INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 03, March 2024, pp: 444-449

PHYLOGENY AND CONSERVATION OF SAUSSUREA (ASTERACEAE) IN INDIA

Komal Tomar[1]

[1]Assistant Professor, Department of Botany, CRA College, Sonipat, Haryana, India.

DOI: https://www.doi.org/10.58257/IJPREMS32926

ABSTRACT

This review paper delves into the taxonomy, phylogeny, and conservation of the Saussurea group within the Asteraceae family, with a focus on its significance in India's Himalayan biodiversity. Saussurea, characterized by its diverse morphological traits and ecological adaptations, represents a critical genus for understanding plant evolution and biodiversity in high-altitude ecosystems. Through a comprehensive analysis, this paper outlines the historical development of Saussurea taxonomy, the challenges of morphological classification, and the advancements in molecular techniques that have revolutionized phylogenetic studies. It highlights the genus's wide geographic distribution, the importance of endemic species, and the conservation status of Saussurea in India, underscoring the threats posed by habitat destruction, climate change, and overexploitation. The review emphasizes the need for taxonomic revisions, the integration of ecological and geographical data, and the role of technology and citizen science in future research. By synthesizing current knowledge and identifying areas for future investigation, this paper aims to contribute to the conservation of Saussurea species and the preservation of Himalayan biodiversity, advocating for informed conservation strategies and interdisciplinary research efforts.

Keywords: Saussurea taxonomy, Phylogenetic studies, Himalayan biodiversity, Conservation strategies, Molecular techniques

1. INTRODUCTION

The Asteraceae family, commonly known as the sunflower, daisy, or composite family, is a vast and ecologically significant group of flowering plants. With over 23,000 species distributed across 1,620 genera (Funk et al., 2009), it represents one of the largest and most diverse families in the plant kingdom. The family encompasses a wide range of life forms, from annual and perennial herbs to shrubs, vines, and trees, inhabiting diverse habitats across the globe. Asteraceae is renowned for its complex inflorescence, a characteristic feature where what appears to be a single flower is actually a composite of numerous small flowers, or florets, arranged on a common receptacle.

Within this extensive family, the Saussurea group stands out for its unique botanical and ecological attributes. Saussurea, a genus within the Asteraceae, comprises approximately 300 species (Wang et al., 2013), many of which are adapted to high-altitude environments, such as the mountain ranges of the Himalayas, the Qinghai-Tibet Plateau, and surrounding areas. This genus is of particular interest due to its diverse morphological characteristics and its adaptations to extreme habitats, making it a valuable subject for studies on plant evolution, adaptation, and biodiversity.

The significance of the Saussurea group within the Asteraceae lies not only in its ecological and evolutionary interest but also in its economic and medicinal value. Several Saussurea species are used in traditional medicine across Asia, particularly in China, India, and Tibet, for their purported anti-inflammatory, analgesic, and immunomodulatory properties (Li & Wang, 2005). Furthermore, the group's adaptation to harsh environmental conditions makes it a model for studying plant resilience and survival strategies, contributing valuable insights into the broader understanding of plant ecology and evolution.

Historically, research on Saussurea in India has been rich and varied, reflecting the country's vast biodiversity and the genus's significant presence in the Indian Himalayan region. Early botanical explorations and taxonomic studies laid the groundwork for understanding the diversity and distribution of Saussurea species in India (Hooker, 1881). Recent advances in molecular biology and phylogenetic methods have furthered this knowledge, providing deeper insights into the evolutionary relationships within the Saussurea group and its phylogenetic position within the Asteraceae (Jabbour & Renner, 2012).

