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RHEUM NOBILE HOOK. F. & THOMSON: A REVIEW OF THE UNIQUE AND PRECIOUS GIANT HIMALAYAN RHUBARB

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ABSTRACT

Rheum nobile Hook.f. & Thomson (Polygonaceae), commonly known as Himalayan rhubarb or *Sikkim sundari*, is an unique, precious and vulnerable alpine species endemic to the eastern Himalayas, a subtropical alpine zone located within a global biodiversity hotspot. The diverse flora of the Himalayas, including *R. nobile*, contributes significantly to the region's rich biodiversity, this species exhibits remarkable adaptations to the challenging environmental conditions characteristic of its high-altitude habitat, including low temperatures, high levels of solar radiation, strong desiccating winds, and a short growing season. It's morphological and physiological features contribute in survival and reproductive success in this harsh alpine environment. Prominent among these are the large, translucent bracts that enclose the developing inflorescence. These bracts, in conjunction with the green basal bracts, create a greenhouse-like microclimate, effectively trapping solar radiation and elevating the temperature surrounding the reproductive structures. This localized warming is crucial for development in the face of low ambient temperatures. Furthermore, the bracts provide protection from ultraviolet radiation and strong winds, mitigating potential damage. The compact inflorescence itself minimizes exposure to wind and cold, reducing convective heat loss. *R. nobile* exhibits a monocarpic life cycle, characterized by a single reproductive episode after a period of vegetative growth. This strategy allows the plant to accumulate resources over multiple years before investing heavily in a single, large reproductive effort, maximizing reproductive output under resource-limited conditions. The unique morphology and physiology of *R. nobile* make it a valuable subject for research in diverse fields. The common name "glasshouse plant" aptly reflects the functional role of the translucent bracts in creating a greenhouse-like environment that promotes the development of the inflorescence, ensuring successful reproduction in this challenging habitat.

KEYWORDS- *Rheum nobile*, *Padhmachal*, *Sikkim Sundari*, Traditional medicine, Himalayan rhubarb.

INTRODUCTION

Rheum nobile Hook.f. & Thomson (Polygonaceae), commonly known as Himalayan rhubarb or *Sikkim sundari*, an unique, precious and vulnerable alpine species endemic to the eastern Himalayas, a subtropical alpine zone within a global biodiversity hotspot. The diverse flora of the Himalayas, including *R. nobile*, contributes significantly to the region's rich biodiversity. This species exhibits remarkable adaptations to the challenging environmental conditions characteristic of its high-altitude habitat, including low temperatures, high levels of solar radiation, strong desiccating winds, and a short growing season. Its morphological and physiological features contribute to its survival and reproductive success in this harsh alpine environment. Specialized cauline leaves, termed bracts (referred to hereafter as yellowish "glasshouse leaves"), comprise the structure.[1] Prominent among these are the large, translucent bracts that enclose the developing inflorescence. These bracts, in conjunction with the green basal bracts, create a greenhouse-like microclimate, effectively trapping solar radiation and elevating the temperature surrounding the reproductive structures. This localized warming is crucial for development in the face of low ambient temperatures. Furthermore, the bracts provide protection from ultraviolet radiation and strong winds, mitigating potential damage. The compact inflorescence itself minimizes exposure to wind and cold, reducing convective heat loss.

R. nobile exhibits a monocarpic life cycle, characterized by a single reproductive episode after a period of vegetative growth. This strategy allows the plant to accumulate resources over multiple years before investing heavily in a single, large reproductive effort, maximizing reproductive output under resource-limited conditions. The unique morphology and physiology of *R. nobile* make it a valuable subject for research in diverse fields. The common name "glasshouse plant" aptly reflects the functional role of the translucent bracts in creating a greenhouse-like environment that promotes the development of the inflorescence, ensuring successful reproduction in this challenging habitat. *R. nobile* was first described by Joseph Dalton Hooker and Thomas Thomson in 1855. This species exhibits remarkable adaptations to its challenging environment at elevations above 4000 m a.s.l., making it one of the few giant and most charismatic monocarpic perennials above the tree line in the Himalayas.[2]

