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Review Article

Diversity and Medicinal Significance of the Genus Pinanga: A Review of Taxonomic and Pharmacological Studies

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Abstract

Palms are an important group of plants that grow in tropical and subtropical areas. They are not only significant for their beauty but also play a key role in providing food and raw materials for the economy. In 1839, a scientist named Blume introduced the genus *Pinanga*. While he described some new species, *P. schwanerensis* was described much later, and the precise timing of his descriptions of *P. patula*, *P. salicifolia*, and *P. albescens* in relation to the genus introduction is unclear from the available evidence. Later, more species, such as *P. arinasae*, *P. javana*, *P. leonardcoi*, and *P. coronata*, along with *P. lepidota*, *P. salicifolia, P. mirabilis, P. chaiana*, and *P. veitchii*, were added. There are also other species, such as *P. gruezoi, P. samarana, P. limosa, P. riparia* Ridley, *P. auriculata* Becc. var. *merguensis* Becc. and a new variety, *P. auriculata* Becc. var. *leucocarpa* and *P. nuichuensis*. These species grow in various places, such as Java, montane forests, and on islands such as Samar, Bucas Grande, Dinagat, and northeastern Mindanao in the Philippines, Vietnam, Malaysia, and many other parts of the world. In India, five species of *Pinanga*—*P. dicksonii, P. gracilis, P. griffithii, P. manii*, and *P. sylvestris*—exist, of which *P. dicksonii* and *P. manii* occur only in this region and are thus endemic to the region. A review article studied the karyomorphology of *Pinanga* species in Java and Bali, such as *P. arinasae, P. javana*, and *P. coronata*, and explored how their physical features and molecular characteristics are related. The present review further examines the complete chloroplast genome of the rare endemic species P. arinasae. Cytotoxic activity has also been reported for P. limosa, which is commonly referred to as P. puteri. In addition, microsatellite-based investigations have provided information on the molecular diversity of wild P. dicksonii (Roxb.) Blume populations occurring in the Western Ghats of Karnataka. Traditional uses and scientific studies highlight *Pinanga* as one of the most widely used genera in certain regions. Researchers have focused on identifying new species within this genus, underscoring its importance as a medicinal plant. This review provides an updated overview of the taxonomy and pharmacological aspects of the *Pinanga* genus.

Keywords

Pinanga, Arecaceae, Taxonomy, Distribution, Pharmacological Studies, *P. Dicksonii*, *P. Arinasae*

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1. Introduction

Palms belong to the family Arecaceae (also known as Palmae) and represent one of the dominant and ecologically important groups of plants in tropical rainforest ecosystems. Numerous studies have highlighted their importance, including the work of Dransfield et al. [7], who described them as among the oldest surviving groups of monocotyledonous plants. This means that they have been around for a long time, having started to diversify in tropical rainforest-like biomes during the mid-Cretaceous period [4, 43]. Palms are prevalent in humid tropical and subtropical regions globally, particularly in rainforests and swamplands, although certain groups, such as Phoeniceae, are also adapted to semi-arid climates [15, 31]. In dense tropical forests, palms often form either large areas where one species dominates or diverse communities with many different types of palm species growing together [36, 38].

The palm genus *Pinanga* Blume, which comprises 40 species, has spread widely throughout Borneo [42]. However, little is known about the distribution of several Bornean species; only their classification is known. Five *Pinanga* species are known to exist in India: *P. dicksonii, P. gracilis, P. griffithii, P. manii*, and *P. sylvestris*. Of these, two species, *P. dicksonii* and *P. manii*, are endemic [23, 37]. The *Pinanga* diversity of Borneo has not received much attention recently. *P. jambusana* [17], *P. limbangensis* [17], *P. schwanerensis* Randi, Hikmat & Heatubun, and others, such as *P. salicifolia* and *P. albescens* have been described from Borneo in the twenty-first century, despite the fact that there are numerous unnamed taxa [30].

