

INTRODUCTION

Nokrek biosphere reserve is one of the eighteen biosphere reserves in India. It got its status in 1988 by the Government of India. This biosphere reserve is included in the UNESCO world network of Man & Biosphere Reserve on 26th May, 2009 and now it is one of the eight biosphere reserves in India which have been included in the world network. It is located in the North-West part of Meghalaya. It consists of East, West and South Garo Hill Districts of Meghalaya. The total area of the biosphere reserve is 820 sq.km. which includes a core zone represented by Nokrek National Park, a buffer zone and a transition zone. The entire biosphere reserve is hilly terrain with an average elevation of 600 m and composed of gneisses, granites, nigmalites, amphibolites and banded iron formation. The soil is mainly red loamy but in certain areas it varies from clayey to sandy loam. The highest elevation is the Nokrek Peak (1412 m) inside the Nokrek National Park.

The total human population of the biosphere reserve is 40,000 (Census, 1991) which is distributed in 167 villages located mainly in the transition zone and few in the buffer zone. [MAP 3] The core zone is entirely free from any human interference. The local communities within the reserve belong to the Garo tribe. They are totally dependent upon the forest for their livelihoods like timber, fuel wood, thatching leaves, honey, wax, etc. By and large local people are very poor and a number of families are living below the poverty line. Due to

the lack of any alternatives they practice Jhum cultivation (Shifting cultivation). Almost 85% of the families are practicing shifting cultivation and about 16.4% of total biosphere reserve is under shifting cultivation. They cultivate betel nut, cashew nut, banana, maize, rice, pulses, jack fruit, pine apple, cinchona, litchi, pear, tea etc. at commercial scale in the buffer and transition zones of the biosphere reserve area. Most of the villagers are interested to keep livestock like cattle, goats and hens.

The area forms a part of one of the global hot spots of biodiversity. It is endowed with natural beauty, diverse flora and fauna and varied human cultures. This area is the reservoir of large variety of wild relatives of cultivated Citrus fruits, which are grown in different parts of the region by the villagers. The special feature of the area is the natural occurrence of *Citrus indica*. It seems to be most primitive and perhaps the progenitor of the *Citrus spp* and endangered and endemic species to Nokrek Biosphere Reserve. The area, is therefore, is considered to constitute an important gene pool for future hybridization program for evolving disease resistant *Citrus* plants. The Biosphere Reserve is also blessed with variety of animal species. Some of the animals are elephant, leopard, clouded leopard, tiger, rhesus macaque, pig tailed macaque, giant squirrel, barking deer and a variety of butterflies and birds. Hoollock gibbons the only Apes in India a primate of reserve is considered as an endangered species. [PLATES 6 & 7] The vegetation of Nokrek Biosphere Reserve consists of evergreen, semi evergreen, deciduous species, bamboo patches and grassland including riverine forest. About 90% of the park

area is covered by evergreen forest. The other forest types are Tropical semi-evergreen forests, Tropical moist deciduous forests, Sub-tropical broad leaf forests and Bamboo forests. The density of the forest is very high along the ridges making the entire area dark even during day time.

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LOCATION & GEOGRAPHICAL FEATURE

This biosphere reserve is located in the North West part of Meghalaya (25°20' to 25°29'N Latitude and 90°13' to 90°35' E Longitude) and comes under the Burma monsoon forests and represents biogeographical unit 9B Meghalaya Hills in the North East India. It consists of East Garo Hills, West Garo Hills and South Garo Hills Districts of Meghalaya. [MAP 1]

This area is a close cluster of hills of highly undulating topography at the both sides of the ridge and are commonly called "Giri" prefix with local names. It is entirely a hilly terrain and the configuration of the ground presents numerous variations. In the northern side of the National Park, the area is comparatively of gentle slope. Where the southern flank consists of steep to moderate and very steep slopes with the upper reaches having less precipitous areas. Most of these hills are less than 600m in altitude except in the Arbela range where the elevation reaches 960m The highest peak is Nokrek, which is 1,412m in height, and is included in the National Park area.

ZONATION PATTERN FOR CONSERVATION & MANAGEMENT

Total area of Nokrek Biosphere Reserve is 820 sq.km. which is divided in to three zones viz. Core Zone, Buffer Zone and Transition Zone for the purpose of management and conservation as designed under the Man & Biosphere Reserve concept.