UNIQUE MORPHOLOGICAL AND PHYSIOLOGICAL ADAPTATIONS

R. nobile possesses two distinct sets of adaptations that enable it to flourish in its challenging habitat:

Light Considerations

- UV Radiation Protection: Translucent bract transmittance of ultraviolet (UV) to infrared (IR) radiation (between 320 and 800 nm) and leaf anatomy were examined in a glasshouse plant, *Rheum nobile Hook.f. & Thomson* (Polygonaceae) to assess the function of avoiding injury by UV radiation while keeping the inflorescence warm by photosynthetically active (PA) and IR radiation.[3]
- Photosynthesis: The basal bracts are solid green leaves containing chlorophyll. These structures function as the primary photosynthetic organs, producing carbohydrates for the entire plant. Their green coloration signifies the presence of chlorophyll, essential for capturing light energy and converting it into chemical energy through photosynthesis.

Thermal Considerations

- Thermal Insulation: The overlapping, curved morphology of the bracts creates an insulating air pocket around the reproductive structures. This structural feature contributes to heat retention, acting as a thermal insulator. This is crucial in environments with fluctuating temperatures, helping to maintain a stable microclimate for optimal development. This trapped heat may also play a role in attracting pollinators, as some insects are attracted to warmer temperatures.

  These combined adaptations enable *Rheum nobile* to not only survive but also flourish in the unique environment of the Himalayas.

Morphology and Habitat

Rheum Snobile is a large perennial herb, reaching a height of 1-1.5 meters. It is native to the alpine regions of the eastern Himalayas, including Nepal, Sikkim, Arunachal Pradesh, and parts of Afghanistan, Pakistan, Bhutan, and Tibet. It thrives on skeletal soil slopes at altitudes of 4,700 to 5,500 meters. This species is well-adapted to the harsh conditions of its habitat, which include a short growing season, low temperatures, strong winds, and intense UV radiation. *R. nobile* grows as a large rosette for seven to eight years before producing a large panicle with numerous fruits in its final year (monocarpic).

R. nobile features a conical tower of delicate, straw-colored, shiny, translucent, and regularly overlapping bracts, often with a pink tinge on the upper edges. Large, glossy, green radical leaves with red petioles and veins form a broad base. Below the bracts are membranous, fragile, pink stipules, and small green flowers arranged in branched panicles. The root is often 1-2 meters long and as thick as an arm, with a bright yellow interior. After flowering, the stem elongates, and the bracts separate, turning a coarse red-brown. Bracts fall after fruit ripening, leaving the stem ragged with dark brown pendulous fruits and panicles.

Reproduction and Ecology

The reproductive ecology of alpine plants like *R. nobile* is often understudied. Despite low temperatures and limited insect pollinators during the growing season, *R. nobile* produces abundant ripe fruit, suggesting the potential for self-pollination and apomixis. Alpine species often exhibit higher ploidy levels compared to their lowland counterparts, a characteristic often associated with self-pollination and apomixis. Bracts of the plant might play an important role in normal reproduction under low temperature at high altitudes.[4]

Edibility

The stems of *R. nobile* are pleasantly acidic and are used in salads by local people, who call the plant "*Chuka*." The hollow stem contains potable water. Dried leaves are sometimes used as a tobacco substitute.

