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Pollen Catalogue of Contemporary Dry Flower Samples of Bangladesh by Establishing a Standard Sample Processing Technique

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Abstract

Palynological research is a powerful tool in the fields of stratigraphy, biostratigraphy, palaeoenvironment, palaeoecology, hydrocarbon resource analysis, and palaeobiogeography. The Geological Survey of Bangladesh (GSB) has undertaken a significant step towards creating a pollen-spore inventory to support contemporary palynological research. This study aims to prepare a pollen catalogue from different modern dried flower samples of the Bandarban area that have been collected from the Bangladesh National Herbarium, Dhaka, and to establish a complete sample processing technique from dry flowers for pollen analysis in the laboratory of the GSB. The research outcomes will help to identify the prehistoric palynological zone and palaeoenvironment since most of the biota of the Holocene period are almost identical to current flora and fauna assemblages. Twelve dry flower samples of seven families were analyzed using the acetolysis technique, prepared temporary slides, and then observed under the microscope in 400x and 1000x magnification. This study records the pollen morphology of different taxa, including plant habit, category, and local and botanical names of flowers. Ecological information is also collected from various open-source resources. This pollen catalogue will be a valuable resource for students, teachers, oil-petroleum industrial sector, professionals, and researchers to learn and conduct research in the field of palynology. This research will significantly contribute to understanding the natural history of the country and other similar climatic regions. With a complete pollen-spore inventory, researchers will be able to explore the natural resources of the country, including its hydrocarbon resources, to make informed decisions about the country's economic progress. Therefore, the study is of utmost importance, and its results will be beneficial for the future generations of Bangladesh.

Keywords: Sample Processing, Acetolysis, Pollen Catalogue, Palynology, Chimbuk

1. INTRODUCTION

Pollen grains produced by different species of plants have a distinctive appearance. This helps us determine what kind of plant they were from, which tells us the plants that used to grow in the adjacent area. Palynology is the scientific discipline concerned with studying plant spores, pollen, and certain microscopic planktonic organisms, in both living and fossil form (University of Arizona, 2013). This branch is associated with the plant sciences and the geologic sciences, notably those aspects dealing with stratigraphy, historical geology, and paleontology (Petruzzello, 2017). The scope of the palynological investigation is excessively broad, ranging from the analysis of pollen morphology with transmitted light and electron microscopes to the study of organic microfossils (palynomorphs) extracted from ancient coals (Akhtar and Kosanke, 2000; Akhtar, 2001). Stratigraphic palynology uses palynomorphs (pollen and organic microfossil), their identification, distribution, and abundance to correlate among sedimentary sequences of any age or to provide chronological control for these sedimentary sequences. Pollen and spores can also be indicators of climate change (Saxena et al., 2015).

Vegetation responds to ecological change and human impacts. It also leaves traces of itself behind in the landscape in the form of pollen. This is preserved in the subsurface as fossils for thousands (and sometimes millions) of years. This characteristic allows for the use of pollen and spores as indicators of past vegetation types. Accordingly, Palynology is one of the most efficient methods we have to reconstruct past environments. Because the hard-outer shells of pollen grains which are called exines, of different species are distinctive and can survive in favorable conditions for thousands of years (Kurman and Doyle, 1994). Because of these features pollen grains and spores have proved extremely useful to geologists, ecologists, palaeoecologist, medical scientists, agriculturists etc.

Geological Survey of Bangladesh (GSB) has been conducting Palynological research for several years (Hossain et al., 2011; Haque and Rahman, 2015; Haque et al., 2017; Haque et al., 2020 and Haque et al., 2024). However, one of the biggest challenges faced by Palynological research is the lack of a complete and adequate pollen catalogue in Bangladesh. To successfully conduct research, it has become an urgent necessity to prepare the Pollen catalogue. Dried flower specimens were collected from the Bangladesh National Herbarium in Mirpur and sorted by area. This study focused on samples from the Chimbuk area in the Bandarban District, located in the hilly region of Bangladesh (Figure 1). This area has been selected for its distinct ecological and geological features. The purpose of this analysis is to recognize the recent pollen, identify the plant taxonomy, their environment and prepare a pollen catalogue with morphological characteristics for further research on Holocene pollen and establish a complete sample processing technique for pollen analysis of dry flower samples.

2. DESCRIPTION OF THE SAMPLING AREA

Studied dried flower samples of the National Herbarium of Bangladesh have been collected from the Chimbuk, Bandarban District. The Chimbuk hills of Bandarban is the third largest mountain in Bangladesh, located 26-28 km from Bandarban district town. It is about 762 meters above sea level. The development of the Bengal Basin is directly related to the development of the Himalayan mountains in the north and the Arakan Yoma Range in the east due to the north and north-eastern collision of the Indian Plate with the Eurasian Plate and subduction with the Burmese Plate, respectively (Alam et al., 2003; Hossain et al., 2014). The southeastern boundary of the Bengal Basin comprises the Eastern Folded Flank of the Bengal Foredeep, popularly known as the Chittagong (Chattogram) Tripura Folded Belt (CTFB). The Folded Belt stretches from the Chittagong Hill Tracts in the southeast to the southern edge of the Shillong Massif in the north, traversing the Indian state of Tripura and the eastern portion of the Surma Basin (Alam, 1995). The sampling area is an uplifted anticline that resulted from this collision and is situated in the southeastern part of Bangladesh. This is known as the Bandarban anticline. Sedimentation in this part of the Bengal Basin was controlled by the movement of the Indian plate with the Burmese and the Tibetan plates and by the uplift and erosion of the Himalayan and Indo-Burma mountain ranges (Alam, 1989). Heavy rainfall (average 261mm) and a small range of mean temperature are the major climatic characteristics of this region (Rashid, 1991; Bangladesh Bureau of Statistics 2023).