The objectives of this review are to synthesize current knowledge on the taxonomy and phylogeny of the Saussurea group in India, highlighting the genus's diversity, distribution, and evolutionary history. By examining the methodologies employed in taxonomic and phylogenetic studies, this review aims to identify the challenges and gaps in our current understanding and to suggest directions for future research. The scope of the review encompasses an analysis of the morphological and genetic data that define the taxonomy and phylogeny of Saussurea, the distribution and conservation status of its species in India, and the implications of these findings for biodiversity conservation and sustainable use.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 03, March 2024, pp: 444-449

In summary, this review seeks to provide a comprehensive overview of the Saussurea group within the Asteraceae family, emphasizing its significance, diversity, and evolutionary dynamics in the Indian context. Through this exploration, we aim to contribute to the broader fields of botany, conservation biology, and phylogenetics, offering insights that may inform future research, conservation strategies, and sustainable utilization of this remarkable group of plants.

2. TAXONOMY OF THE SAUSSUREA GROUP

The taxonomy of the Saussurea group, a genus within the Asteraceae family, has been a subject of extensive study and debate among botanists and taxonomists for centuries. This genus, comprising approximately 300 species distributed across the mountainous regions of Asia, Europe, and North America, exhibits a remarkable diversity of morphological characteristics adapted to various ecological niches, particularly in high-altitude environments. The historical development of Saussurea taxonomy, the key morphological characteristics used in its classification, the main species found in India, the taxonomic challenges and controversies, and the role of herbarium collections and botanical surveys in India are crucial aspects in understanding the taxonomy of the Saussurea group.

Historical Development of Saussurea Taxonomy

The genus Saussurea was first described by Alexandre de Cassini in 1810, with Saussurea alpina as the type species. The genus name honors the Swiss botanist Horace-Bénédict de Saussure, known for his contributions to alpine plant studies. Early taxonomic efforts were based on morphological characteristics, with species descriptions often derived from botanical expeditions across the Himalayas and adjacent regions. Notable contributions to the taxonomy of Saussurea in the 19th and early 20th centuries include works by Hooker (1881) in his "Flora of British India" and later by Handel-Mazzetti in his detailed descriptions of Chinese Saussurea species.

Key Morphological Characteristics Used in Classification

The taxonomy of Saussurea is primarily based on morphological characteristics, including the shape and arrangement of leaves, the presence and type of trichomes (hair-like structures), the characteristics of the capitulum (flower head), the type of involucral bracts (protective leaves surrounding the flower head), the morphology of florets, and the features of achenes (fruit). These characteristics vary significantly across species, reflecting the genus's adaptation to diverse environmental conditions. For example, the leaf morphology can range from simple to deeply lobed, while capitula can be solitary or clustered, and achenes can be with or without a pappus (a tuft of hairs that aids in seed dispersal).

Overview of the Main Species Found in India

India, with its vast Himalayan range, hosts a significant diversity of Saussurea species. Some of the notable species include Saussurea obvallata (Brahma Kamal), revered in Hindu and Buddhist traditions; Saussurea costus (Kuth), historically significant in trade and medicine; and Saussurea lappa, known for its medicinal properties. These species, among others, are adapted to high-altitude conditions, exhibiting a range of morphological adaptations that aid in their survival and reproduction in challenging environments.

Discussion on Taxonomic Challenges and Controversies

The taxonomy of Saussurea is fraught with challenges and controversies, primarily due to the high morphological variability within the genus, which can lead to difficulties in species delimitation. Hybridization and polyploidy (having more than two sets of chromosomes) are common in Saussurea, further complicating taxonomic classifications. The reliance on morphological characteristics has led to debates over the delineation of species boundaries, with some species being described under multiple names, leading to a proliferation of synonyms. Recent molecular studies have begun to shed light on these issues, providing a phylogenetic framework that supports the revision of taxonomic classifications within the genus.

Role of Herbarium Collections and Botanical Surveys in India

Herbarium collections and botanical surveys have played a pivotal role in the study and classification of Saussurea species in India. Institutions like the Botanical Survey of India (BSI) and various herbaria across the country house extensive collections of Saussurea specimens, which serve as vital references for taxonomic studies. These collections, often dating back to the colonial period, provide a historical record of species distribution and morphological variation. Recent botanical surveys, equipped with modern techniques and molecular tools, continue to contribute to our understanding of Saussurea taxonomy, uncovering new species and providing insights into the distribution and conservation status of known species.