PLANT DESCRIPTION OF RHEUM NOBILE (NOBLE RHUBARB)

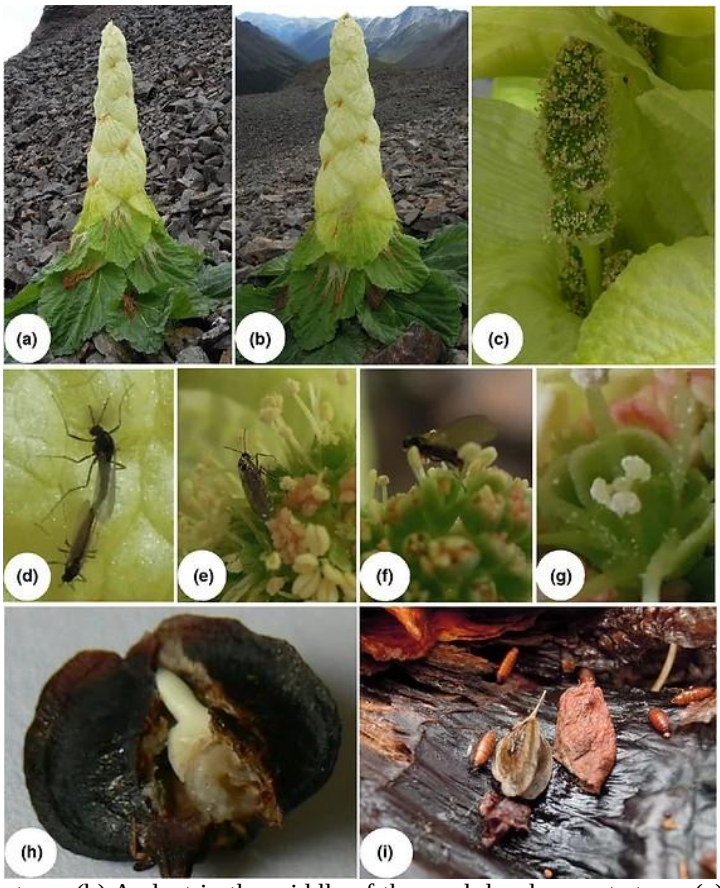
Synonyms

- **Sanskrit:** *Padhmachal, Amlaparni, Ekavira, Revandachini bheda*
- **English:** Noble Rhubarb, Sikkim Rhubarb
- **Nepali**: *Kenjo, Thulo, Padmaguru*
- **Local names**: *Chuka, Chuba (Bhutia), Sikkim Sundari*

Table 1: Taxonomic Classification.

1.	**KINGDOM**	Plantae
2.	**PHYLUM**	Tracheophyta
3.	**CLASS**	Magnoliopsida
4.	**ORDER**	Caryophyllales
5.	**FAMILY**	Polygonaceae
6.	**GENUS**	*Rheum*
7.	**SPECIES**	*Rheum nobile*

Description



(a) A plant at the anthesis stage. (b) A plant in the middle of the seed development stage. (c) A flower head concealed by bracts. (d) Female and male Bradysia sp. Mating outside the bract. (e) A female fly visiting a flower. (f) An ovipositing female fly. (g) A pollinated stigma. (h) A fruit infested by a fly larva. (i) Pupae of fly under litter. Bo Song et al., 2014.
[SOURCE- https://www.plantscience-blog.com/post/the-master-of-adaption]

Rheum nobile, commonly known as Noble Rhubarb or Sikkim Rhubarb, is a striking plant reaching up to 2 meters in height. It is characterized by its large, glossy, green radical leaves, red petioles and veins, and prominent, imbricate bracts with pale red margins.

Vegetative Characteristics

- **Roots and Rhizomes**: Thick, 7-8 cm in diameter.
- **Stem**: Erect, unbranched, glabrous, 2-3 cm in diameter. Locally known as "*chuka*," the stem has a pleasant acidity and is consumed.
- **Leaves**: **1**. **Basal Leaves**: Form a rosette, large, round, ovate, or cordate-ovate, 20-30 cm, subcoriaceous, glabrous on both surfaces. Base rounded or subcordate, margin entire, apex obtuse. Petioles stout, 5-15 cm long, glabrous, red.

2. Stem Leaves: Densely arranged, becoming smaller upwards, round, 5-13 cm.

- **Ocrea (Sheathing Stipule)**: Red, broadly lanceolate, large, 10-15 cm, glabrous on both surfaces.