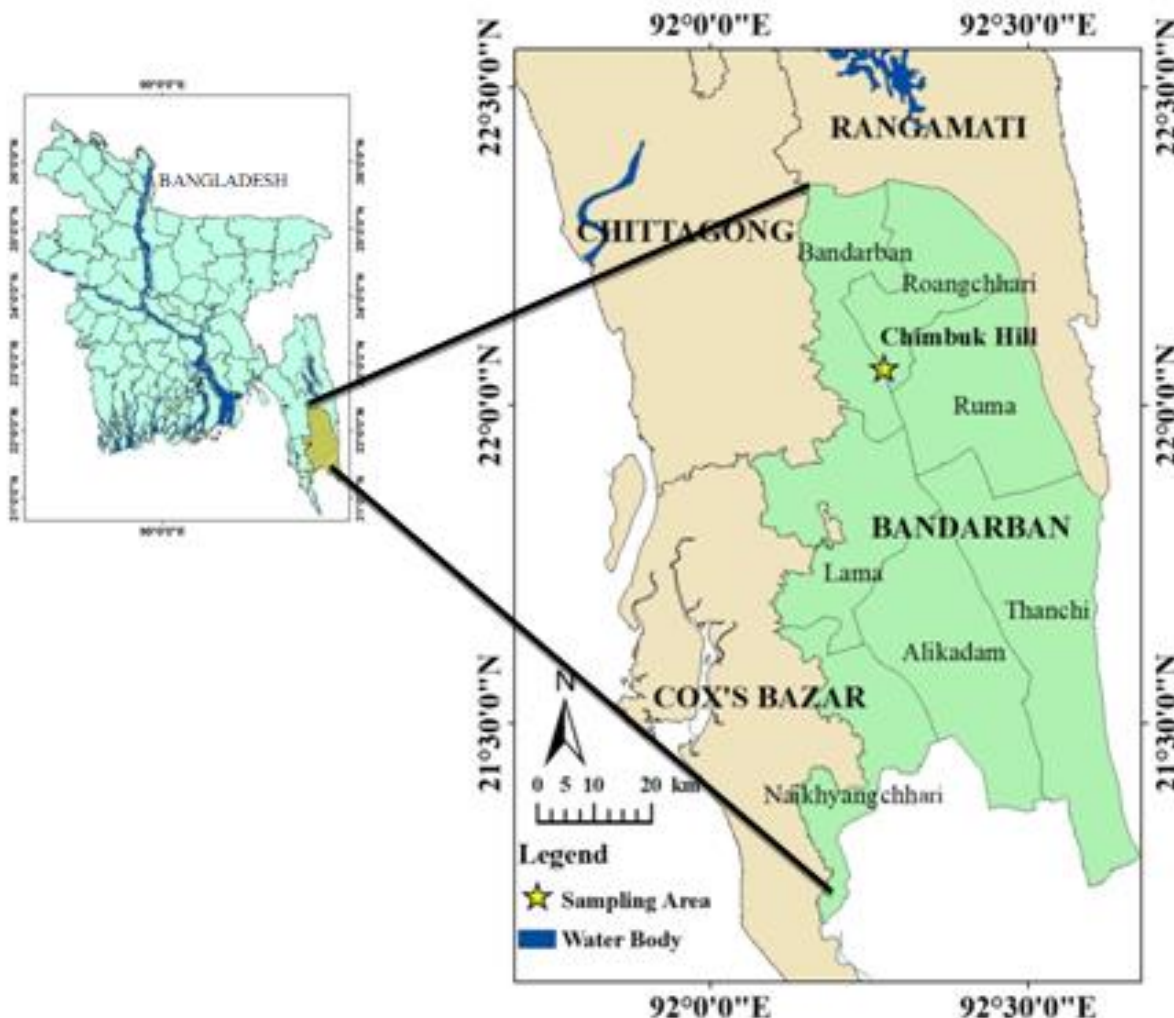


Figure 1. Location of the dried flower samples.

