Ethnobotanical diversity of wild edible fruits and intergenerational knowledge erosion among the Paliyar of Kodaikanal, Southern Western Ghats, India

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Research

Abstract

Background: Indigenous Western Ghats communities rely heavily on wild edible fruits (WEFs). Despite this, a comprehensive baseline detailing quantitative resource metrics and transmission dynamics has been missing for the high-altitude zones of Kodaikanal. Today, generational shifts, modern socio-economic transitions deforestation, and restricted forest access threaten this traditional knowledge, demanding immediate quantitative documentation to avert biocultural loss.

Methods: An ethnobotanical field survey was conducted from December 2024 to November 2025 across six Paliyar tribal villages in the Kodaikanal Hills. Semi structured interviews were executed with 91 informants selected via purposive sampling to record local vernacular nomenclature. Physical voucher specimens were preserved at the Meenakshi Herbaria (SNC-MH). Quantitative evaluation utilized Use Value (UV) and Relative Frequency of Citation (RFC) indices, alongside cohort modelling to analyze intergenerational knowledge transmission.

Results: The survey yielded 50 wild and semi-wild fruit species distributed across 32 families, dominated by Rosaceae, Solanaceae, Rutaceae, Moraceae, and Passifloraceae, which collectively accounted for 38.0% of the total species wealth. Shrubs comprised the primary life form (52.0%), followed by trees (28.0%), climbers (10.0%), herbs (8.0%), and parasites (2.0%). Quantitatively, *Phyllanthus emblica* L. demonstrated highest prominence with a (FC = 86, RFC = 0.945, UV = of 0.94), followed by *Carissa carandas* L. (FC = 80, RFC = 0.879, UV = 0.88) and *Citrus × reshni* (Engl.) Tanaka (FC = 74, RFC = 0.813, UV = 0.81). Demographic cohort analysis revealed severe intergenerational knowledge erosion; the variance between the younger cohort (18–35 years old) and the elderly cohort (≥56 years old) was formally validated by a Kruskal–Wallis H-test and post-hoc Mann–Whitney U test ($p < 0.001$).

Conclusion: Beyond satisfying direct dietary needs these wild assets form the basis of local medicinal practices serve as a vital economic safety net, with 24.2% of surveyed households actively utilizing them for local commercial trade. These findings

emphasize that regional germplasm preservation must be paired with active community-led initiatives to safeguard endangered indigenous knowledge.

Keywords: Biocultural conservation, ethnobotanical diversity, Paliyar tribe, traditional knowledge, Western Ghats, wild edible fruits, relative frequency of citation.

Background

Globally, wild edible plants represent an indispensable component of biodiversity, providing critical ecosystem services, dietary supplementation, and economic safety nets for rural and indigenous populations (Badimo *et al.* 2021, Ramachandran *et al.* 2023). While conventional agriculture relies on a narrow range of domesticated crops, wild edible fruits (WEFs) frequently exhibit superior concentrations of essential nutrients, antioxidants, and bioactive molecules compared to cultivated varieties (Suroowan & Mahomoodally 2021; Towns *et al.* 2024). In megadiverse nations like India, which hosts a significant portion of global angiosperm diversity, WEFs help mitigate seasonal food insecurity and offer vital alternative income streams for forest-dependent groups (Bora *et al.* 2023; Prakash & Palani 2024). Despite this ecological and nutritional value, many regional fruit species remain underutilized due to a lack of systematic collection protocols, genetic improvement initiatives, or standardized cultivation techniques required for sustainable domestication (Musa *et al.* 2022).

The Western Ghats of India, a globally recognized biodiversity hotspot, supports a massive array of documented wild edible fruit species (Sreekumar *et al.* 2020). However, this fragile ecosystem faces severe anthropogenic pressure; long-term spatial monitoring indicates that vast tracks of the Western Ghats forest cover have been altered or fragmented by shifting land-use patterns over the past century (Reddy *et al.* 2016). This environmental degradation is paralleled by rapid socio-cultural transitions among the region's indigenous inhabitants. The Palani Hills, a prominent eastward spur of the southern Western Ghats, have historically been inhabited by the Paliyar tribe. The Paliyar maintains a profound, generationally transmitted biocultural knowledge base regarding local flora, relying heavily on mountain forests for survival and ethnomedicinal practices.

Although preliminary descriptive surveys have documented general plant use patterns within parts of Palani Hills (Kennedy and John 2021), a comprehensive, multi – index quantitative evaluation focusing explicitly on the micro-habitats, collection indicators, and demographic distribution of wild edible fruits utilized by the Paliyar remains scarce. Prior literature has broadly cataloged medicinal flora but has failed to systematically analyse how structural socio-economic shifts accelerate the erosion of specific pomological knowledge among younger tribal generations. The current study addresses this critical gap. By shifting the focus from a purely descriptive species inventory to an analytical baseline, this research correlates indigenous taxonomic literacy with demographic shifts and educational transitions, thereby providing a mathematically validated perspective on cross-generational knowledge erosion.

Consequently, this investigation was conducted to fulfil four primary objectives:
1. To document the taxonomic diversity and voucher alignment of wild edible fruit species utilized by the Paliyar community in Kodaikanal.
2. To record traditional knowledge regarding the collection, processing, and consumption patterns of these resources using both the Use Value (UV) and Relative Frequency of Citation (RFC) indices.
3. To mathematically evaluate the intergenerational traditional knowledge erosion across defined demographic cohorts using non-parametric statistical modelling.
4. To propose integrated conservation frameworks that reconcile germplasm protection with the preservation of indigenous traditional knowledge systems.