Reproductive Characteristics

- **Inflorescence:** A large, branched panicle, 5-9 cm long, with 5-8 branches, sometimes with branchlets. Flowers arranged in fascicles of 5-9.
- **Flowers**: Inconspicuous, small, green.
- **Bracts:** Pale yellow, membranous when dry.
- **Pedicel**: Slender, 2-3 mm long, jointed near or slightly below the middle.
- **Tepals:** 6, connate at the base, not spreading, the inner 3 larger, yellowish-green, about 2 x 1 mm.
- **Androecium**: **Stamens:** 8-9. Filaments 3-3.5 mm long, compressed, base swollen. Anthers compressed, oblong-elliptic.
- **Gynoecium: Ovary**: Ovoid. Style short. Stigma capitate.
- **Fruit:** Broadly ovoid or ovoid, 6-7 x 5-6 mm, base rounded, apex obtuse. Wings dark brown, narrow, less than 1 mm wide, with longitudinal veins near the margin.
- **Seeds:** Blackish-brown, ovoid.

PHYTOCONSTITUENTS OF PLANT

Rheum nobile bracts are 110-170 µm thick and are not differentiated into palisade and spongy layers. The major

UV blockers found in the bracts are all quercetin flavonoids:

- Rutin, quercetin 3-O-rutinoside: Widely distributed in higher plants and previously reported in the leaves and petioles of other Rheum species.
- Guaijaverin, quercetin 3-O-arabinoside: First time reported in Rheum.
- Hyperin, quercetin 3-O-galactoside: Widely distributed in plants and previously reported in the leaves and petioles of R. rhaponticum.
- Isoquercitrin, quercetin 3-O-glucoside: Widely distributed in plants and previously reported in the leaves and petioles of R. rhaponticum.
- Quercetin 3-O-[6″-(3-hydroxy-3-methylglutaroyl)-glucoside]: Found for the first time in nature.

OTHER COMPOUNDS

Table 2: Compounds and Their Details.

S. No.	Compound	Details
1.	Oxalic acid	Slightly poisonous compound found in all parts of the plant.
2.	Malic acid	Nontoxic compound that gives the plant its tart flavor.
3.	Citric acid	Compound produced by the plant.
4.	Anthraquinone glycosides	Compound produced by the plant.

UV-absorbing substances were isolated from the translucent bracts of *Rheum nobile*, which grows in the alpine zone of the eastern Himalayas. Nine kinds of the UV-absorbing substances were found by high performance liquid chromatography (HPLC) and paper chromatography (PC) surveys. All of the five major compounds are flavonoids, and were identified as quercetin 3-O-glucoside, quercetin 3-O-galactoside, quercetin 3-O-rutinoside, quercetin 3-O-arabinoside and quercetin 3-O-[6″-(3-hydroxy-3-methylglutaroyl)-glucoside] by UV, 1H and 13C NMR, mass spectra, and acid hydrolysis of the original glycosides, and direct PC and HPLC comparisons with authentic specimens. The four minor compounds were characterised as quercetin itself, quercetin 7-O-glycoside, kaempferol glycoside and feruloyl ester. Of those compounds, quercetin 3-O-[6″-(3-hydroxy-3-methylglutaroyl)-glucoside] was found in nature for the first time. The translucent bracts of *R. nobile* accumulate a substantial quantity of flavonoids (3.3–5 mg per g dry material for the major compounds).[6]

AIM AND OBJECTIVES

This review article aims to provide a comprehensive and critical analysis of *R. nobile*, a rare and endemic plant species. It synthesizes existing research on the plant's taxonomy, morphology, distribution, ecology, phytochemistry, traditional uses, and reported pharmacological activities, critically evaluating previous studies' methodologies and findings of previous studies. The review will identify key knowledge gaps and suggest future research directions to fully understand *R. nobile's* properties, applications, and ecological role. The article will assess its conservation status and analyze threats to its survival, such as habitat loss, while also exploring current conservation efforts and proposing protection strategies. Furthermore, it will explore *R. nobile's* potential applications in fields like medicine critically assessing supporting evidence. This review will serve as a valuable resource for researchers, conservationists, and anyone who is interested in this plant. The main focus of this article is to promote future research and conservation initiatives on this remarkable species.