A highly protective area of 47.48 sq. km. is designated as core area. It is totally undisturbed nature reserve and wilderness portion where monitoring is conducted from time to time. This area includes Nokrek National Park (47.48sq.km.) and is purchased from 20 private (*Akhing*) land owners by the Government of Meghalaya.

Buffer zone consists of forest covers of 227.92 sq. km. This area is still under private land but state government is trying to acquire it from the Akhings for its proper management and conservation of the biodiversity. Due to non availability of any alternatives local people are involved in shifting cultivation in this area that has lead to destruction of primary forests in some parts. Due to population pressure the rotation gap of shifting cultivation is also decreasing causing the denuded lands with regeneration of mainly herbs and few shrubs. At some places they are replaced by bamboo forests but they are secondary in origin. Forest department is providing some alternatives to the villagers to reduce the shifting cultivation.

Transition zone consists of an area of 544.60 sq. km. The entire area belongs to the private Akhings. The boundary of transition zone is delimited by the metallic road in the southern and northern sides. Most of the villages are concentrated near the metallic road. The population pressure is maximum in this zone leading to optimum disturbance in the form of degradation of forest land for shifting cultivation, excavation for calcium rocks for industries, mining activities, and poaching of timber and animals. At some places land sliding and

soil erosion are also very frequent. Forest department is trying to negotiate with the local communities to control the disturbances. They are also providing the alternatives of shifting cultivation. [MAP 2]

PHYSIOGRAPHY & DRAINAGE PATTERN

In general the mountain ranges in Meghalaya run from west to east. The physiographic characteristic is remarkable as these ranges are not continuous, particularly in the south, which are separated by deep gorges carved through millennia by wide and fast flowing rivers such as Simsang in Garo Hills, Myngngot and the Umiam in Khasi and Jaintia Hills. The west and northern face has a highly dissected and irregular and steep fall of the southern face to Barrak. The interesting feature in the north is that the boundary of the plateau is not well defined. Practically all the principal rivers of the state run in either a northerly or southerly direction, to join the Brahmaputra and its tributaries. The rivers that flow in a westerly direction are to be found only in Garo Hills.

Nokrek Biosphere Reserve possesses innumerable streams and springs with Simsang, a major river along with a large number of tributaries which together form its perennial catchment system. It flows towards the south. The other important rivers are Ganol, Bhugi, Dareng, Nitai, etc. Simsang River is the biggest and longest river in Garo Hills. It originates from the northern part of the Nokrek National Park. Ganol River is very important as it supplies water

to Tura town. It flows west ward and meets Brahmaputra River. Dareng River originates from the southern part of the peak area.

The Garo hills region is a part of the Meghalaya plateau. Rock types from most ancient to recent period occur in different location of these hills. The oldest known rocks comprise the 'Archeam group' of about 3,600 million years of antiquity. Over these rocks, localized patches of rocks belonging to the 'Gondawana group' of some 350 million years old are also present. [MAP 4]

GEOLOGY & SOIL

The entire Garo Hills is a hilly terrain that constitutes "Shillong plateau". The basement Gneissic complex covering an area about 60% of Garo Hills of Precambrian age is the oldest litho-unit exposed, in central and northern parts of Garo Hills and composed of gneisses, granulites, migmatites, amphibolites and Banded Iron-Formation (BIF) intruded by basic and ultra basic bodies. Over the Precambrian crest localized patchy occurrences of sedimentary rocks belonging to the Gondwana group comprising of pebble bed, sand stone and carbonaceous shale with streak and lenses of coal and contain fossil plant imprints of *Vertebraria indica* that grew luxuriantly during upper carboniferous Permian. Occurrences of basaltic trap rock and rhyolitic crystals tuffs as detached sheet lenses is indicative of Cretaceous – Palaeocene volcanic activity in West Garo Hills district. [PLATE 1 & 2]

In most of the Biosphere area red loamy soil is observed. These soils are poorer in silica but richer in clay forming minerals. The soil are generally loamy by sometimes vary from clay to sandy loam. The surface horizon which is about 30 cm thick has colours ranging from reddish brown to dark reddish brown. The soils are rich in organic matter and nitrogen but deficient in phosphate and potash. These are usually acidic in character and suitable for cultivation of rice, potato and fruits.