According to the bioecological zonation map of Bangladesh, the sampling area is located under Chittagong (Chattogram) Hills and the CHTs (Chittagong Hill Tracts) (Nishat et al., 2002). Brown hill soils are abundant in this zone. The common flora of this zone is Garjan (*Dipterocarpus turbinatus*), Telsur (*Hopea odorata*), Shilbatna (*Quercus velutina*), Goda (*Vitex pubescens*), Civit (*Swintonia floribunda*) trees; Kurchi (*Holarrhena antidysenterica*), Silchaonri (*Mussaenda roxburghii*), Kestoma/Keura (*Glochidion multiloculare*), Swet rangan (*Ixora parviflora*) shrubs; Shothi (*Curcuma zeodaria*), Sharpagandha (*Rauwolfia serpentina*), *Staurogyne argentea* herbs; Guachcha lata (*Calycopteris floribunda*), Jhum alu (*Dioscorea pentaphylla*), Kamkui/Kantakui (*Bridelia retusa*) climbers, and *Pholidota pallida*, *Acampe premorsa*, *Aerides odoratum* orchids.

3. METHODOLOGY

For preparing a spore-pollen catalogue from dry flowers, collected samples were treated in the laboratory with various techniques to make temporary or permanent slides and then observed under the microscope (Figure 2a, b). About twelve dry samples of natural flowers have been analyzed and pollen descriptions included in this article. Flower samples have been collected very simply using a small brush, forceps, scissors, and a sample bag (poly bag and cloth bag) (Figure 2c). All the samples were processed in the Stratigraphy and Biostratigraphy

laboratory of the GSB. For dry flowers, the Acetolysis method is the proper way for pollen sample preparation technique (Figure 2a).

At first, the powdered samples were sieved through an 80 μ mesh sieve. Then 5c.c acetolysis solution mixture (9c.c acetic anhydrite+ 1c.c sulfuric acid) was added with a pipette. There after samples were placed in a hot bath temp. <70 °C, heated the water bath to 100 °C, switched off the bath, and tubes were left in the hot bath for 1-2 minutes, stirring the contents. Centrifuged the content for 1 or 2 minutes about 1800 rpm and then decanted the liquids. Samples have been washed with distilled water. After washing, the samples were chlorinated with 5c.c of glacial acetic acid, 1 to 3 drops of a saturated solution of sodium chlorate/ potassium chlorate, and 1 to 2 drops of concentrated HCl. Samples have been centrifuged and decanted the chlorination mixture. Added distilled water, samples were transferred to the small tube fraction, stirred, centrifuged, and decant the supernatant. The tube was inverted on a clean filter paper for a few minutes, added a few drops of 50% aqueous-glycerin mixture and aqua safranin, centrifuged for 2-3 minutes, and decant. Slides have been Prepared with one drop of glycerol and a sample (Figure 2b, d). The pollen contained slides ready for microscopic observation.

After slide preparation, all samples were observed under the Nikon Eclipse 50i microscope, and photographs were captured with the help of a camera attached to the microscope. Data sheets have been prepared for all pollen samples with their morphological characteristics and cross-matched with available records collected from available online sources, published literature, books and reports. Information on pollen size has been collected from online sources and compared with the observed pollen as well. An inventory has been prepared with all the information and references.

4. RESULTS AND DISCUSSION

4.1. Pollen Morphology

Among twelve dry flower samples, one sample from each Amaranthaceae, Asteraceae, Convolvulaceae and Polygonaceae family; two samples from the Fabaceae family, three samples from each Lamiaceae and Malvaceae family have been observed and taxonomical and morphological characteristics were incorporated in an inventory. Taxonomical information of the studied samples is included in Table 1 and morphological information of the pollen is described below:

Scientific Name: *Argyrea nervosa* (Burm.f.) Bojer (GBIF, 2018; The Plant List, 2013)