METHOD AND MATERIALS

This review on *Rheum nobil* (Giant Rhubarb) utilized a systematic literature search across PubMed, Scopus, Web of Science, Google Scholar, and Science Direct. The search strategy combined keywords and phrases such as *"Rheum nobil,"* "Giant rhubarb," "Rheum species," and specific phytochemicals (e.g., "anthraquinones," "polyphenols") with terms like "phytochemistry," "pharmacology," "traditional medicine," "ethnobotany," and "biological activity." Boolean operators (AND, OR, NOT) and wildcard characters (*) were used for refined results.

Inclusion criteria encompassed peer-reviewed journal articles, original research (experimental studies, clinical trials, phytochemical analyses), review articles, and book chapters in English (with consideration for key non-English publications). Studies focusing specifically on *R. nobil* or relevant Rheum species were included.

Exclusion criteria excluded abstracts, conference proceedings, unpublished data (unless crucial), studies solely on other Rheum species irrelevant to *R. nobil*, duplicates, and studies lacking original data or sufficient detail.

RESULT

Sikkim Rhubarb (*Rheum nobile*) is a unique alpine plant found in the high Himalayas. Its distinctive transparent bracts and traditional medicinal uses make it a subject of interest for both horticulture and scientific research. However, conservation efforts are crucial due to threats from overgrazing and harvesting.

Traditional Uses and Medicinal Properties

R. nobile has a history of use in traditional medicine. In Nepal, the root extract is used orally for pain,

inflammation, digestive issues, arthritis, and bone fractures. It's also used as a tonic, purgative, astringent, diuretic, depurative, and carminative. Small doses are believed to have astringent and tonic effects on the digestive system, while larger doses act as a mild laxative. The sour-tasting flowering stem is considered to have a "hot potency" and is used as a laxative, diuretic, antiemetic, and for abdominal fullness, swelling, and fluid retention.

Scientific Research

- Adaptation to High Altitude: A cDNA-AFLP analysis identified differentially expressed genes in *R. nobile* bracts compared to normal leaves. Down-regulation of photosynthesis-related genes may be crucial for bract development and adaptation to the alpine environment. The transparent bracts are thought to protect the inflorescences in cold conditions, ensuring successful reproduction. Further research on these genes could provide valuable insights into high-altitude adaptation mechanisms.
- Phytochemical Analysis: Preliminary phytochemical analysis of methanolic extracts has revealed the presence of alkaloids, flavonoids, tannins, phenols, steroids, phlobatannins, saponins, anthraquinones, glycosides, and carbohydrates. Terpenoids and proteins were not detected.
- Preliminary Phytochemical Analysis of *R. nobile* Methanol Extracts.[7] Research shows presence of alkaloids flavonoids, tannins, phenols, steroids, phlobatannins, saponins etc.
- Potential Benefits and Safety Concerns: While research specifically on *R. nobile* is limited, studies on other Rheum species suggest potential antioxidant, anti-inflammatory, and laxative properties. However, more research is needed to confirm these effects and establish safety and efficacy. Rheum species contain oxalic acid, which can be toxic in large amounts, potentially affecting mineral absorption. Cooking can reduce oxalic acid content. Individuals with rheumatism, arthritis, gout, kidney stones, or hyperacidity should exercise caution when consuming this plant.