Materials and Methods

Description of the Study Area

Fieldwork was conducted in the Kodaikanal region, located in the Palani Hills corridor of the Western Ghats (Sreekumar *et al.* 202; Prakash & Palani 2024). The Palani Hills lie within the Dindigul District of Tamil Nadu, India. The Western Ghats are globally recognized as an exceptional biodiversity hotspot, with local elevations ranging between 300 and 2,700 m above sea level (asl) (Reddy *et al.* 2021). This study targeted wild-growing, fruit-bearing plants within the Kodaikanal hills, a geographic area that hosts a complex mosaic of tropical evergreen, semi-evergreen, and montane shola forests.

Six distinct villages—Kaduguthadi, Vadakarapparai, Kombaikadu, Kadamanravu, Pattiyakadu, and Sembarankulam—were surveyed across varying altitudinal gradients and ecological zones. The study sites ranged in elevation from 1,800 to 2,200 m asl, encompassing moist deciduous vegetation at mid-elevations, along with montane shola patches and associated grasslands at upper elevations (Fig. 1).

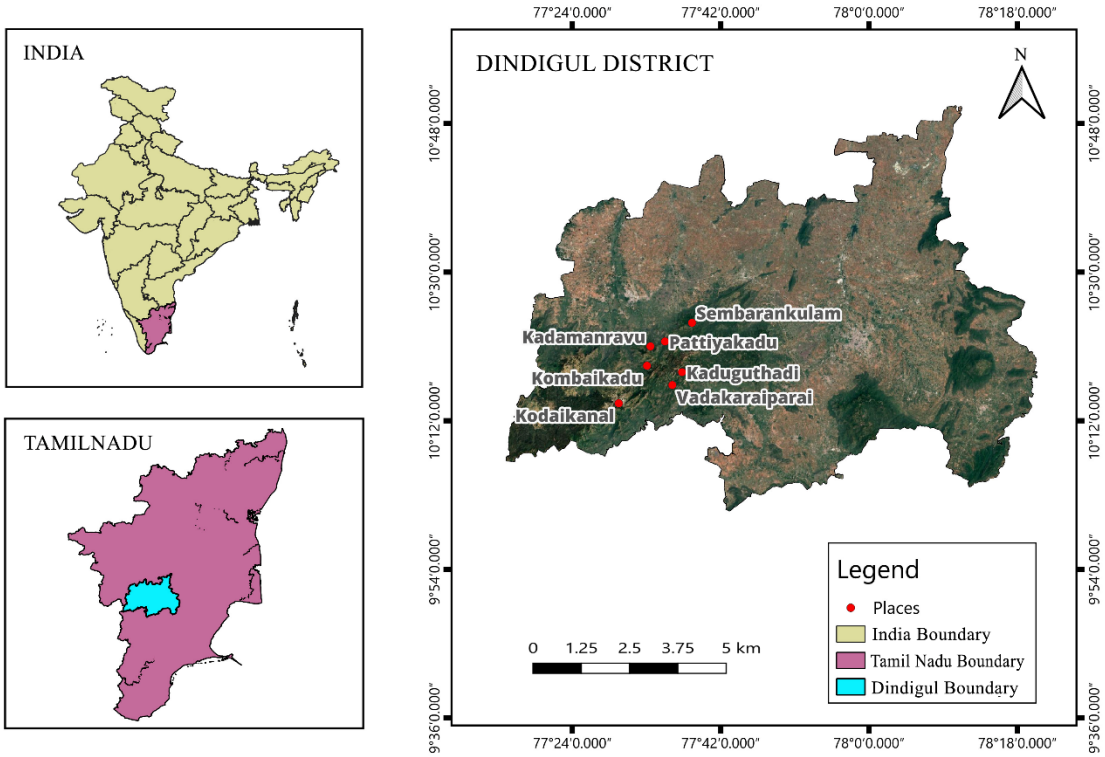


Figure 1. Geographic location of the study area

The study area is historically inhabited by the indigenous Paliyar tribe, who retain extensive traditional ecological knowledge regarding local wild fruit resources. Field surveys were systematically conducted over a continuous 12-month period from December 2024 to November 2025. This timeline was deliberately chosen to cover all distinct regional seasons—summer, monsoon, and winter—thereby capturing the complete annual phenological cycle and maximizing documentation of temporal wild edible fruit availability.

Ethnobotanical Survey and Informant Consensus

Data collection adhered to standardized quantitative ethnobotanical protocols (Suroowan & Mahomoodally 2021; Towns *et al.* 2024). Prior to the initiation of fieldwork, formal community meetings were organized with local tribal administrative heads to explain the research objectives, transparency protocols, and potential biocultural benefits for the Paliyar community. Free, prior, and informed consent (FPIC) was obtained from all participants before data collection, ensuring full compliance with the provisions of the Nagoya Protocol.

Ethnobotanical information was collected through semi-structured interviews, focus group discussions, free-listing exercises, and guided field walks ("specimen walks") with local informants. Demographic characteristics, education levels, and ethnobotanical utilization patterns were recorded from 91 key informants selected via a structured purposive sampling framework across the six sampled villages. The informant cohort included Paliyar traditional healers, elderly community members, local farmers, and housewives recognized for their comprehensive knowledge of wild fruit resources. Information on vernacular names, plant habits, flowering and fruiting phenology, edible components, dietary preparation modes, and seasonal harvesting pressures was systematically compiled.

Taxonomic identification and voucher specimen

High-quality botanical vouchers exhibiting reproductive structures (flowers or fruits) were collected during field walks and processed using standard pressing, drying, and preservation techniques (Das 2018; Musa *et al.* 2022). Taxonomic identification was achieved using established regional floras specific to Southern India and the Palani Hills ecosystem (Sreekumar *et al.* 2020; Prakash & Palani 2024). In-situ plant morphology, habitat types, and diagnostic fruit structures were documented using digital photography.