CLIMATE

Garo hills, as a whole has a tropical climate characterized by high humidity, generally moderate cold winter and mild summer seasons. Monsoon rains of high intensity are received during the months of April to October. The region experiences occasional rainfall during the months of November to March. June and July are the wettest months of the year. The average annual rainfall is 5,621.4 mm. which spread over 119 days. The temperature varies from place to place depending on the aspects, vegetation and altitude. The southern part of the biosphere reserve is slightly warmer than the northern part. The average relative humidity is 30% (minimum) and 87% (maximum).

GENERAL ACCOUNT OF FOREST TYPES OF NOKREK BIOSPHERE RESERVE

The biosphere reserve supports broad-leaves evergreen and semi-evergreen forests with patches of bamboo at lower altitudes. Vegetation on the southern slopes is limited to occasional patches of moist deciduous forests. The density of the entire forest is very high along the ridges making the entire area dark even during the day time. The entire region is highly humid and dense. *Citrus indica* plants are present in isolated and scattered form throughout the biosphere reserve. The area with heavy rainfall, high humidity and high temperature provides an ideal environment for rich luxuriant tropical vegetation with a great diversity of species. The vegetation of biosphere reserve area can be broadly classified into the tropical and subtropical vegetation that covers an area up to the elevation of about 1,000m. The plants are evergreen, semi evergreen, moist deciduous types and included bamboo thickets. The biosphere reserve consists of following forest types: [PLATE 3 & 4]

A. Tropical moist evergreen forests: These forests are generally found along the ridges of the inner core of the National Park area. These are almost virgin forest and confined to moderate slopes area of the ridges and deep gorges. These evergreen forests form climatic climax and have not been disturbed by man. Epiphytic growth is rich in these forests and almost every tree perched over by dense growth of epiphytic orchids, ferns and other plants. These forests provide

ideal habitats for many endangered arboreal species. These forests also provide shelter for the migratory wild elephants during summer season that used to migrate from the neighboring areas. The representative species of this forest are: *Michelia* sp., *Schima wallichii*, *Aporusa oblonga*, *Mesua ferrea*, *Ziziphus* sp., etc.

B. Tropical semi-evergreen forests: This type of forests is found over rocky areas and steep slope areas. The general canopy of these forests is typically less dense than the evergreen forest. In this area the land is devoid of tree vegetation. The characteristic species are: *Schima wallichii*, *Terminalia* sp., *Albizia* sp., *Litsia* spp., etc.

C. Tropical moist deciduous forests: These forests are sub-climax (successional type and are man-made forests). These forests are characterized by almost complete leaf shedding and profuse flowering when the trees are devoid of foliage. These occupy the fringe areas mainly the gentle slope area where shifting cultivation was possible. The plants include: *Albizia lebbek*, *A. lucidior*, *Dilenia pentagyna*, *Gmelina arborea*, *Holarrhaena antidysentrica*, *Terminalia belerica*, *Sterculia vilosa*, *Vitex quinata*, etc.

D. Sub-tropical broad leaves hill forests: These forests occur at elevation about 1,200m from sea level and restricted to Nokrek peak. These are mainly evergreen forests but a few elements of deciduous species are also found. The representative species are: *Cinnamomum* sp., *Schima wallichii*, *Magnolia* sp. *Gynochordia odorata*, *Saurauia* sp. etc.

E. Bamboo forests: These forests are scattered in small patches mixed with the above forest types. These are found in the slope areas of moderate intensity along the streams. This comprises of *Bambusa balcooa*, *B. tulda*, *Dendrocalamus hamiltonii*, *D. strictus*. The bottom land of the steep slopes are covered by the slopes of moderate intensity and 'jhum' cultivation used to be practiced by the local people in many of these areas in the past. Bamboo bushes mostly cover such areas and shrubs jungle with medium sized trees of various species occurring sporadically.