Tropical Asia is home to palms in the genus *Pinanga* [1], many of which have historically been utilized for local medicines, food, or material purposes. There are few scientific investigations on the pharmacology and phytochemistry of *Pinanga* species. Here, all available research on the bioactivity or phytochemical composition of *Pinanga* spp. is reviewed, together with the names and years of the authors, summarizing current knowledge, outlining its limitations, and suggesting future lines of inquiry. *P. arinasae* is an endangered species native to Bali, Indonesia. In a tropical montane rainforest on Mount Halimun in West Java, Indonesia, we investigated the allometry and life history of understory palm *P. coronate*. Native to South Asia, *P. dicksonii* is a slender, clustered understory palm prized for its aesthetic and ecological qualities. In this review, we have compiled information on its taxonomy, morphology, distribution, ecology, cultivation, ethnobotanical uses, and conservation status. This review also identifies significant information gaps and recommends areas of focus for future studies and conservation efforts.

Among the numerous genera within this family, Pinanga Blume (1838) is recognized as one of the most species-rich genera [9, 30, 35]. Arecaceae trees, shrubs, and climbers are tenacious [21]. *Pinanga* can grow in various ways, such as shrubs, tree-like plants, or plants without stems [5]. The genus displays considerable morphological diversity, with variations in plant size, growth form, stem colour, crownshaft, leaf morphology, and pollen characteristics (Randi et al. [30]). In addition, Pinanga species can be distinguished from other palm genera by the entire margins of their leaves or leaflets, together with their characteristic inflorescences, floral arrangement, and fruit morphology [2].Because each species usually prefers a particular environment, *Pinanga* species occupy a broad range of ecological environments, reflecting their adaptability to different habitat conditions [6, 8]. For example, *P. javana* Blume is commonly associated with hilly and sloping terrain (Zulkarnaen et al. [44]), whereas P. simplicifrons (Miq.) Becc. occurs primarily in shaded, swamp-associated habitats (Ang et al. [2]).Certain *Pinanga* species [8, 34]). *Pinanga* palms are frequently used as tools and food supplies by local populations. Traditional uses of Pinanga species include both food and practical applications. The fruits of *P. patula* Blume var. microcarpa Becc. are traditionally consumed together with betel, while the stalks of *P. auriculata* Becc. have been used in the construction of fish traps [11, 14].The leaves, fruits, and stems of *P. arinasae* Witono, locally referred to as Nyabah or Jabah, are significant in Balinese culture in Bali, Indonesia [33]. *P. arinasae* for ornamental purposes by the local population [33, 35]. For example, the leaf sheath of *P. arinasae* is used to make traditional umbrellas known as "Cukup" [33]. Although its effectiveness needs to be confirmed, the extract from *P. limosa* Ridl. It may have anticancer properties [21].

Figure 1. *Morphological Diversity of Selected Pinanga Species.*

2. Distribution of Pinanga Species

At present, there are 143 species of *Pinanga* known in the world [42]. *Pinanga* usually exhibits high species diversity and notable levels of endemism in Southeast Asian tropical rainforests [1]. Southeast Asia is the global center of *Pinanga* diversity [1]. These variations in *Pinanga* species richness throughout Southeast Asian nations are partially due to the greater sampling and research efforts in Indonesia and Malaysia than in nations such as Timor-Leste, Cambodia & Laos [20, 28, 29].

Pinanga palms have been found throughout Southeast Asia over the last ten years, as research on palm communities has drawn more attention [2, 8, 19 18, 35, 30]. *P. simplicifrons*, which was previously thought to be extinct in Singapore, was rediscovered by Ang *et al*., [2]. In Singapore, *P. simplicifrons* was also found close to the Lornie Trail on the outskirts of the MacRitchie Reservoir [16]. Although *P. simplicifrons* is not listed on the IUCN Red List [14], it has been classified as "critically endangered" in Singapore because of rediscoveries in particular areas [2, 16, 18]. *P. chaiana* J. Dransf., *P. crassipes* Becc., and *P. jambusana* C. K. Lim were discovered strewn along paths in this national park, whereas the *Pinanga genus* ranked third among palm genus in Malaysia, according to the Dered *Daemonorops* [35]. At least 11 palm species, including an unnamed Pinanga species, were discovered on the higher hills during an expedition to Long Banga, Sarawak [34]. Although the *P. arinasae* was originally thought to be limited to Mt. Tapak Bedugul, Bali [33, 40], this species was discovered in Pilan Forest in Bali, Indonesia [39].