Common Name: Baby wood-rose, Elephant Creeper, Woolly Morning Glory

Local Name: Bichtarak, Goguli, Baro dudhi

Category: Indigenous

Habit: Climber

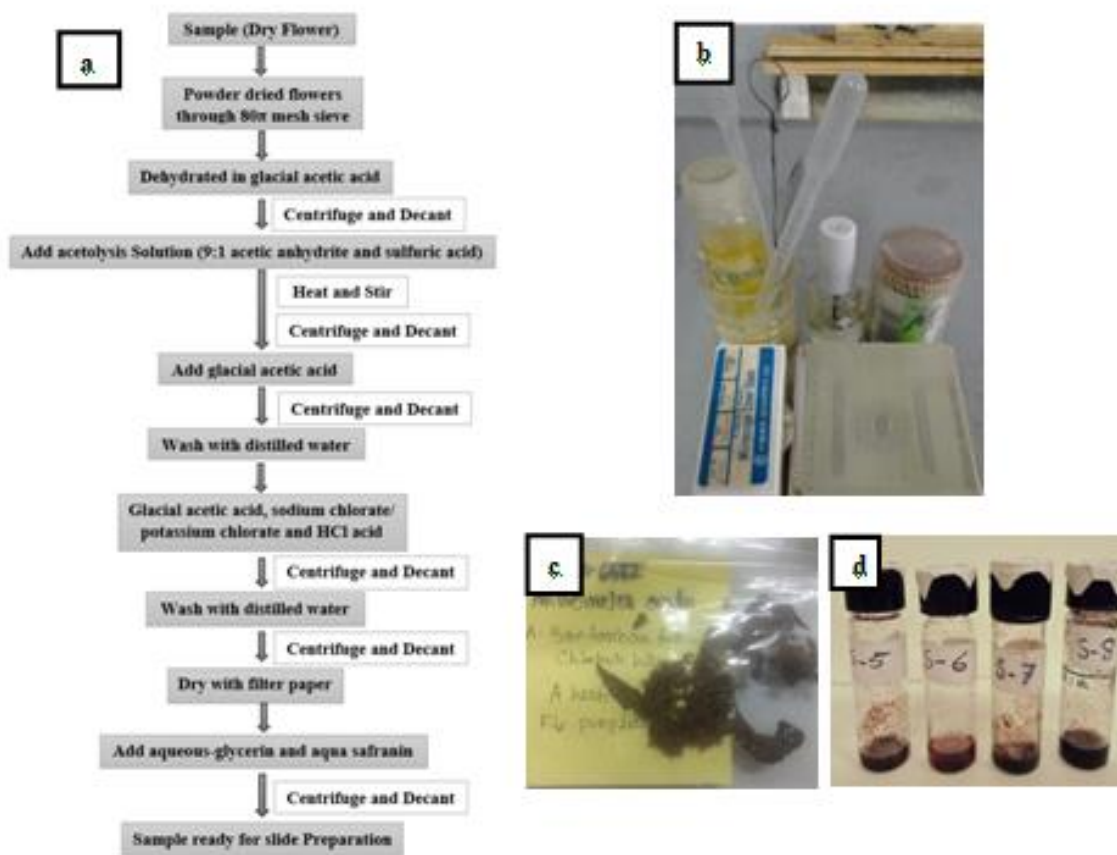


Figure 2. a) Laboratory technique flow chart; b) Slide preparation kits; c) Collected samples stored in sample bags with proper labeling; d) Prepared samples in vials.

Pollen morphology: Circular Spheroidal shape, Pantoporate type, Echinate-tips acute ornamentation with monad grain arrangement (Plate 1; A-B).

Pollen size: Both equatorial and polar size is 101.20 µm (Ghosh and Mandal, 2016).

Table 1. Taxonomical information of the observed pollen species.

Scientific Name	Kingdom	Class	Order	Family
<i>Argyrea nervosa</i> (Burm.f.) Bojer	Plantae	Angiosperms	Solanales	Convolvulaceae
<i>Ajuga</i> sp.			Lamiales	Lamiaceae
<i>Polygonum chinense</i> L.			Caryophyllales	Polygonaceae
<i>Mikania scandens</i> Willd.			Asterales	Asteraceae
<i>Desmodium gangeticum</i> (L.) DC.			Fabales	Fabaceae
<i>Desmodium triflorum</i> (L.) DC.			Fabales	Fabaceae
<i>Triumfetta bartramia</i> L.			Malvales	Malvaceae
<i>Urena lobata</i> L.			Malvales	Malvaceae
<i>Anisomeles indica</i> Kuntze			Lamiales	Lamiaceae
<i>Hyptis suaveolens</i> (L.) Poit.			Lamiales	Lamiaceae
<i>Hibiscus surattensis</i> L.			Malvales	Malvaceae
<i>Cyathula prostrata</i> (L.) Blume			Caryophyllales	Amaranthaceae

Scientific Name: *Ajuga sp.* (GBIF, 2018; The Plant List, 2013)

Common Name: Ground Pine_Bugle

Local Name: Not Known

Category: Indigenous

Habit: Herb

Pollen morphology: Prolate-Spheroidal shape, Tricolpate, Echinata-tips acute ornamentation with monad grain arrangement (Plate 1; C-D).

Pollen size: Equatorial size 33.0 μm (30.0 μm - 37.7 μm) and polar size 30.4 μm (28.6 μm - 33.0 μm).

Scientific Name: *Polygonum chinense L.* (GBIF, 2018; The Plant List, 2013)

Common Name: Chinese knotweed, Creeping Smartweed.

Local Name: Not known

Category: Indigenous

Habit: Herb

Pollen morphology: Suboblate-spheroidal shape, Tricolpate, Reticulate ornamentation with monad grain arrangement (Plate 1; E-F).

Pollen size: Equatorial size 38.8 μm (31.0 μm - 46.7 μm) and polar size 36.4 μm (28.6 μm - 42.7 μm) (APSA, 2007).

Scientific Name: *Mikania scandens* Willd. (GBIF, 2018; The Plant List, 2013)

Common Name: Climbing Hempvine, Climbing Hempweed

Local Name: Assam Lota

Category: Indigenous

Habit: Climber

Pollen morphology: Prolate to subprolate shape in equatorial view and Triangular (spheroidal) in polar view, Tricolporate, Psilate to finely scabrate ornamentation with monad grain arrangement (Plate 1; G-H).

Pollen size: Equatorial size 61.4 μm (55.0 μm - 64.7 μm) and polar size 44.4 μm (40.6 μm - 48.7 μm).

Scientific Name: *Desmodium gangeticum* (L.) DC. (GBIF, 2018; The Plant List, 2013)

Common Name: Not Known

Local Name: Shalaparni

Category: Indigenous

Habit: Shrub

Pollen morphology: Prolate to subprolate shape in equatorial view and Triangular in polar view, Tricolporate, Reticulate ornamentation with monad grain arrangement (Plate 1; I-J).