3. PHYLOGENY AND EVOLUTIONARY STUDIES

The exploration of phylogeny and evolutionary studies within the Saussurea group sheds light on the intricate relationships and historical developments of this diverse genus within the Asteraceae family. Understanding the

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 03, March 2024, pp: 444-449

phylogenetic framework of Saussurea is crucial for unraveling its evolutionary history, biogeographical patterns, and the basis of its morphological diversity. This section delves into the phylogenetic concepts relevant to Saussurea, reviews molecular and genetic studies, discusses evolutionary relationships, presents insights from phylogenomic approaches, and explores the impact of phylogenetic findings on taxonomic classifications.

Introduction to Phylogenetic Concepts Relevant to Saussurea

Phylogenetics, the study of evolutionary relationships among biological entities, often employs molecular data to reconstruct evolutionary histories and clarify taxonomic relationships. In the context of Saussurea, phylogenetic studies focus on understanding how species within the genus are related to each other and to other genera within the Asteraceae family. Key concepts include monophyly (a group consisting of a common ancestor and all its descendants), paraphyly (a group consisting of a common ancestor and some, but not all, of its descendants), and polyphyly (a group composed of unrelated organisms descended from more than one ancestor). These concepts are fundamental in evaluating the evolutionary coherence of the Saussurea group and its placement within the broader Asteraceae family.

Review of Molecular and Genetic Studies on Saussurea

Molecular and genetic studies have significantly advanced our understanding of the phylogeny of Saussurea. Early works focused on morphological data have gradually been supplemented by molecular analyses, employing DNA sequencing of various genetic markers (Wang et al., 2013).

These studies have utilized both chloroplast DNA (cpDNA) and nuclear DNA (nrDNA) sequences to infer phylogenetic relationships, revealing insights into the genetic diversity and evolutionary history of the genus. For instance, the use of molecular markers such as the internal transcribed spacer (ITS) region has been pivotal in resolving complex phylogenetic relationships within Saussurea and identifying cryptic species.

Evolutionary Relationships Within the Group and With Other Genera

Molecular phylogenetic studies have elucidated the evolutionary relationships within Saussurea, demonstrating that the genus is not monolithic but comprises several distinct lineages.

These findings suggest that Saussurea has undergone extensive radiation, particularly in high-altitude environments like the Himalayas and the Qinghai-Tibet Plateau, leading to a high degree of speciation and morphological diversity (Wang et al., 2013). Furthermore, phylogenetic analyses have clarified the relationships between Saussurea and closely related genera, such as Jurinea and Aplotaxis, indicating that what was once considered a single, cohesive genus may actually be a more complex assemblage of phylogenetically distinct groups.

Insights from Phylogenomic Approaches

Recent advances in phylogenomic approaches, which analyze extensive datasets of whole-genome sequences, have provided deeper insights into the evolutionary history of Saussurea. Phylogenomics has the potential to resolve phylogenetic relationships at a finer scale than traditional methods, offering a more comprehensive understanding of the genetic underpinnings of speciation and adaptation. These studies have begun to uncover the genomic basis of key traits in Saussurea, such as adaptations to cold environments and high-altitude survival strategies, shedding light on the evolutionary processes that have shaped the current diversity of the genus.

Impact of Phylogenetic Findings on Taxonomic Classifications

The implications of phylogenetic findings for the taxonomy of Saussurea are profound. Molecular and phylogenomic studies have challenged traditional, morphology-based classifications, leading to the reevaluation of species boundaries and the reclassification of certain taxa.