In Kalimantan, *Pinanga schwanerensis* Randi, Hikmat & Heatubun was recently found to grow on steep slopes and undulating terrain [30]. There are currently 27 *Pinanga* species known to exist in the Philippines after *P. lepidota* Rendle was rediscovered in 2020 on Palawan Island [8]. [12] found *P. spiralis* A. J. Hend. & N. Q. Dung in Vietnam. Despite having a

larger geographical area and more diverse habitats, Kalimantan, Indonesian Borneo, has fewer *Pinanga* records [25, 30]. More sampling efforts than those in Kalimantan are probably a contributing factor to Malaysian Borneo's higher species richness. Notably, Brunei Darussalam has reported 23 species of *Pinanga* despite having the smallest land area in Borneo. Nearly all *Pinanga* species were found in Borneo are unique to the island, except for three species (*P. auriculata, P. patula*, and *P. simplicifrons*),[27].

P. patula Blume var. *riparia* Becc.: Peninsular Malaysia: Terengganu (Saw Leng Guan, pers. comm.), Pahang, Selangor, Negri Sembilan, and Johor; Indonesia: S. Sumatra and Banka; Thailand: Narathiwat [26]. Blume var. merguensis, and *P. patula* Becc. is common from Mergui to the west coast of Peninsular Thailand, where Kerr, Whitmore, and others collected it. It was also found in Perlis, where L. G. Saw and C. K. Lim collected it in 1995 (H1837, H1840 KEP), and it was recorded as a new record for Peninsular Malaysia. Only the east coasts of Peninsular Malaysia, Peninsular Thailand, and Singapore are home to *P. auriculata*. var *leucocarpa*.

This *Pinanga schwanerensis* A. Randi, Hikmat, and Heatubun is the first new species of *Pinanga* to be described from Kalimantan for more than a century since the description of *P. salicifolia* Blume (1843: 93) and *P. albescens* Becc. (1912: 89) from South Kalimantan [30]. The distribution pattern of *P. javana* on the southern slopes of Mt. Slamet, based on the calculation of the Morisita Index, shows that *P. javana* has a distribution pattern that spreads in groups [44] *Pinanga arinasae* Witono is an endemic palm species native to Bali, Indonesia. This species has been reported only in Bukit Tapak, part of the Batukahu Nature Reserve. The distribution of *P. arinasae* was assessed at three locations in Bali: Bukit Tapak (Batukahu Nature Reserve), Jatiluwih Village (Tabanan), and Pilan Customary Forest (Gianyar).

Pinanga subterranea is native to the tropical island of Borneo in Southeast Asia. *P. subterranea* is scattered across the primary rainforests of western Borneo, crossing state lines from Sarawak in Malaysia to Kalimantan in Indonesia. *P. coronata* was conducted in a tropical montane forest in Mount Halimun National Park (6°44′57″S, 106°32′08″E), West Java, Indonesia [24]. *Pinanga acaulis,* species include *P. adangensis*, *P. pantiensis* and *P. malaiana, P. disticha*, *P. glaucescens*, *P. limosa*, P. *paradoxa*, *P. scortechinii* and *P. simplicifrons* range into the lower montane forest. *Pinanga perakensis*, *P. sembilan* and *P. subintegra* are found at higher elevations in lower montane and montane forests. *Pinanga polymorpha* has only been recorded in montane forests. *Pinanga riparia* is found in freshwater swamps, and P. *palustris* and *P. singaporensis* are often found in both swampy areas and near riverbanks that are subject to occasional floods [10].