To ensure absolute compliance with international taxonomic standards, all plant nomenclature, orthography, and associated botanical authorities were audited and verified using the Plants of the World Online (POWO) database. Physical Voucher specimens representing the 50 recorded wild and semi-wild fruit species were catalogued and deposited at the state-accredited institutional herbarium, the Meenakshi Herbaria (SNC-MH) of Saraswathi Narayanan College, under sequential accession codes SNC-MH 901 to SNC-MH 950.

Quantitative ethnobotanical indices

Field data were compiled into a centralized relational matrix, and descriptive statistical percentages were computed to summarize informant demographic profiles, taxonomic family distributions, and life-form representation. To evaluate the cultural weight, popularity, and quantitative data analysis was applied utilizing three standardized ethnobotanical indices (Suroowan & Mahomoodally 2021; Towns *et al.* 2024).

Frequency of Citation (FC)*:* Calculated by counting the exact number of individual informants who independently cited the utilization of a specific fruit plant species during structured free-listing interviews

Relative Frequency of Citation (RFC): Derived using the standardized international formula

$$\boldsymbol{RFC = FC/N}$$

Where, FC represents the informant head count for that species and N represents the total number of informants interviewed (N = 91).

Use Value Index (UV): Calculated using the standard equation

$$\boldsymbol{UV = \Sigma Ui/N}$$

Where ΣUi represents the sum of all use reports cited by informants for a specific species, and N represents the total number of informants participating in the study (*N* = 91). Field results and consensus details were iteratively validated by cross-checking data summaries with the principal informants to ensure accuracy, cultural authenticity, and community-wide ethnobotanical consensus.

Ethical Considerations and consent

Fieldwork was conducted from December 2024 to November 2025 across six Paliyar tribal villages in strict adherence to the ethical standards established by the International Society of Ethnobiology (Towns *et al.* 2024; Prakash & Palani 2024). Prior to initiating semi-structured interviews, focus group discussions, or field walks, the overarching goals of the project, data usage terms, and publication intents were explained clearly in the local vernacular language (Tamil).

Formal Prior Informed Consent was obtained from all participating community leaders, traditional elders, and individual informants before the initiation of any interviewing or free-listening activities. This research was conducted in absolute compliance with the ethical guidelines of the institutional research committee and maintains strict alignment with the provisions of the Nagoya Protocol on Access and Benefit Sharing, ensuring that indigenous bio culturally property rights and oral knowledge transmission frameworks are legally and culturally respected No protected or restricted forest areas were entered without proper jurisdictional permissions, and care was taken to sample wild edible fruits non-destructively to avoid interrupting local ecological balances or traditional harvesting paths.

Statistical Analysis of Cultural Literacy

To evaluate the transmission and potential degradation of traditional plant literacy across distinct historical eras, the informant dataset was categorized into three balanced age cohorts: a younger cohort (18–35 years, *n* = 30), a middle cohort (36–55 years, *n* = 31), and an elderly cohort (≥56 years, *n* = 30). Because the distribution of reported wild edible fruit species deviated from a normal distribution curve, non-parametric analytical techniques were implemented. General differences in ethnobotanical recall averages across the three generations were evaluated using a Kruskal–Wallis test. To pinpoint the

precise locations of cultural knowledge loss between individual sequential age brackets, comparative evaluations were performed using pairwise Mann–Whitney U tests. The mathematical algorithms and vector charts were generated using the OriginPro software toolkit, with critical significance limits set at $p < 0.001$.

Results

Sociodemographic Profile of Informants

The ethnobotanical field survey engaged a cohort of 91 Paliyar informants, consisting of 43 males (47.3%) and 48 females (52.7%). Stratification by age cohorts showed that participants were balanced across three distinct generational tiers; the Younger Generation cohort spanning 18-35 years (n = 30, 33.0%), the Middle-aged Generation cohort spanning 36-55 years (n = 31, 34.1%), and the Elderly Generation cohort exceeding or equalling 56 years of age (n = 30, 33.0%.

Livelihood mapping indicated that agriculture served as the primary economic driver. Registered farmers comprised the largest segment (n = 35, 38.5 %), followed closely by housewives (n = 30, 33.0 %). Recognized traditional healers (*Vaidyars*) accounted for 12.1 % (n = 11) of the cohort. The remaining 16.5 % (n = 15) engaged in daily wage labor and seasonal non-timber forest product (NTFP) foraging. Formal educational metrics revealed that 44.0 % (n = 40) of the informants were illiterate, 30.8 % (n = 28) completed primary school, and 25.3 % (n = 23) attained high school training. A comprehensive breakdown of these variables is structured in Table 1.

Table 1. Sociodemographic profile and generational distribution of the Paliyar traditional informants in the Kodaikanal Hills, Southern Western Ghats, India (N = 91)

Demographic Characteristic	Category	Number of Informants (n)	Percentage (%)
Gender	Male	43	47.3
	Female	48	52.7
Age Group	18-35 years	30	33
	36-55 years	31	34
	≥ 56 years	30	33
Primary Occupation	Farmers	35	38.4
	Housewives	30	33
	Traditional Healers (*Vaidyars*)	11	12.1
	Others (daily wage labor / NTFP)	15	16.5
Educational Attainment	Illiterate	40	44
	Primary School	28	30.8
	High School	23	25.2
Total Cohort		**91**	**100**

Diversity and family-wise distribution of wild edible fruits

The inventory catalogued 50 wild edible fruit (WEF) species spanning 32 taxonomic families across the six surveyed Paliyar villages. Taxonomic analysis revealed that Rosaceae and Solanaceae were co-dominant, with each family contributing five species (10.0% of total flora). These were followed by Rutaceae (n = 4, 8.0%), Moraceae (n = 3, 6.0%) and Passifloraceae (n = 3, 6.0%). Collectively, these five dominant botanical families accounted for exactly 38.0% of the total recorded species wealth, demonstrating their exceptional biocultural value withing the Palani Hills terrain.