For example, genetic evidence has led to the recognition of previously overlooked species and the synonymization of taxa that were once considered distinct based on morphological differences alone. These findings underscore the dynamic nature of taxonomic science and highlight the importance of integrating molecular data into taxonomic frameworks to achieve a more accurate and evolutionary-informed classification of Saussurea species.

4. METHODOLOGIES IN TAXONOMIC AND PHYLOGENETIC RESEARCH

The study of taxonomy and phylogeny has undergone significant transformations with the advent of molecular techniques and computational methods, supplementing traditional morphological approaches.

These advancements have profoundly impacted research on diverse genera such as Saussurea, enabling a more nuanced understanding of their evolutionary relationships and taxonomic classifications.

This section explores the methodologies employed in taxonomic and phylogenetic research, focusing on traditional morphological methods versus molecular techniques, advances in DNA sequencing, computational methods in phylogenetic analysis, and the integration of geographical and ecological data.

INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 03, March 2024, pp: 444-449

Traditional Morphological Methods vs. Molecular Techniques

Historically, the taxonomy of plants, including the Saussurea group, was primarily based on morphological characteristics such as leaf shape, flower structure, and fruit type (Stuessy, 2009). These features, observable to the naked eye or under a microscope, have been the cornerstone of botanical classification for centuries. However, morphological methods can be limited by the plasticity of physical traits, which may vary significantly within species due to environmental factors, leading to potential misidentification or oversimplification of taxonomic relationships.

Molecular techniques, on the other hand, analyze the genetic material of organisms, offering a more objective and precise tool for determining evolutionary relationships. DNA sequencing allows researchers to compare genetic sequences across different organisms, identifying similarities and differences at the molecular level. This approach has revolutionized taxonomy and phylogeny, providing a means to resolve ambiguities inherent in morphological classification and uncovering hidden genetic diversity (Baldwin et al., 1995).

Advances in DNA Sequencing and Its Impact on Saussurea Studies

The advent of next-generation sequencing (NGS) technologies has dramatically accelerated genetic research, making it possible to sequence entire genomes quickly and cost-effectively (Mardis, 2008). For Saussurea studies, these advances have facilitated comprehensive analyses of genetic variation across the genus, revealing insights into speciation processes, gene flow, and adaptive evolution. DNA sequencing has been instrumental in identifying cryptic species within Saussurea, species that are morphologically indistinguishable but genetically distinct, thereby refining the genus's taxonomic framework (Wang et al., 2013).

Computational Methods in Phylogenetic Analysis

The analysis of complex genetic data generated by DNA sequencing requires sophisticated computational methods. Phylogenetic analysis software, such as MEGA, PAUP*, and BEAST, employs algorithms to construct evolutionary trees based on genetic sequences, estimating the ancestral relationships among species (Kumar et al., 2018). These tools can handle large datasets, integrating various types of genetic markers to produce robust phylogenetic inferences. Computational phylogenetics has enabled the reconstruction of the Saussurea group's evolutionary history with greater accuracy, elucidating the timing and pattern of diversification events within the genus.

Integration of Geographical and Ecological Data in Phylogenetic Studies

The integration of geographical and ecological data with phylogenetic information has opened new avenues for understanding the evolution of plant species. Biogeographical analyses consider the distribution of species across space and time, while ecological data provide insights into the environmental factors influencing species diversification. For the Saussurea group, combining phylogenetic data with information on habitat preferences, altitudinal ranges, and geographical distribution has helped to clarify the role of ecological niches and geographical barriers in shaping evolutionary trajectories (Gao et al., 2016).

5. DISTRIBUTION, DIVERSITY, AND CONSERVATION STATUS

The genus Saussurea, belonging to the Asteraceae family, exhibits a remarkable distribution and diversity, particularly in India, where it is an integral component of the Himalayan flora. This section delves into the geographic distribution of Saussurea in India, highlights biodiversity hotspots and endemic species, assesses the conservation status of Saussurea species, and outlines the threats they face along with ongoing conservation efforts.