Pinanga nuichuensis A. J. Hend., N. K. Ban & B. V. Thanh, *sp. nov* was found in Ninh Thuan Province, Vietnam, near the summit of Nui Chua mountain on rocky slopes in lowland rainforest at 800 m elevation [13]. *Pinanga dicksonii* (Roxburgh) Blume (1839: 76) is endemic to the southern Western Ghats (Karnataka, Kerala, Maharashtra, and Tamil Nadu) [32]. It grows in lowland forests at elevations of 350–1000 m in India. It is a slender clustering palm, 4–6 m tall. It grows in evergreen forests or as an associate of *Myristica* swamp forests in Uttara Kannada, Karnataka, India [22]. *Pinanga lepidota* (Arecaceae), previously known only from Borneo, is reported here as a new record for the Philippines from Palawan Island [8].

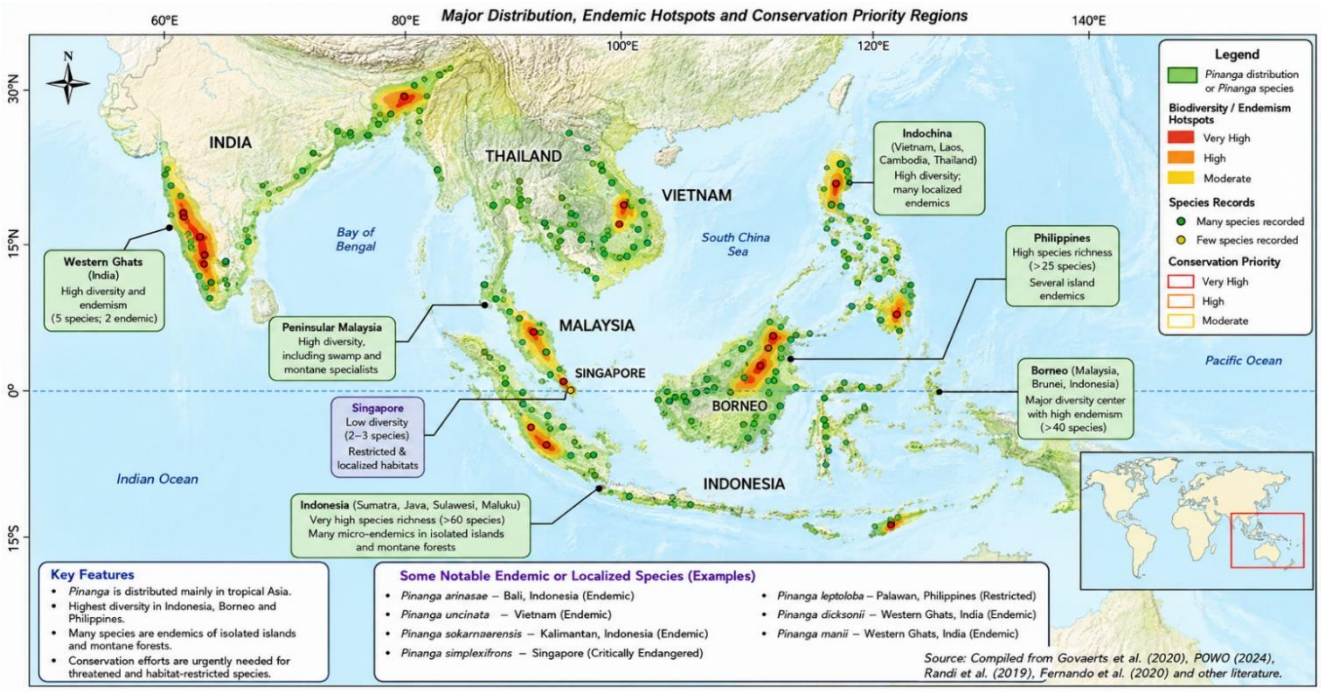

Figure 2. *Global Distribution Map of Pinnga species.*

3. Phytochemical Constituents

Although phytochemical investigations on *Pinanga* species remain limited, preliminary studies have indicated the presence of biologically active secondary metabolites, including flavonoids, phenolic compounds, alkaloids, terpenoids, steroids, and glycosides. These phytochemicals are widely recognized for their antioxidant, anticancer, antimicrobial, and anti-inflammatory activities. Methanolic extracts of *Pinanga limosa* have demonstrated significant cytotoxic activity against MCF-7 breast cancer cell lines, suggesting the possible involvement of phenolic and flavonoid compounds in this activity. However, detailed metabolomic profiling and compound isolation studies are still lacking for many *Pinanga* species.