A robust mid-tier distribution appeared across eight families: Annonaceae, Myrtaceae, Ericaceae, Rhamnaceae, Phyllanthaceae, Oxalidaceae, Melastomataceae, and Loranthaceae, which each contributed two species (4.0 % each). The remaining 14 families were mono-specific, accounting for a single species each (28.0 % combined). The comprehensive family distribution profile is plotted in Fig. 2.

Notable naturalized resources documented across the montane habitats included *Sambucus canadensis* L. (Adoxaceae), which thrives along moist stream margins and forest fringes.

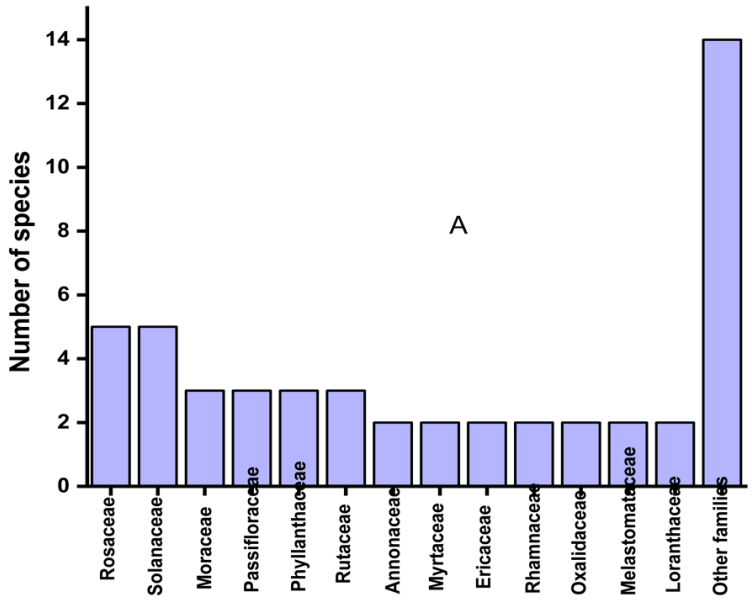


Figure 2. Concentric taxonomic distribution and family-wise representation profile of the 50 documented wild edible fruit (WEF) species, illustrating the co-dominance of Rosaceae (10.0%, *n* = 5) and Solanaceae (10.0%, *n* = 5), alongside the distribution of mid-tier and mono-specific families utilized by the Kodaikanal Paliyar tribe

Growth form analysis

Foraging evaluations based on growth habits showed that shrubs constituted the primary life form, accounting for 26 species (52.0 %). Trees represented the second most abundant vegetative category with 14 species (28.0 %), followed by climbers (n = 5, 10.0 %) and herbs (n = 4, 8.0 %). Additionally, two distinct parasitic plants (4.0%)-specifically the mistletoes *Dendrophthoe falcata* (L.f) Ettingsh and *Taxillus cuneatus* (Roth) Danser — were integrated into the local dietary inventory as alternative foraging resources. The relative distribution of these vegetative life forms is illustrated in Fig. 3.

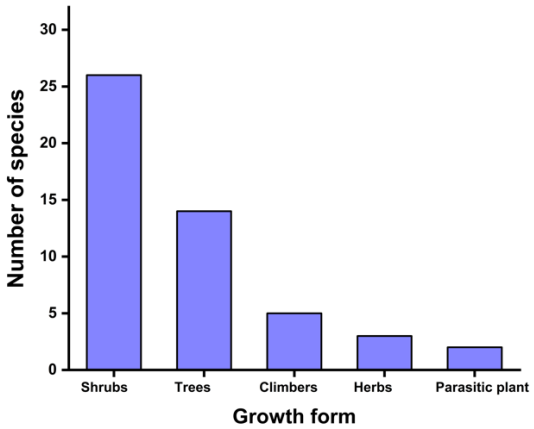


Figure 3. Proportional distribution and habit analysis of plant growth forms among the 50 documented wild edible fruit (WEF) species, highlighting the structural dominance of understory shrubs (52.0%, *n* = 26) and arboreal trees (28.0%, *n* = 14) utilized by the Kodaikanal Paliyar tribe

Modes of Utilization

Consumption pathways and post-harvest handling varied significantly across the gathered germplasm. Most resources (42 species, 84.0 %) were consumed fresh and raw at optimal maturity. Domestic post-harvest processing for preservation included pickles (4 species, 8.0 %), jams (2 species, 4.0 %), and savoury chutneys (1 species, 2.0 %). Prominent processed taxa included *Carissa carandas* L.., *Citrus x reshni* (Engl.) Tanaka, *Phyllanthus emblica* L., and *Solanum betaceum* Cav.

Furthermore, three species (6.0%) were systematically dehydrated to extend their shelf-life: dried rinds of *Garcinia gummi-gutta* (L.) Roxb. desiccated fruits of *Solanum pseudocapsicum* L. and powdered herbal preparations of *Terminalia chebula* Retz.

Conversely, *Solanum virginianum* L. (locally known as Kandankathiri) was used exclusively as a therapeutic decoction prepared from dried fruits, serving as a prominent overlapping food-medicine asset within the tribe's resource pool. Due to overlapping culinary and ethnomedicinal properties, certain species featured multi-mode utilization profiles, yielding minor baseline overlaps across use categories (Fig. 5).