Pollen size: Equatorial size 74.8 μm (67.0 μm - 80.7 μm) and polar size 40.4 μm (38.6 μm - 45.7 μm) (APSA, 2007).

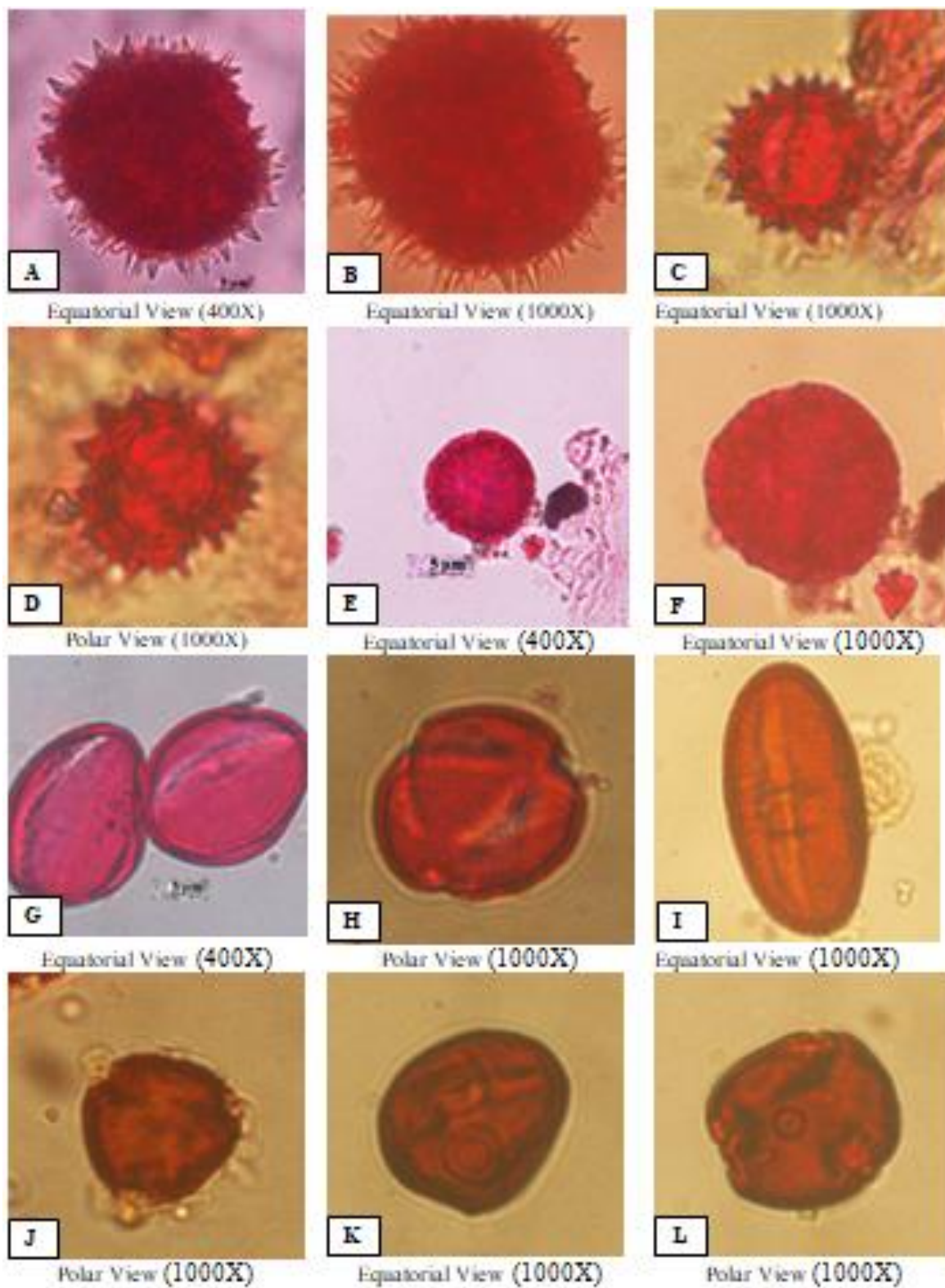


Plate 1. A-B *Argyreia nervosa* (Burm.f.) Bojer; C-D *Ajuga sp.*; E-F *Polygonum chinense* L.; G-H *Mikania scandens* Willd.; I-J *Desmodium gangeticum* (L.) DC.; K-L *Desmodium triflorum* (L.) DC.

Scientific Name: *Desmodium triflorum* (L.) DC. (GBIF, 2018; The Plant List, 2013)

Common Name: Three-flower beggar weed, Tick clover

Local Name: Kudaliya

Category: Indigenous

Habit: Herb

Pollen morphology: Pollen Subprolate-spheroidal shape in equatorial view and Triangular in polar view, Tricolporate, Psilate ornamentation with monad grain arrangement (Plate 1; K-L).

Pollen size: Equatorial size 56.8 μm (44.3 μm - 60.2 μm) and polar size 46.4 μm (38.6 μm - 50.3 μm).

Scientific Name: *Triumfetta bartramia* L. (GBIF, 2018; The Plant List, 2013)

Common Name: Burbark.