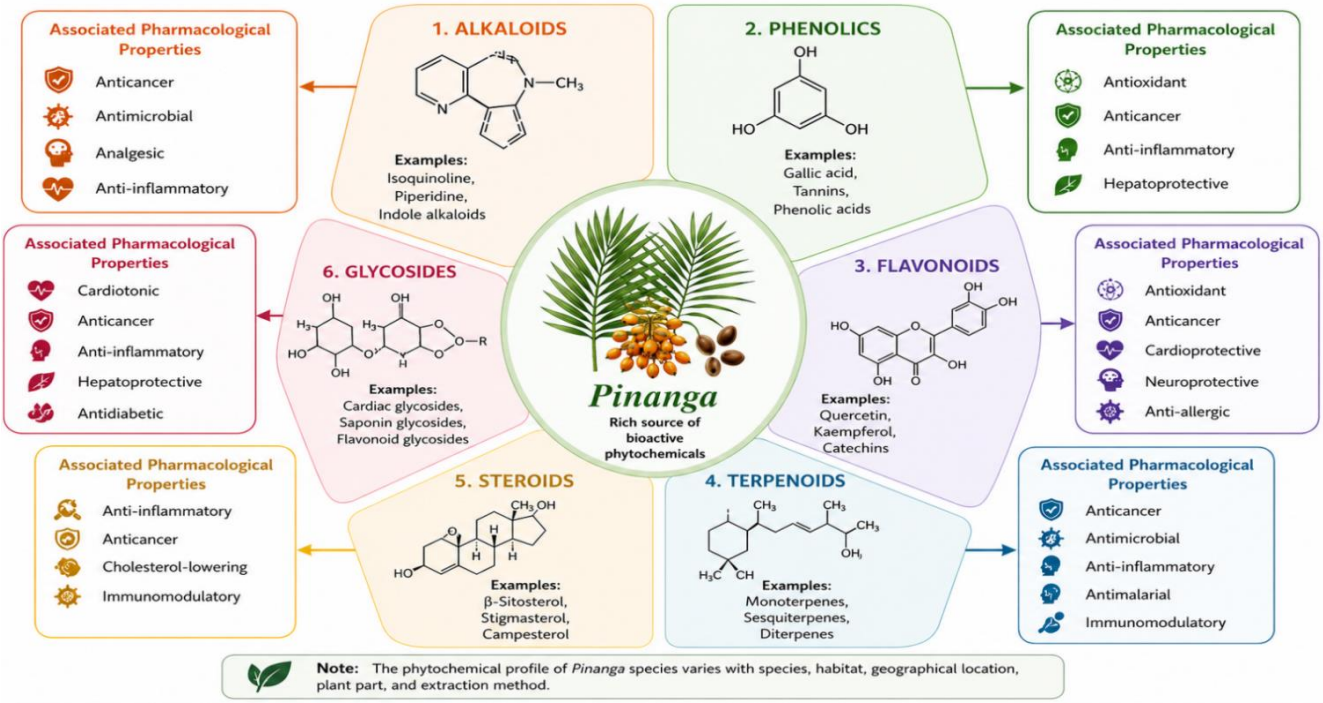

Figure 3. *Major Phytochemical Classes Reported in Pinanga and Their Associated Pharmacological Properties.*

Table 1. *Pharmacological activities of Pinanga species.*

Species	Extract	Bioactivity	Experimental Model	Key Findings
P. limosa	Methanol extract	Cytotoxic activity	MCF-7 cell line	Significant apoptosis induction
P. dicksonii	Genomic DNA	Molecular diversity	SSR markers	High genetic polymorphism
P. arinasae	Chloroplast genome	Phylogenetic analysis	cpDNA sequencing	Clarified evolutionary relationship