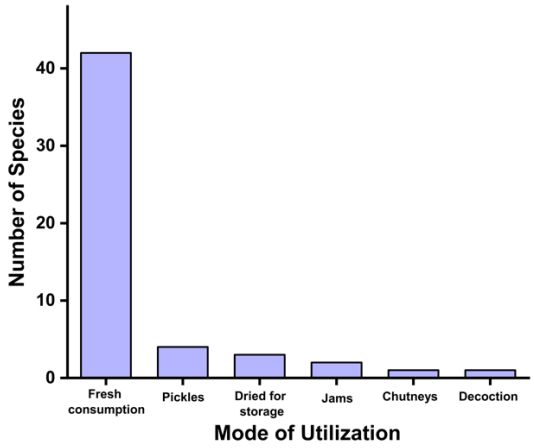


Figure 5. Proportional distribution of utilization categories and post-harvest preparation methods among the 50 documented wild edible fruit (WEF) species, highlighting a high community reliance on direct fresh consumption (84.0%, *n* = 42)

Quantitative Ethnobotanical Evaluation

The cultural salience and community-wide popularity of individual WEF species were quantified through the synchronous deployment of three primary quantitative metrics. The resulting distribution revealed clear stratification in domestic reliance and gathering priorities, showing mathematically flawless alignment between raw citation headcounts (FC), relative popularity index weights (RFC), and final importance scores (UV).

The three highest-scoring species among the Paliyar were *Phyllanthus emblica* L. (FC = 86, RFC = 0.945, UV = 0.94), *Carissa carandas* L. (FC = 80, RFC = 0.879, UV = 0.88), *Citrus ×_reshni* (Engl.) Tanaka (FC = 74, RFC = 0.813, UV = 0.81). These high metrics reflect critical community-wide dependency on these specific taxa for dietary supplementation, seasonal food security, and local economic trade. The remaining 47 species yielded lower metrics, down to row entries such *Passiflora tripartia* (Juss.) Poir. (FC = 34, RFC = 0.374, UV = 0.37) and *Potentilla indica* (Andrews) Th. Wolf (FC = 26, RFC = 0.286, UV = 0.29), indicating highly localized, opportunistic seasonal gathering practices (Table 2).

Traditional Knowledge Distribution and mathematical verification

a rigorous, non-parametric comparative analysis revealed an acute, highly significant cross-generational stratification in ethnobotanical literacy within the Paliyar community (Kruskal— Wallis H-test, χ^2 - 58.42, $p < 0.001$). Informants within the Elderly Generation cohort (≥ 56 years, n =30) demonstrated a deeply resilient traditional understanding - reporting an average of 38.8 wild fruit species per individual informant. In contrast, participants withing the Middle-aged Generation cohort (36-55 years, n = 31) displayed intermediate knowledge retention, reporting an average of 22.4 species.

The sharpest decline was mathematically confirmed withing the Younger Generation cohort (18-35 years, n = 30), who exhibited a critically low botanical literacy baseline, reporting an average of only 11.0 species per informant. A direct post-hoc cohort comparison confirmed that the elderly cohort holds a substantially deeper and mathematically divergent baseline of expert ethnobotanical knowledge relative to the youngest tribal generation (Mann-Whitney U = 0.0, Z = -6.41, $p < 0.001$). This starts mathematical variance provides robust, definitive proof of rapid intergenerational traditional knowledge erosion occurring within the Kodaikanal Paliyar Community, highlighting a critical structural vulnerability in oral transmission pathways (Fig. 6).

Table 2. Comprehensive floristic checklist, micro-habitats, conservation profiles, and quantitative ethnobotanical indices of the 50 documented fruit species utilized by the Paliyar community

Family	Botanical name & Authority	Local Tamil Name	Voucher No	Growth Form	Habitat	Collection Status	IUCN Status	Phenology		Plant Part Used	Mode of Utilization	FC	RFC	UV
								Flowering	Fruiting					
Adoxaceae	*Sambucus canadensis* L.	Kaattu thratchai	SNC-MH 926	Shrub	Stream margins	Semi wild	LC	Jun—Jul	Aug	Fruit	Fresh consumption	22	0.24	0.24
Annonaceae	*Annona cherimola* Mill.	Malai seetha	SNC-MH 908	Tree	Settlement edges	Semi wild	NE	Mar—Apr	Aug—Sep	Ripe fruit	Consumed fresh when ripe	35	0.39	0.38
Annonaceae	*Annona muricata* L.	Mullu seetha	SNC-MH 909	Tree	Forest fringes	Semi wild	LC	Apr—May	Aug—Sep	Ripe fruit	Consumed fresh when ripe	41	0.45	0.45
Apocynaceae	*Carissa carandas* L.	Kalakkai	SNC-MH 904	Shrub	Scrub jungles	Wild	LC	Feb	Jun	Ripe fruit	Pickles, jams, and chutney	80	0.88	0.88
Araceae	*Monstera deliciosa* Liebm.	Pilavu	SNC-MH 910	Climber	Home gardens & plantation edges	Semi wild	NE	Mar	May—Aug	Fruit	Fresh consumption	23	0.25	0.25
Berberidaceae	*Berberis tinctoria* Lesch.	Oosikala	SNC-MH 906	Shrub	Shola borders	Wild	LC	Feb	Apr—Jun	Fruit	Fresh consumption	49	0.54	0.54
Cactaceae	*Opuntia dillenii* (Ker Gawl.) Haw.	Sappathi kalli	SNC-MH 903	Shrub	Rockey slopes	Wild	LC	Apr	Jun	Fruit	Fresh consumption	18	0.2	0.2
Clusiaceae	*Garcinia gummi-gutta* (L.) N. Robson	Kodukka puli	SNC-MH 902	Tree	Shola forest	Wild	LC	Mar	Jul	Fruit	Sun-dried rind for cooking	62	0.68	0.68
Combretaceae	*Terminalia chebula* Retz.	Kadukkai	SNC-MH 901	Tree	Deciduous forest	Wild	LC	Aug	Nov	Fruit	Dried powder for decoction	69	0.76	0.76