Local Name: Banokra

Category: Exotic

Habit: Shrub

Pollen morphology: Pollen Subprolate-spheroidal shape in equatorial view and Triangular in polar view, Tricolporate, Psilate ornamentation with monad grain arrangement (Plate 2; A-B).

Pollen size: Equatorial size 37.8 μm (31.0 μm - 40.7 μm) and polar size 36.9 μm (32.5 μm - 38.1 μm).

Scientific Name: *Urena lobata* L. (GBIF, 2018; The Plant List, 2013)

Common Name: Caesar weed, Aramina Fibre, or Congo jute.

Local Name: Jangli Ghagra

Category: Indigenous

Habit: Shrub

Pollen morphology: Pollen Circular-spheroidal shape, Triporate, Baculate ornamentation with monad grain arrangement (Plate 2; C-D).

Pollen size: Equatorial size 182.0 μm (178.6 μm - 190.7 μm) and polar size 185.3 μm (175.9 μm -195.0 μm) (APSA, 2007).

Scientific Name: *Anisomeles indica* Kuntze (GBIF, 2018; The Plant List, 2013)

Common Name: Indian Catmint, Malabar catmint

Local Name: Gobura

Category: Indigenous

Habit: Herb

Pollen morphology: Pollen Prolate shape in equatorial view and Triangular (convex) in polar view, Tricolpate, Faintly Reticulate ornamentation with monad grain arrangement (Plate 2; E-F).

Pollen size: Equatorial size 36.30 μm and polar size 33 μm (Ghosh and Mandal, 2016).

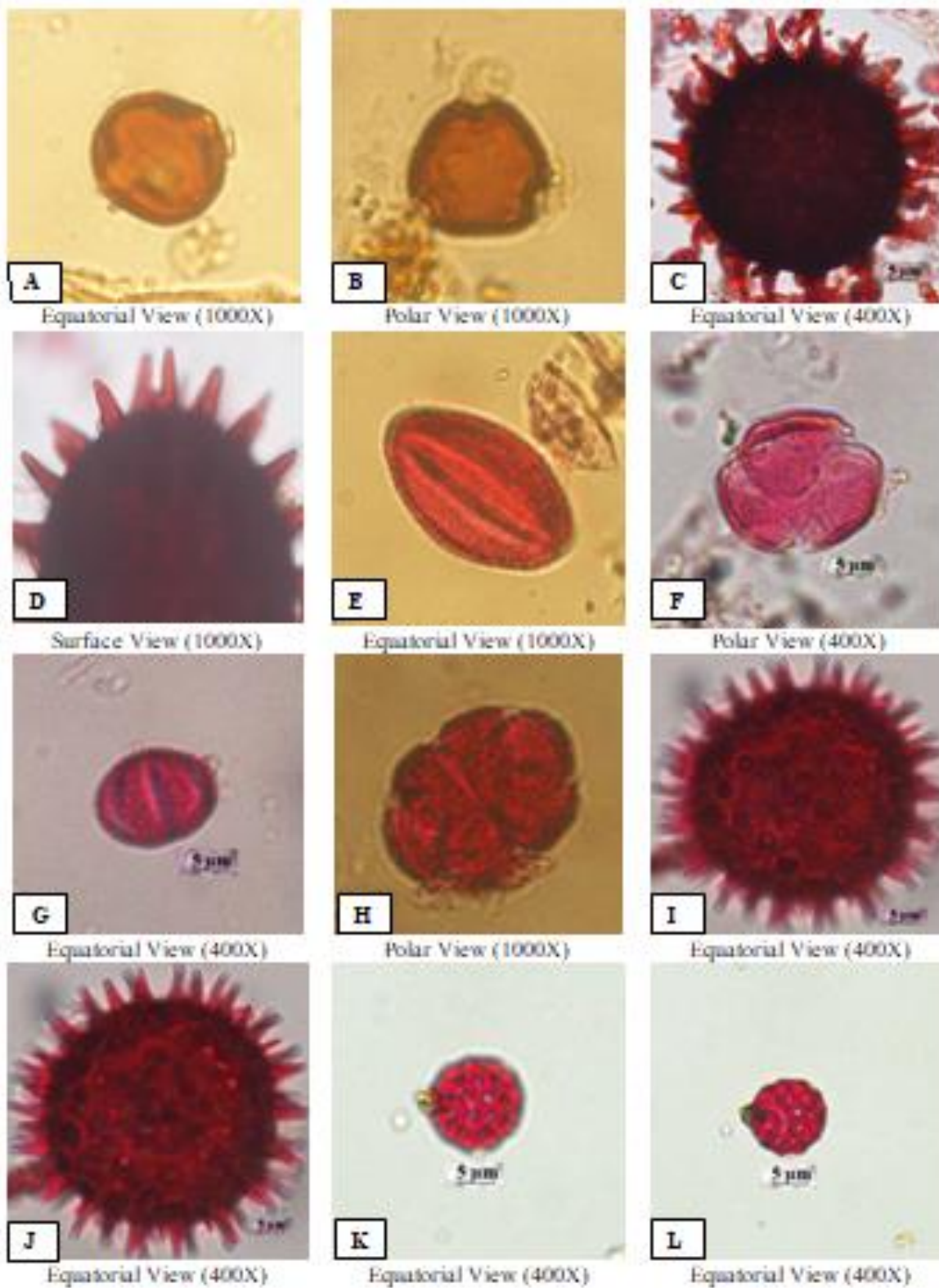


Plate 2. A-B *Triumphetta bartramia* L.; C-D *Urena lobata* L.; E-F *Anisomeles indica* Kuntze; G-H *Hyptis suaveolens* (L.) Poit.; I-J *Hibiscus surattensis* L.; K-L *Cyathula prostrata* (L.) Blume.