4. Karyomorphology Study

Witono *et al.,* [41] studied karyomorphology, which has been infrequently reported for palms, including *Pinanga*. This study aimed to observe the karyomorphology of *Pinanga* species in Java and Bali, namely *P. arinasae, P. javana*, and *P. coronata* and their relationships with morphological and molecular characteristics. The karyomorphological approach showed that *P. arinasae* was more closely related to *P. javana* than *P. coronata*. This is supported by ITS sequence data and ISSR genetic markers. In this study, the karyomorphology of *Pinanga arinasae* and *P. javana* is reported for the first time.

5. Cytotoxic Activities

P. limosa (whole plant) were evaluated on MCF-7 cells (hormone-dependent breast cancer). The response of the cell

lines was assessed using the MTT assay. Cell cycle arrest and apoptosis were evaluated using flow cytometry. The extracts of *P. limosa* were found to induce cytotoxicity against MCF-7 cells, with IC_{50} values of 18.00 µg/mL and 4.80 µg/mL. The extract showed a significant cytotoxic effect compared to the chemotherapeutic anticancer drug doxorubicin (DOX). Cell cycle analysis showed that *P. limosa* induced apoptosis at various stages in the cell line, and a significant reduction in viable cells was observed. Apoptosis was observed as early as 24 h and significantly increased after 48 and 72 h of treatment. These findings suggest that *P. limosa* extract is a potential anticancer agent [21].

6. Complete Chloroplast Genome Study

The review by Asih *et al.,* [3] aimed to characterize its chloroplast genome through comparison with other chloroplast genomes, including its phylogenetic position within the subfamily Arecoideae, and to identify potential molecular markers. The chloroplast genome of *P. arinasae* was characterized and compared within the subfamily Arecoideae. These findings help bridge gaps in knowledge relating to palm phylogenetics, while the generated molecular markers have the potential to serve as cost-effective tools for the assessment of genetic diversity and the provision of support for future conservation efforts and sustainable utilization of *P. arinasae* [3].