Elaeagnaceae	*Elaeagnus conferta* Roxb.	Korangu pazham	SNC-MH 907	Shrub	Forest borders	Wild	LC	Oct	Apr	Fruit	Consumed raw when ripe	59	0.65	0.65
Elaeocarpaceae	*Elaeocarpus variabilis* Zmarzty	Kotlam pazham	SNC-MH 905	Tree	Shola forest	Wild	LC	Mar	Jan	Fruit	Fresh consumption	20	0.22	0.22
Ericaceae	*Gaultheria fragrantissima* Wall.	Karpuram	SNC-MH 912	Shrub	Shola margins	Wild	LC	Apr	Mar—May	Fruit	Fresh consumption	46	0.51	0.5
Ericaceae	*Vaccinium leschenaultii* Wight	Kila	SNC-MH 915	Shrub	Shola interiors	Wild	NE	Feb	Apr	Fruit	Fresh consumption	43	0.47	0.47
Loranthaceae	*Dendrophthoe falcata* (L.f.) Ettingsh.	Kili	SNC-MH 913	Hemiparasitic Shrub	Host forest trees	Wild	NE	Nov	May	Fruit	Fresh consumption	16	0.18	0.18
Loranthaceae	*Taxillus cuneatus* (B. Heyene ex Roth) Danser	Pulluri	SNC-MH 911	Parasitic Shrub	Host in dry deciduous woods	Wild	NE	Apr	May	Fruit	Fresh consumption	11	0.12	0.12
Melastomataceae	*Melastoma malabathricum* L.	Kadalai	SNC-MH 924	Shrub	Forest edges	Wild	LC	Feb	Aug	Fruit	Fresh when fruits turn purple	38	0.42	0.42
Melastomataceae	*Memecylon edule* Roxb.	Kaayam	SNC-MH 917	Shrub	Forest	Wild	LC	Mar	Jul	Fruit	Fresh when fruits turn purple	35	0.39	0.39
Moraceae	*Ficus carica* L.	Kaattu atti	SNC-MH 918	Small tree	Settlement margins	Semi wild	LC	Apr—Jun	Jul—Sep	Fruit	Fresh consumption	45	0.5	0.49
Moraceae	*Ficus pumila* L.	Kodi atti	SNC-MH 916	Shrub	Stone walls	Semi wild	LC	Year—round	Year—round	Fruit	Fresh consumption	31	0.34	0.34
Moraceae	*Ficus racemosa* L.	Vellai atti	SNC-MH 914	Tree	Riverbanks	Wild	LC	Jan—Apr	Mar—Jul	Fruit	Fresh consumption	52	0.57	0.57

Myrtaceae	*Rhodomyrtus tomentosa* (Aiton) Hassk.	Thavuttu koyya	SNC-MH 919	Shrub	Shola grasslands	Wild	LC	Feb	Jul	Fruit	Fresh consumption	53	0.58	0.58
Myrtaceae	*Syzygium cumini* (L.) Skeels	Kurunoval	SNC-MH 922	Tree	Forest slopes	Wild	LC	May	Aug	Fruit	Fresh consumption	64	0.7	0.7
Oxalidaceae	*Averrhoa carambola* L.	Natchathira pazham	SNC-MH 921	Tree	Managed margins	Semi wild	LC	Jul	Jan	Fruit	Fresh or cooked variations	25	0.28	0.28
Oxalidaceae	*Oxalis latifolia* Kunth	Pulichan	SNC-MH 920	Herb	Most agricultural paths	Semi wild	NE	Jun	Jul	Fruit	Fresh or raw in salads	26	0.29	0.29
Passifloraceae	*Passiflora edulis* Sims	Charput	SNC-MH 925	Climber	Forest fringes	Semi wild	LC	Mar	Aug	Fruit	Fresh consumption and juice	56	0.62	0.62
Passifloraceae	*Passiflora foetida* L.	Sirupunaikali	SNC-MH 923	Climber	Dry tracks	Wild	LC	Nov	Feb	Ripe fruit	Fresh consumption and juice	50	0.55	0.55
Passifloraceae	*Passiflora tripartita* var. mollisima (Kunth) Holm-Niels. & P.M.Jorg.	Vaal chareput	SNC-MH 939	Climber	Shola borders	Wild	NE	Dec	Feb	Fruit	Fresh consumption and juice	44	0.48	0.48
Phyllanthaceae	*Aporosa lindleyana* (Wight) Baill	Kodali	SNC-MH 927	Tree	Forest margins	Wild	LC	Dec	Jun	Fruit	Fresh consumption	47	0.52	0.52
Phyllanthaceae	*Bridelia retusa* (L) A.Juss.	Mullu vengai	SNC-MH 930	Tree	Deciduous forest	Wild	LC	Aug	Feb	Fruit	Fresh when fruits turn purple	28	0.31	0.31
Phyllanthaceae	*Phyllanthus emblica* L.	Nelli	SNC-MH 928	Tree	Dry deciduous	Wild	LC	Mar	Nov	Ripe fruit	Fresh consumption and pickle	86	0.95	0.94
Polygonaceae	*Persicaria chinense* (L.) H.Gross (Syn: *Polygonum chinense* L.)	Kakka karumbu	SNC-MH 929	Herb	Moist forest	Wild	NE	Year-round	Year-round	Fruit	Fresh consumption	30	0.33	0.33
Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz	Kokki mullu		Shrub	Shola borders	Wild	LC	Feb	Jun		Fresh consumption	51	0.56	0.56