Scientific Name: *Hyptis suaveolens* (L.) Poit. (GBIF, 2018; The Plant List, 2013)

Synonym of *Mesosphaerum suaveolens* Kuntze

Common Name: Pignut or Chan.

Local Name: Tokma

Category: Indigenous

Habit: Herb

Pollen morphology: Suboblate-spheroidal shape in equatorial view and Circular in polar view, Zonocolpate, Reticulate ornamentation with monad grain arrangement (Plate 2; G-H).

Pollen size: Equatorial size 27.0 μm (24.0 μm - 33.0 μm) and polar size 31.0 μm (24.0 μm - 35.0 μm) (APSA, 2007).

Scientific Name: *Hibiscus surattensis* L. (GBIF, 2018; The Plant List, 2013)

Common Name: Wild sour, Shrub Althea.

Local Name: Not Known

Collected From: Chimbuk, Bandarban District

Category: Exotic

Habit: Shrub

Pollen morphology: Pollen circular -spheroidal shape, Zonoporate, Baculate ornamentation with monad grain arrangement (Plate 2; I-J).

Pollen size: Equatorial size 132.0 μm and polar size 132.0 μm (APSA, 2007).

Scientific Name: *Cyathula prostrata* (L.) Blume (GBIF, 2018; The Plant List, 2013)

Common Name: Pasture weed, Cyathula

Local Name: Not known

Collected From: Chimbuk, Bandarban District

Category: Indigenous

Habit: Herb

Pollen morphology: Pollen Circular-spheroidal shape, Pantoporate, Reticulate to perforate ornamentation with monad grain arrangement (Plate 2; K-L).

Pollen size: Equatorial size 28.6 μm (25.0 μm - 32.7 μm) and polar size 28.3 μm (27.4 μm - 31.0 μm).

4.2. Ecological Significance

Argyria nervosa is a Perennial, seed-propagated climber. It grows mainly in tropical and subtropical regions including rainforests, open woodlands, dense grasslands, roadsides, river banks, edges of lakes, disturbed sites, and waste areas (Csurhes, 2009). It is native to the Indian subcontinent. It is found at altitudes from sea level up to 900 m (Padhi et al., 2013). It prefers fertile, moist soils in a protected sunny disposition and it is drought resistant. The minimum tolerable temperature of *A. nervosa* is -4 °C (PROTA, 2016). The mean annual tolerable temperature is 10 °C to 30 °C and mean tolerable rainfall is 724 mm (lower) to 2474 mm. *Ajuga sp.* is an annual and perennial herbaceous flowering plant with most species native to Europe, Asia and Africa (Bailey et al., 1976; Hay, 1978). It is easily grown in well-drained soils in part-sun to part-shade. While it prefers moist soils with good drainage, it will tolerate moderately dry conditions. *Polygonum chinense* is a perennial, seed-propagated herbaceous plant that is native to much of Asia (Maharajan and Rajendran, 2014; USDA-ARS, 2014). It is a fast-growing herb that forms dense mats and tolerates diverse environmental conditions (Galloway and Lepper, 2010). *P. chinensis* grows from sea level to 3000 m.

Mikania scandens is an herbaceous broadleaved, perennial, seed-propagated, climbing vine. It acts as a weed on a local scale (Moon et al., 1993; Anderson et al., 2012) but it is also endangered or extirpated in other parts of its native range (USDA-NRCS, 2013). *M. scandens* is known to occur in all the areas of Asia and the Pacific Islands. It prefers fine-medium textured wet soils pH of 5.7-8.7 and has low salinity tolerance (USDA-NRCS, 2013). Minimum and maximum tolerable temperature range from -15 °C to 33 °C. Mean annual rainfall has lower limits of 750 mm and upper limits of 1500 mm. *Desmodium gangeticum* is a very variable perennial shrub plant (Allen and Allen, 1981). A very common weed mainly found in anthropogenic habitats in the lowlands, under ever-wet or seasonal conditions. Native in Tropical Africa, E. Asia, and Australia. *Desmodium triflorum* is a perennial, herbaceous plant. It grows in terrestrial lands like grassland or scrubland and is disturbed in open ground. The favorable conditions of *D. triflorum* are moist soils, well-drained soils, and poor infertile soils.

