 + H^+$

$Fe^{2+} + 1/4 0_2 + H^+ \longrightarrow Fe^{3+} + 1/2H_2O$

$Fe^{3+} + 3H_2O \longrightarrow Fe(OH)_3 + 3H^+$

$FeS_2 (S) + 14Fe^{3+} 8H_2O \longrightarrow 15Fe^{2+} + 2SO^{2-}_4 + 16\ H^+$

Due to oxidation of pyritic material from the abandoned coal mines, acid mine drainage results posing environmental problems. The rate of pyrite oxidation is influenced by iron and sulphur oxidation, particularly *Thiobacillus sp. a* chemoautotrophic acidophilic bacteria (Salari *et al*., 2008).

3. Results

3. 1. About Nepenthes khasiana - the pitcher plant that preys on insects

Nepenthes khasiana belongs to the monogeneric family Nepenthaceae with about 70 species, and are mostly found in Indo-Malaya and Madagascar. One species is found in Meghalaya, India. It is erect, prostrate or scandent evergreen under shrub, up to 4 m; leaves 5-50 × 1.5-8 cm, oblong-lanceolate or oblong-oblanceolate, acuminate, base attenuate, amplexicaulous, glabrous, often reddish, pitchers subcylindric, 10-20 × 3-7 cm, constricted towards mouth; racemes up to 70 cm long; flowers 0.5-1.5 cm across, greenish-red or greenish-brown; capsules 2-3 cm long, ellipsoid-oblong, supported by the perianth; seeds 0.5 to 0.7 cm long, spindle shaped. The flowering and fruiting season is from June to December (Haridasan and Rao, 1987; Joseph and Joseph, 1986; Rogers and Gupta, 1989; Choudry, 2000; Mao and Kharbuli, 2002; Rashi Devi, 2004).

3.2. Ecology

The species is found growing on rocky or sandy pockets and along hill streams facing west or north. Extreme humid conditions and well-drained soils are necessary for the growth of this species. The ideal humidity and temperature is from 70 to 90 % and 18 to 28^0C, respectively. The tribes of Meghalaya call it variously and the names are given in table 2.

Table 2. Local name of *Nepenthes khasiana* used by the tribes of Meghalaya.

Name of the tribe	Local name	Meaning of the name
Khasi	Tiew-Rakot	Demon-flower or a devouring plant
Jaintia	Kset Phare	Kset – net with a lid and Phare – fly or a device for trapping insects
Garo	Memang-Koksi	Basket of the devil

3.3. Folklore and Medicinal Use

It has been observed that this species is used as a medicine among the indigenous community of Meghalaya for various ailments. The Khasi and Jaintia traditional Medicinal Practitioners (TMP) prescribe the fluid from the unopened pitcher of the plant to diabetic patients and others suffering from difficulties in urination; while the Garo TMP apply the crushed powder of the pitcher to affected parts of leprosy patients. The present study indicates that the medicinal uses of this species vary from community to community and from place to place. In Malaya, the local doctors were found to use water of the pitcher as eyewash or on inflamed skin. Recent study on exploration of medicinal plants of the state by the Centre for Environmental Studies, North-Eastern Hill University, reported that this species is used as a medicine in the south precipitatious region of Meghalaya, characterized by steep slopes and heavy rainfall, which includes Southern part of West and East Khasi Hills, part of Jaintia Hills and a small part of South Garo Hills District (Tynsong *et al*., 2006).

Figure 3. a) Habitat of *Nepenthes khasiana* – an endemic to Jaintia hills in Meghalaya, India
b-c) Rat-hole mining of coal and coal product leachate (Acidic substance) posing threat to its survival.
d-f) *Nepenthes khasiana* with toxicity symptoms (necrotic spots on leaf margins and pitcher

4. Conclusions

Nepenthes khasiana is the only insectivorous pitcher plant of India. It is critically endangered and reported to have medicinal properties (Jain, 1987; Jeeva *et al*., 2007). The phenomenal increase of commercial demand for herbal drugs, dependence on material harvested from the wild, and their unsustainable harvesting has led to rapid depletion of the species in its natural habitat (Devi and Venugopal, 2006). The species is also in great demand for its ornamental value among city dwellers and has thus led to its further exploitation. Balakrishnan (1983) reported that this species become endangered due to constant and reckless collection for its curious pitcher. The rampant coal mining, which become impoverished presenting a very rigorous condition for the growth with necrotic spots on leaf margin and drastically affect the regeneration of this species.

The acidic nature and low nutrient level of soil in coal mining area is due to the sulphur content oozing out from the acid mine drainage. Plants that prey on insects are well adapted to grow in places where the soil is thin or poor in nutrients, especially nitrogen, such as acidic bogs and rock outcroppings. Although in vitro propagation has been attempted the reintroduction to nature is not successful in large scale (Redwood and Bowling 1990, Rathore *et al*., 1991, Latha and Seeni, 1994) Hence, adequate measure must be taken to conserve this "*botanical and ecological curio*" through appropriate approached and regulatory methods.

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