BIOTIC FACTORS & DISTURBANCE OF FORESTS

Jhum cultivation or shifting cultivation is the only livelihood option lying with the Garo people living in the biosphere reserve area. The jhum cultivation is some thing linked to their heritage that they are practicing it since the forefather times. The people of the biosphere reserve area are socio-economically very poor and economically very backward. Almost 85% of the

families are practicing shifting cultivation. About 17% of the total Biosphere Reserve comes under Jhum cultivation resulting in soil erosion and loss of top soil and disturbing the wild life habitats, especially movement of wild life. But this is confined to the transition and buffer zones only. In this cultivation they select any plot of their choice and burn the standing vegetation irrespective of type of plants resulting to a significant loss of flora and fauna. Later they cut down the partially burnt trees and use the field for cultivation for 2-3 consecutive years. After 3 years they move to a fresh land abandoning the previous piece of land. They may return to the previously used land even after ten years or more. During this period some primary and secondary successor plants use to establish in these abandoned fields. Due to increased population pressure, the duration of this rotation has reduced to 5 years or even 3 years. During this short period, only some exotic species like *Lantana sp.*, *Macaranga sp.*, *Rubus sp.*, *Polygonum sp.*, *Ageratum sp.*, *Solanum sp.*, etc. colonize in the field causing deleterious effect to the native flora. [PLATE 8]

HISTORY OF PREVIOUS BOTANICAL EXPLORATION AND REVIEW OF LITERATURE

Many botanists have made their collections from the forests of Meghalaya. The first collector from this region seems to be Mr. M.R. Smith. Sir J.D. Hooker and T. Thomson collected several specimens from Meghalaya and included it in 'Flora of British India'. C.B. Clarke has made significant

contributions on the floristic of Meghalaya. Gaustav Mann was the first to make organized collections mainly for understanding the rich forest flora of North East India. He was succeeded by U.N. Kanjilal, A. Das, C. Purkayastha and R.N. De and whose efforts resulted in the publication of the 'Flora of Assam'. N.L. Bor has made elaborate collections particularly grasses from N.E. India. M.M. Srinivasan has made his collections from the Garo hills. Apart from these, a number of revisionary accounts on the various families/genera of the Indian region have been published and these include collections from Meghalaya as well (Biswas, 1934; Bremekamp, 1934, 1948; Bioenberg, 1934, 1952; Chatterjee, 1947, 1948; Wit, 1947, 1956; Chakravarthy, 1949, 1959; Mukherjee, 1950, 1958; Rao, 1953; Kostermans, 1957a, 1957b, 1961, 1962; Maheswari, 1960, 1964; Corner, 1960, 1965; Thothathri, 1961; Klotz, 1963; Meeuwe, 1962; Jacobs, 1965; Airy Shaw, 1965; A.S. Rao, 1978; Bhag Singh, 1977, 1979, 1980a, 1980b, 1980c, 1981a, 1981b; Majumdar, 1979; Basak, 1980; Nayar and Giri, 1980; Das and Jain, 1980; J.N. Singh and V. Mudgal, 1998a, 1998b, 1999a, 1999b, 1999c, 2000; J.N. Singh, 2000). There are also some publications on ethnobotany of Meghalaya (Joseph and Kharkongor, 1981; Kharkongor and Joseph, 1981; R.R. Rao, 1981a, 1981b; R.R. Rao and Neogi, 1980; M.K.V. Rao and Shanpru, 1981; Kumar et.al., 1982).

The establishment of the North-Eastern Hill University in Shillong has further boosted the floristic activity in this region and numerous contributions on the flora of Meghalaya (R.R. Rao and M.K.V. Rao, 1980; R.R. Rao and Neogi, 1978; R.R. Rao and Kharkongor, 1977; R.R. Rao and Dam, 1979; R.R. Rao and

Haridasan, 1982; Neogi, 1980; Myrtong and R.R. Rao, 1982; Haridasan et.al, 1981; Baishya and R.R. Rao, 1982). Later K. Haridasan and R.R. Rao presented their work in the form of two volumes of 'Forest Flora of Meghalaya'.

The above accounts deal either with the flora of N.E. India as a whole or on certain specialized groups, families or genera or mainly restricted to the Khasi and Jaintia hills of Meghalaya. Very little emphasis was given to the complete floristic account of the Nokrek Biosphere Reserve.