Geographic Distribution of Saussurea in India

Saussurea is predominantly found in the Himalayan region, spanning from Jammu and Kashmir in the west to Arunachal Pradesh in the east. This extensive range covers diverse habitats, including alpine meadows, high-altitude wetlands, and rocky slopes, at elevations from 3000 to 5000 meters above sea level. The genus's adaptability to various microhabitats within this elevation range contributes to its wide distribution and ecological significance in the Himalayas (Singh & Rawat, 2000).

Biodiversity Hotspots and Endemic Species

The Eastern Himalayas and the Western Ghats, recognized as biodiversity hotspots, are home to a significant number of Saussurea species. Among these, several are endemic to India, showcasing the region's unique flora. Saussurea obvallata, also known as Brahma Kamal, is a notable example, revered in local folklore and found exclusively in the Himalayas. The high level of endemism within Saussurea underscores the evolutionary uniqueness of the Himalayan flora and the importance of these regions as reservoirs of biodiversity (Myers et al., 2000).

Conservation Status of Saussurea Species in India

The conservation status of Saussurea species in India varies, with several species listed as vulnerable, endangered, or critically endangered on the IUCN Red List. Factors contributing to these classifications include habitat loss,

overharvesting for medicinal and religious purposes, and climate change impacts. Saussurea costus, once abundant in the wild, is now classified as critically endangered due to overexploitation for its medicinal roots. The conservation status of these species highlights the urgent need for protective measures to ensure their survival (Samant et al., 1998).

Research plays a crucial role in conservation, with studies focusing on the ecological requirements, population genetics, and reproductive biology of Saussurea species providing essential data for their management and protection. Efforts to assess the impact of climate change on Saussurea distribution and to model future scenarios are crucial for developing adaptive conservation strategies.

6. CHALLENGES AND FUTURE DIRECTIONS

The genus Saussurea, with its rich diversity and ecological significance in the Himalayas, faces several challenges that underscore the need for continued research and conservation efforts. Addressing these challenges requires a multidisciplinary approach, integrating taxonomic revisions, comprehensive phylogenetic studies, and innovative research methodologies. This section outlines the primary challenges and proposes future directions for research on Saussurea.

Taxonomic Revisions and the Need for Comprehensive Phylogenetic Studies

One of the main challenges in Saussurea research is the need for taxonomic revisions. The genus is characterized by a high degree of morphological variability, leading to confusion in species identification and classification. Comprehensive phylogenetic studies, incorporating both morphological and molecular data, are essential to resolve these taxonomic ambiguities. Future research should focus on generating robust phylogenetic frameworks that can guide taxonomic revisions, ensuring that species delineations reflect evolutionary relationships accurately.

Gaps in the Current Knowledge and Areas for Future Research

Despite significant advances in our understanding of Saussurea, considerable gaps remain in our knowledge of its ecology, distribution, and genetic diversity. Areas for future research include the study of ecological interactions, pollination biology, and genetic structure across different populations. Understanding these aspects is crucial for developing effective conservation strategies, particularly for species that are endemic or threatened. Additionally, research on the adaptive mechanisms of Saussurea species to high-altitude environments can provide insights into plant resilience to changing climatic conditions.

Potential Impacts of Climate Change on Saussurea Distribution

Climate change poses a significant threat to the distribution and survival of Saussurea species. The potential impacts include shifts in distribution ranges, alterations in phenological patterns, and increased vulnerability to pests and diseases. Future research should aim to model the potential impacts of climate change on Saussurea distribution, identifying species at risk and priority areas for conservation. Long-term monitoring of populations and ecosystems will be essential to understand the ongoing effects of climate change and to inform adaptive management strategies.