Triumfetta bartramia is an erect shrub with stems that are woody at the base. Grows like an abundant weed along roads and trails, in clearings, waste places, thickets, cane fields, and on open hillsides (Smith, 1979). *Urena lobata* is an herbaceous, perennial, seed-propagated, shrub that is also a cultivated crop in many regions (Langeland et al., 2008). It can be found growing throughout moist tropical and subtropical regions of the world including Asia, tropical Africa, Australia, North, Central and South America, the West Indies, and islands in the Pacific (PIER, 2012). It can be found growing in disturbed areas, waste grounds, roadsides, forest margins, coastal dunes, swamps and salt marshes, as well as in pastures and active and abandoned croplands (Francis, 2000; Langeland et al., 2008). It grows from sea level to elevations of 1500 meters, in areas that receive about 600 to 3000 mm of mean annual rainfall (Francis, 2000) and can grow in acidic soils with a pH of 3.5 (Nascimento and Vilhena, 1996; Souza-Filho et al., 2000). Seeds germinate well from 15°C to 40°C, with an optimal temperature of 28°C (Wang et al., 2009). Table 2 shows the climatic status for *A. nervosa*, *P. chinensis*, *M. scandens* and *U. lobata*. *Anisomeles indica* is a strongly aromatic, large, perennial, seed-propagated (Tropical Plants Database, 2014). *A. indica* is widely native in E. Asia - China, Japan, the Indian subcontinent, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Indonesia, Philippines and New Guinea. Grows in Sunny and open locations, grasslands, on wet soils along streams, and irrigated rice fields, at elevations of 600-1800 meters. *Hyptis suaveolens* is a coarse erect annual or often a perennial with stems that become more or less woody and Seed propagated herb plant. It grows in wet to dry thickets and fields, often in hedges or waste ground, at elevations of 1600 meters or less (Standley and Steyermark, 1976). The plant has spread to tropical and subtropical areas worldwide.

Hibiscus surattensis is a seed-propagated annual shrub plant (Ruffo et al., 2002; CABI, 2018). Grows in Tropical Africa - widespread in the moister regions; Madagascar, Indian subcontinent, Indo-China, Malaysia, Indonesia and Philippines. Found in Grassland, coastal sand dunes and at forest edges in lowlands, and at medium elevations up to 1700 meters. It is found in regions with an average annual rainfall of 1000 - 1600mm (Ruffo et al., 2002). *Cyathula prostrata* is an annual to perennial seed propagated, herb plant. This species ranges widely, in the tropics, through many parts of Africa, through Asia to New Guinea, northern Australia and into the western Pacific. *C. prostrata* grows as an understory of deciduous to evergreen vine thickets, vine forests, closed forests and monsoonal thickets, growing mostly on loamy and sandy soils (DeFilipps et al., 2004).

Table 2. Climatic condition for *A. nervosa*, *P. chinensis*, *M. scandens* and *U. lobata* (CABI, 2018).

Climate	Status for				Description
	<i>A. nervosa</i>	<i>P. chinensis</i>	<i>M. scandens</i>	<i>U. lobata</i>	
Tropical rainforest climate	Tolerated	Preferred	-	Preferred	> 60mm precipitation per month
Tropical monsoon climate	Preferred	Preferred	-	Preferred	Tropical monsoon climate (< 60mm precipitation driest month but > (100 - [total annual precipitation(mm)/25]))
Tropical wet and dry savanna climate	Preferred	Preferred	-	Preferred	< 60mm precipitation driest month (in winter) and < (100 - [total annual precipitation{mm}/25])
Tropical savanna climate with dry summer	-	Preferred	-	Preferred	< 60mm precipitation driest month (in summer) and < (100 - [total annual precipitation{mm}/25])
Warm temperate climate with dry summer	Tolerated	-	Preferred	Tolerated	Warm average temp. > 10°C, Cold average temp. > 0°C, dry summers
Warm temperate climate with dry winter	-	-	Preferred	Tolerated	Warm temperate climate with dry winter (Warm average temp. > 10°C, Cold average temp. > 0°C, dry winters)
Warm temperate climate, wet all year	-	-	Preferred	-	Warm average temp. > 10°C, Cold average temp. > 0°C, wet all year
Continental climate, wet all year	-	-	Tolerated	-	Continental climate, wet all year (Warm average temp. > 10°C, coldest month < 0°C, wet all year)

5. CONCLUSION

In this research, twelve dried flower specimens from the Bandarban area have been analyzed, all of which were obtained from the Bangladesh National Herbarium. Different plant groups and species have been identified and created a simple pollen catalogue that includes various pollen types and characteristics of different genera and species within the plant kingdom. Twelve species have been categorized into seven families they are; Convolvulaceae, Lamiaceae, Polygonaceae, Asteraceae, Fabaceae, Malvaceae and Amaranthaceae. Online information with references has also been added to enhance the morphological records of pollen.

For the first time, a comprehensive pollen sample preparation methodology for dry flowers has been established in the Stratigraphy and Biostratigraphy Laboratory of GSB, utilizing the acetolysis method as the preferred technique. This advancement is significant for future research on pollen, allowing for the reconstruction of plant community history, habitats, and environmental conditions through the identification of plant species. The pollen catalogue created through this methodology will be a valuable resource for academics and professionals studying Holocene pollen and palaeoenvironmental conditions. Future updates to the catalogue will enhance our understanding of the region's overall ecology.

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