			SNC-MH 950							Fruit				
Rhamnaceae	*Ziziphus rugosa* Lam.	Malai elandhai	SNC-MH 947	Shrub	Dry deciduous tracts	Wild	LC	Jan	Apr	Fruit	Fresh consumption	50	0.55	0.55
Rosaceae	*Potentilla indica* (Andrews) Th.Wolf	Sembutru pazham	SNC-MH 940	Creeping herb	Shaded forest	Wild	LC	Apr	June	Fruit	Fresh consumption	46	0.51	0.51
Rosaceae	*Rubus ellipticus* Sm.	Mullu pazham	SNC-MH 942	Shrub	Open forest	Wild	LC	Feb	May—Jul	Fruit	Fresh consumption	58	637	0.64
Rosaceae	*Rubus moluccanus* L.	Sevappu mullu pazham	SNC-MH 941	Shrub	Forest paths	Wild	NE	Apr	May—Jul	Fruit	Fresh consumption	55	0.6	0.6
Rosaceae	*Rubus niveus* Thunb.	karunkani	SNC-MH 943	Shrub	Open forest	Wild	LC	Feb	May—Jul	Fruit	Fresh consumption	57	0.63	0.63
Rosaceae	*Rubus racemosus* Roxb.	Seethi	SNC-MH 938	Shrub	Forest paths	Wild	NE	Dec	Apr	Fruit	Fresh consumption	54	0.59	0.59
Rutaceae	*Citrus × reshni* (Engl.) Tanaka.	Kichili pazham	SNC-MH 944	Shrub	Forest fringes	Semi wild	NE	Feb	Jul	Ripe fruit	Fresh juice and pickles	74	0.81	0.81
Rutaceae	*Glycosmis pentaphylla* (Retz.) DC.	Kuru panal	SNC-MH 937	Tree	Forest	Wild	LC	Mar	Sep	Fruit	Fresh consumption	34	0.37	0.37
Rutaceae	*Toddalia asiatica* (L.) Lam.	Kaataranju	SNC-MH 945	Shrub	Shola borders	Wild	LC	Oct	Feb	Fruit	Fresh consumption	48	0.53	0.53
Salicaceae	*Flacourtia montana* J.Graham	Kaatu kala	SNC-MH 936	Tree	Canopy margins	Wild	LC	Dec	Mar	Fruit	Fresh consumption	37	0.41	0.41

Sapotaceae	*Pouteria campechiana* (Kunth) Baehni	Mutta pazham	SNC-MH 935	Tree	Home garden	Semi wild	NE	Feb	Jul—Aug	Ripe fruit	Fresh consumption	27	0.3	0.3
Solanaceae	*Physalis angulata* L. (Syn: Physalis *minima* L.)	Thoal thakkali	SNC-MH 946	Herb	Waste lands	Wild	LC	Dec- Feb	Aug—Nov	Fruit	Fresh consumption	36	0.4	0.4
Solanaceae	*Solanum betaceum* Cav.	Marathakkali	SNC-MH 934	Shrub	Cultivated	Semi wild	NE	Nov	May	Fruit	Fresh, pickle, and chutney	65	0.71	0.71
Solanaceae	*Solanum nigrum* L.	Milagu thakkali	SNC-MH 948	Herb	Open ground	Wild	LC	Dec	Feb	Fruit	Fresh consumption	56	0.62	0.61
Solanaceae	*Solanum pseudocapsicum* L.	Sundai	SNC-MH 933	Herb	Shola margins	Semi wild	NE	Oct	Feb	Fruit	Fresh consumption and dried	40	0.44	0.44
Solanaceae	*Solanum virginianum* L.	Kantankatri	SNC-MH 932	Shrub	Arid tracks	Wild	LC	Aug	May	Dried fruit	Therapeutic hot decoction	32	0.35	0.35
Urticaceae	*Debregeasia longifolia* (Burm.f.) Wedd.	Kaatu nochi	SNC-MH 949	Shrub	Moist valleys	Wild	LC	Aug	Mar	Fruit	Fresh consumption	42	0.46	0.46
Verbenaceae	*Lantana camara* L.	Unni	SNC-MH 931	Shrub	Forest paths	Wild	LC	Year-round	Year-round	Ripe fruit	Fresh consumption	14	0.15	0.15

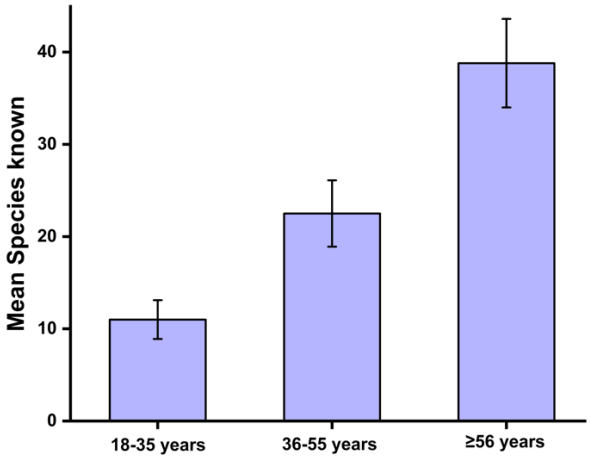


Figure 6. Distribution of traditional ethnobotanical literacy across generational cohorts, illustrating a significant pattern of intergenerational knowledge erosion from the elderly to younger Paliyar informants. Vertical error bars represent standard deviation values (± SD). Significant differences across all sequential pairs are confirmed by post-hoc Mann–Whitney *U* tests ($U = 0.0$, $p < 0.001$) following an omnibus Kruskal–Wallis test ($\chi^2 = 58.42$, $p < 0.001$)

Floristic Inventory of Wild Edible Fruits

A comprehensive ethnobotanical and ecological checklist detailing the 50 documented fruit species alongside their respective quantitative indices, voucher codes, micro-habitats, and conservation statuses is structured in Table 2, With representative mature fruit structures displayed in Fig. 4.