PRESENT STUDY

The present work deals with the complete floristic account of the angiosperm plants of Nokrek Biosphere Reserve. In Angiosperms both the groups viz. Dicotyledons and Monocotyledons get the full emphasis. It is based on the seasonal survey and collection of plant specimens along with their photographs. The work presents the name, description, flowering and fruiting time, place of collection, location of deposited herbarium specimen and key to the families, genus and species with the field characters and color plates of the plants that will help in the identification of the plants in the field with maximum perfection. This is the basic and most important task and is the key to any exploration program. Identification of medicinally important plants will help in formulating the strategy for their conservation. This will also help the scientists, researchers, forest authorities, and biosphere managers to understand the ecosystems and the factors regulating the ecosystems. It also

has the mentioning about the use of various plants in the form of medicines, beverage and food by the Garo people. This provides a clear picture of men and nature relationship inside the biosphere reserve. This will help in the conservation and management activities. At last but not the least, it is a floristic account of the region that presents the floristic wealth of the biosphere reserve to understand and know about the plants those are still unknown to the scientific world and their status in the forest.

METHODOLOGY

Routine procedure is followed for collecting and processing the specimen in the Herbarium. Several excursions are undertaken during the last 5 years to cover the entire region in different seasons so as to collect most of the plants in flowering and fruiting stages and also to note the seasonal changes in the vegetation. During the field work, special attention is given to observe and record the field informations such as habit, correct habitat, frequency, common associates, colour of leaves, flowers, fruits, any prominent field characters, and such other characters that cannot be observed from dry herbarium specimens. In case of deciduous trees, representative twigs of both fertile and vegetative, and as far as possible from the same tree, but different seasons were collected.

In general , for collection, pressing, drying, poisoning, mounting, etc. the routine herbarium methods recommended by Jain & R. R. Rao (1977) have been adopted. But collections of special groups like Moraceae need some

elaboration here. The receptacles or syconium are dried dried without pressing, in order to maintain their size and shape and then mounted on the twing on the harberium sheets. For floral dissection and drawing of floral morphology or micro-morphological study, the plant materials are also preserved in polythene pouches with cotton beads shoaked in FAA solution. [PLATES 9, 10 & 11]

All the specimens are identified with the help of available literature and are later matched and confirmed in the herbaria of the Botanical Survey of India, at Shillong (ASSAM), Herbarium in holding of the Dept. of Botany, Guwahati University and also at Howrah (CAL). Significant help has been obtained from the official websites of International Plant Name Index as <http://www.ipni.org/> and [http://www.theplantlist.org /](http://www.theplantlist.org/) for determining of the validity of name. From the official website of Kew Herbarium (K) as <http://www.kew.org/> it has been possible to verify the authencity of the identification of some critical specimens, as the high resolution image of the same is present there.

Presentation of the Flora:

All the angiospermic plants are presented here. The arrangements of the families in the present flora follows the system of Bentham & Hooker (1862-83) with slight modification in conformity with the recent literature (Hutchinson, 1959; Air-Shaw, 1965; Cronquist, 1968). The genera and species under each family are arranged alphabetically.

Key to the identification of families, genera and species in most cases refer to collections studied from Nokrek Biosphere Reserve only.

The nomenclature of the taxa has been checked and brought up-to-date as per the information given on the official website of International Plant Name Index (<http://www.ipni.org/> and [http://www.theplantlist.org /](http://www.theplantlist.org/)).

In the citation of species, an extensive synonymy is avoided and only important synonym and basionyms, so as to cover Flora of British India (1872-97), Flora of Assam (1934-40), and other important floras of the country or related to Meghalaya viz. Flora of Jowai (1981-83), Forest Flora of Meghalaya (1985-87), Orchida of Meghalaya (1986) & Cyperaceae of North East India are mentioned. Vernacular Name (Garo), wherever available is also given.

Description of the species are largely based on the voucher specimens deposited in the herbarium. Illustrations of the species, wherever provided are also based on voucher specimens and sometimes drawn with fresh plants before pressing or the plant samples preserved in the FAA solution. Some taxa are described on the basis of the available material in the CAL herbarium as at some occasions, in case of very tall trees, it was not possible to collect plant specimens with flower and fruit. All measurements used are in metric system.

For each species, flowering and fruiting period, habit are given. Notes on their field identification characters if any, and information on their uses are also mentioned.