DISCUSSION

Some scientific research details about its genome

The genome of *Rheum nobile* has been the subject of several studies, providing valuable insights into its adaptation to high-altitude environments. Key findings:

- Complete Chloroplast Genome: The complete chloroplast genome of *R. nobile* has been sequenced. This circular molecule spans 161,250 base pairs and encodes 127 genes, comprising 82 protein-coding genes, 35 transfer RNA (tRNA) genes, and 8 ribosomal RNA (rRNA) genes. The sequence data is crucial for understanding the plant's phylogenetic relationships and evolutionary history.[8]
- Transcriptome Analysis: Transcriptomic studies of *R. nobile* have revealed the genes actively expressed in its cells. Some research have identified candidate genes potentially involved in high-altitude adaptation, such as those related to UV protection, DNA repair, and photosynthesis.
- Bract Transcriptome Analysis: A more focused study examined the transcriptome of the specialized bracts of *R. nobile*. These bracts play a critical role in protecting the flowers, functioning similarly to a greenhouse.
- Genome-Scale Transcriptome Analysis: The researchers found that the bracts have a distinct set of genes that are highly expressed compared to the regular leaves of the plant. These genes are involved in processes like:

1. Secondary cell wall biogenesis: This contributes to the structural integrity and translucency of the bracts.
2. Cuticular cutin biosynthesis: This helps to create a waxy layer on the bracts, protecting them from water loss and UV radiation.
3. Suppression of photosynthesis and terpenoid biosynthesis: This suggests that the bracts are not primarily focused on photosynthesis, but rather on protection and heat retention.

The study also revealed that the "glasshouse syndrome" has evolved independently multiple times within the Rheum genus. This means that different species of Rheum have independently developed similar adaptations to cope with the harsh alpine environment.

Cultivation

- Temperature: *R. nobile* thrives in cool temperatures ranging from 0-32°C.
- Water: Consistent moisture is essential. Weekly watering, ensuring well-drained soil, is recommended. The plant's thick leaves provide some drought tolerance.
- Fertilizer: A balanced fertilizer should be applied monthly during the spring and summer growing seasons. During dormancy, bi-monthly applications at half strength are sufficient. Monitor plant response and adjust fertilization accordingly.
- Pruning: Prune in early to late spring, removing dead stems and spent flower stalks. This promotes healthy growth and improves plant structure.
- Propagation: Propagate from seed. Mix ripe seeds with sand or perlite in well-drained soil. Maintain moderate moisture and cool temperatures for germination, avoiding waterlogging.

Conservation

A significant threat to this species is grazing and collection by local herders for pickle making. Conservation efforts are needed to protect this unique and valuable plant in its native habitat.

CONCLUSION

Rheum nobil, a unique alpine plant with a history of traditional medicinal use, holds significant potential for

future research and applications. While its traditional uses in treating digestive issues, inflammation, and fluid retention are documented, further scientific investigation is crucial to validate these claims and elucidate the specific mechanisms of action. Phytochemical analysis has revealed the presence of various bioactive compounds, including anthraquinones, flavonoids, and tannins, which may contribute to its therapeutic properties.

Future research directions should focus on:

- In-depth pharmacological studies: Investigating the efficacy and safety of *R. nobil* extracts in preclinical and clinical settings, particularly for its potential anti-inflammatory, antioxidant, and anti-cancer properties.
- Mechanism of action elucidation: Identifying the specific molecular targets and pathways through which *R. nobil* exerts its therapeutic effects.
- Standardization of extracts: Developing standardized extraction and purification methods to ensure consistent quality and potency of *R. nobil*-based products.
- Sustainable harvesting and conservation: Implementing sustainable harvesting practices to conserve this valuable species and prevent overexploitation.
- Employing techniques such as transcriptomics, proteomics, and metabolomics could elucidate the molecular basis of its adaptations.

Addressing these research gaps, we can unlock the full therapeutic potential of *Rheum nobil* and develop novel, evidence-based applications for human health.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

FUNDINGS DETAILS

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

DATA SOURCES

The data source is a combination of Peer-reviewed scientific literature.

ETHICAL CONSIDERATIONS

This study involved the analysis of publicly available data. Therefore, ethical approval and informed consent were not required.

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