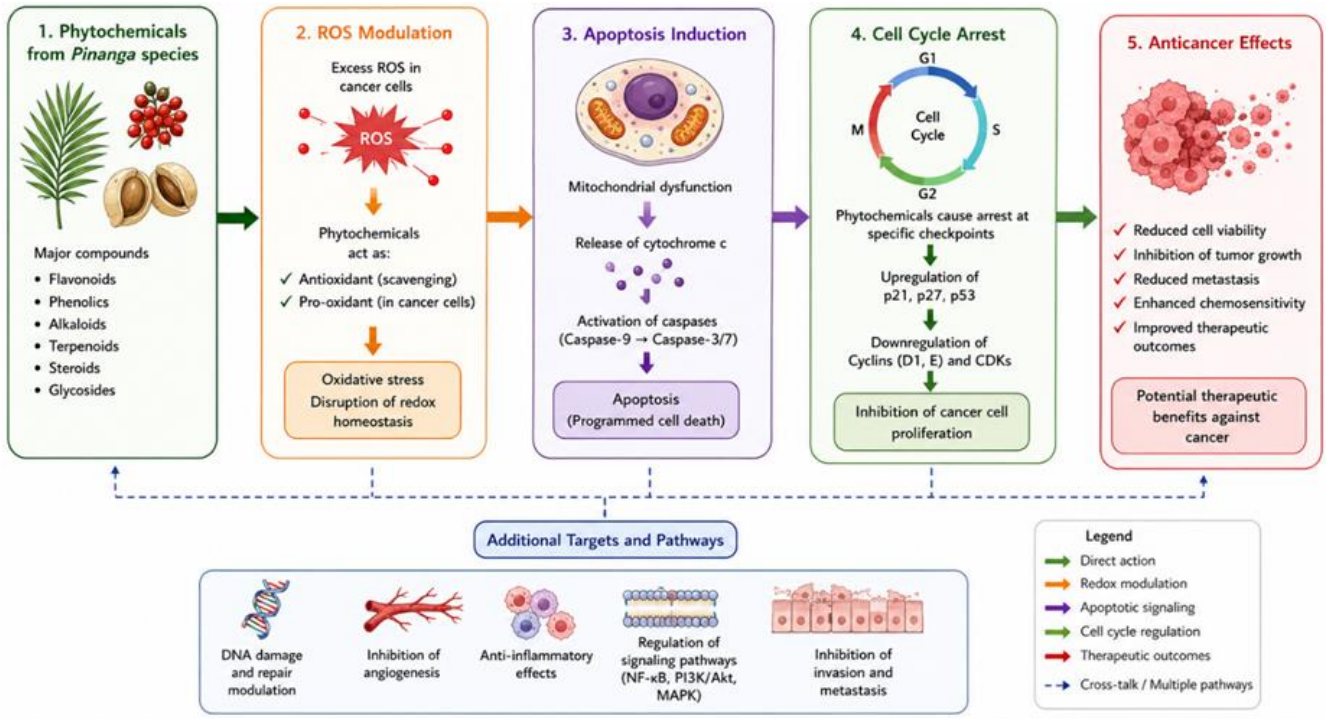

Figure 4. *Proposed Pharmacological Mechanisms of Pinanga phytochemicals.*

7. Molecular Diversity Study

Madar *et al.,* [19] investigated the genetic diversity and relationship among the *Pinanga dicksonii* (Roxb.) population, high-lighting the relevance of genetic information for germplasm conservation and future genetic improvement. The species is an endemic understory palm occurring in western Ghats of Karnataka. Nine P. dicksonii genotypes were evaluated using simple sequence repeat (SSR) markers. Of the 10 SSR primers examined, nine generated polymorphic profiles and collectively detected 123 alleles, with individual primers producing between 20 and 22 alleles. The observed allele frequencies ranged from 22.22% to 100%, with a mean frequency of 71.92%. Polymorphism information content (PIC) values ranged from 0.25 to 0.87, averaging 0.38. Cluster analysis using the unweighted pair-group method with arithmetic mean (UPGMA), implemented in NTSYS-pc version 2.0, indicated substantial genetic variation among the nine genotypes. The similarity coefficients ranged from 0.473 to 0.928, demonstrating varying degrees of genetic relatedness among the studied genotypes.