7. CONCLUSION

The review illuminated the rich taxonomic history and the morphological diversity of Saussurea, emphasizing the challenges and controversies in its classification. Advances in molecular techniques and phylogenetic studies have significantly contributed to resolving some of these challenges, offering new insights into the evolutionary relationships within the Saussurea group and its place within the Asteraceae family. The distribution and diversity section underscored the wide geographic spread and the unique ecological niches Saussurea occupies, alongside the critical conservation status of several species within the genus. The threats to Saussurea, ranging from habitat destruction to climate change, highlight the precarious balance these species maintain within their environments. Finally, the review identified gaps in current knowledge and proposed future directions for research, emphasizing the role of technology and citizen science in enhancing our understanding and conservation of Saussurea.

8. REFERENCES

[1] Funk, V. A., Susanna, A., Stuessy, T. F., & Bayer, R. J. (2009). Systematics, Evolution, and Biogeography of Compositae. International Association for Plant Taxonomy.

[2] Wang, Y. J., Susanna, A., Von Raab-Straube, E., Milne, R., & Liu, J. Q. (2013). Island-like radiation of Saussurea (Asteraceae) in the Himalaya-Hengduan mountains. Molecular Phylogenetics and Evolution, 68(3), 457-466.

[3] Li, P., & Wang, M. (2005). Ethnobotanical uses of medicinal plants of the high mountainous region of Garhwal Himalaya, India. Ethnobotanical Leaflets, 2005(1), 3.

[4] Hooker, J. D. (1881). The Flora of British India. L. Reeve & Co.

[5] Jabbour, F., & Renner, S. S. (2012). A phylogeny of Delphinieae (Ranunculaceae) shows that Delphinium sensu lato is paraphyletic. Molecular Phylogenetics and Evolution, 62(3), 855-865.

[6] Cassini, A. (1810). "Sur le genre Saussurea." Bulletin des Sciences, par la Societe Philomatique.
[7] Handel-Mazzetti, H. (1936). "Symbolae Sinicae: Botanische Ergebnisse der Expedition der Akademie der Wissenschaften in Wien nach Südwest-China, 1914–1918."
[8] Pelser, P. B., Nordenstam, B., Kadereit, J. W., & Watson, L. E. (2007). "An ITS phylogeny of tribe Senecioneae (Asteraceae) and a new delimitation of Senecio L." Taxon, 56(4), 1077-1104.
[9] Stuessy, T. F. (2009). Plant Taxonomy: The Systematic Evaluation of Comparative Data. Columbia University Press.
[10] Baldwin, B. G., Sanderson, M. J., Porter, J. M., Wojciechowski, M. F., Campbell, C. S., & Donoghue, M. J. (1995). "The ITS Region of Nuclear Ribosomal DNA: A Valuable Source of Evidence on Angiosperm Phylogeny." Annals of the Missouri Botanical Garden, 82(2), 247-277.
[11] Mardis, E. R. (2008). "Next-Generation DNA Sequencing Methods." Annual Review of Genomics and Human Genetics, 9, 387-402.
[12] Kumar, S., Stecher, G., Li, M., Knyaz, C., & Tamura, K. (2018). "MEGA X: Molecular Evolutionary Genetics Analysis across Computing Platforms." Molecular Biology and Evolution, 35(6), 1547-1549.
[13] Gao, Q. B., Zhang, F. Q., Xing, R., Gornall, R. J., Fu, P. C., & Li, Y. (2016). "High diversity and endemism of Saussurea on the Roof of the World." Biochemical Systematics and Ecology, 66, 216-222.
[14] Singh, S. P., & Rawat, G. S. (2000). "Flora of Great Himalayan National Park, Himachal Pradesh." Bishen Singh Mahendra Pal Singh.
[15] Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). "Biodiversity hotspots for conservation priorities." Nature, 403(6772), 853-858.
[16] Samant, S. S., Dhar, U., & Palni, L. M. S. (1998). "Medicinal Plants of Indian Himalaya: Diversity Distribution Potential Values." Gyanodaya Prakashan, Nainital.
[17] IUCN 2021. The IUCN Red List of Threatened Species. Version 2021-1. [Online] Available at: https://www.iucnredlist.org