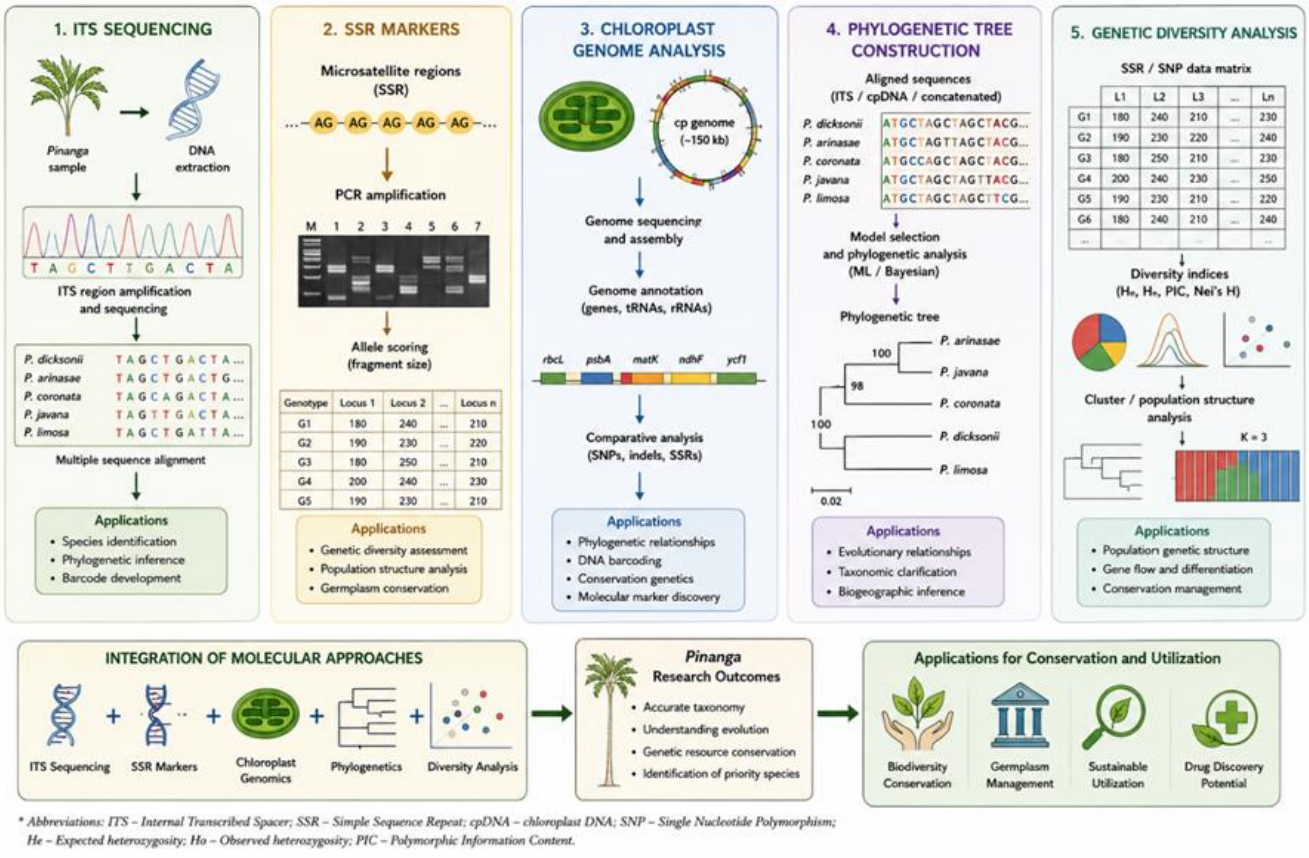

Figure 5. Molecular Approaches Used in Pinanga Research.

8. Conclusion

The genus *Pinanga* (family Arecaceae) is an ecologically and ethnobotanically important group of palms distributed mainly across Southeast Asia, including India, Malaysia, Indonesia, and the Philippines. Taxonomically, *Pinanga* is a diverse genus comprising more than 130 species characterized by high morphological variation influenced by habitat and climatic conditions. This review paper reports the taxonomy, distribution, and pharmacological activities of *Pinanga* genus. It is also noted that new species of *Pinanga* genus have been discovered. Overall, *Pinanga* is a promising but underexplored genus with significant potential for pharmaceutical and nutraceutical development. Future research integrating taxonomy, conservation biology, phytochemistry, and pharmacology is essential to fully realize its medicinal and ecological value.

Abbreviations

ICUN	International Union for Conservation of Nature
MCF-7	Michigan Cancer Foundation-7
SSR	Simple Sequence Repeat
cpDNA	Chloroplast DNA
ITS	Internal Transcribed Spacer
ISSR	Inter-Simple Sequence Repeat
MTT	3-(4, 5-Dimethylthiazol-2-yl)-2, 5-Diphenyltetrazolium Bromide
IC_{50}	Half-maximal Inhibitory Concentration
DOX	Doxorubicin
SSR	Simple Sequence Repeat
PIC	Polymorphic Information Content
NTSYS-pc	Numerical Taxonomy and Multivariate Analysis System – Personal Computer
UPGMA	Unweighted Pair Group Method With Arithmetic Mean

Author Contributions

Prajwal Mysore Prasanna: Writing – original draft
Shri Mathi Kandhasami: Writing – review & editing
Premalatha Selvaraj: Supervison
Jeyasankar Alagarmalai: Conceptualization

Conflicts of Interest

The authors declared no conflicts of interest.

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