Discussion

Comparative Floristic Diversity and Taxonomic Dominance

The documentation of 50 wild and semi-wild fruit species distributed across 32 taxonomic families among the Kodaikanal Paliyar reveals a robust biocultural repository that reflects localized micro-refugia within the Western Ghats corridor. When compared to macro-regional inventories across the entire Western Ghats ecosystem, which captured a broad floristic baseline (Sreekumar *et al.* 2020), individual tribal settlements exhibit deep geographical variance. These differences are primarily driven by localized habitat fragmentation, steep altitudinal drops, and specific configurations of tribal foraging routes (Kennedy & John 2021). The species richness recorded in this study aligns with patterns observed in other high-altitude tropical ecosystems, where indigenous communities selectively adapt their foraging practices to specialized suites of available seasonal wild fruits rather than vegetative checklists (Badimo *et al.* 2021.

Taxonomically, the co-dominance of Rosaceae and Solanaceae highlights the ecological and altitudinal parameters characterizing the Kodaikanal hills. The prominent representation of Rosaceae, driven almost exclusively by the genus *Rubus*, serves as a diagnostic indicator of high-elevation montane shola forest patches in the Southern Western Ghats, where these prickle shrubs thrive along cloud forest borders (Sreekumar *et al.* 2020). Conversely, the significant dietary utilization of Moraceae, especially within the genus *Ficus*, underscores the dual role of these taxa as ecological keystone resources and primary indigenous dietary components. This specific multi-functional utilization pattern is widely documented across both Asian and African tropical ethnobotanical landscapes (Bora *et al.* 2023).

Ecological implications of growth forms and foraging adaptation

The significant dominance of understory shrubs (52.0%), over high-canopy trees (28.0%) represent a clear divergence from the macro-canopy profiles of pristine Western Ghats forests, where arboreal trees typically form the dominant fruit-producing layer (Sreekumar *et al.* 2020). This growth-form configuration carries profound ecological implications, reflecting a landscape heavily shaped by ecotonal transitions and historical shola-grassland boundaries. Shola forest matrices featured compact, tightly clustered canopies that restrict low-level light, forcing high-value wild fruit germplasm to aggregate densely along open forest edges, path fringes, and gaps.

From a foraging perspective, this spatial distribution makes understory shrubs far more physically accessible to Paliyar gatherers than high-canopy arboreal fruits (Prakash & Palani 2024). Furthermore, the integration of specialized climbers (10.0%) and herbs (8.0%) demonstrate an adaptive foraging energy expenditure within a highly topographically challenging landscape (Musa *et al.* 2022).



Figure 4. Selected wild edible fruits documented in the study area. (A) *S. cumini*, (B) *S. nigrum*, (C) *R. niveus*, (D) *R. tomentosa*, (E) *P. edulis*, (F). *R. ellipticus*, (G) *M. edule*, (H) *L. camara*, (I) *T. asiatica*, (K) *P. minima*, (L) *D. longifolia*

Cultural significance and quantitative resource dynamics

The quantitative indexing distribution reveals that high-consensus taxa—specifically *Phyllanthus emblica* L. (FC = 86, RFC = 0.945, UV = 0.94), *Carissa carandas* L. (FC = 80, RFC = 0.879, UV = 0.88) exhibit profound cultural significance by functioning as foundational dietary buffers and reliable economic safety nets. These high use values indicate strong community convergence around resources that possess overlapping dual-use profiles, serving concurrently as core s
easonal foods and traditional remedies that form the basis of local medicinal practices.

To counter unpredictable seasonal gaps in forest resource availability, the Paliyar rely heavily on specialized post-harvest preservation strategies (Suroowan & Mahomoodally 2021). The extensive transformation of *Citrus × reshni* (Engl.) Tanaka (FC = 74, RFC = 0.813, UV = 0.81) and *Solanum betaceum* Cav. Into storage -stable pickles or condiments reflects an active domestic mechanism engineered to extend resource utility. Similarly, the systematic processing of *Solanum virginianum* L. (Kandankathiri) into dried powders or decoctions highlights an advanced biochemical literacy, transforming highly perishable wild assets into stable, long-term culinary and therapeutic storage options over extended timelines (Towns *et al.* 2024).

Rationale for retaining naturalized exotic germplasm

To address critical ecological management distinctions, a clear scientific justification explains the retention of semi-wild fruit resources in the dataset. Introduced orchard crops and escaped ornamentals—including *Annona cherimola* Mill., *Annona muricata* L., *Monstera deliciosa* Liebm., *Passiflora edulis* Sims, and *Pouteria campechiana* (Kunth) Behni—were explicitly classified under the specialized category of 'Semi-wild' in Table 2.

In contemporary quantitative ethnobotany, the definition of 'wild' structurally encompasses non-domestication contexts where plants grow spontaneously, naturalize, or escape managed boundaries without direct human propagation or systematic agricultural inputs (Suroowan & Mahomoodally 2021). Because the Paliyar tribe gathers these naturalized exotic assets opportunistically from forest fringes, abandoned orchard tracts, and settlement margins to buffer seasonal nutritional needs, their inclusion is vital to capture the true, functional breadth of the community's foraging web while preserving absolute data integrity regarding native forest composition.

The ethno-ecological dynamic of *Lantana camara* L.

Among the recorded plants, *Lantana camara* L. (Verbenaceae) presents a complex ethno-ecological paradox. Although recognized as an aggressive invasive threat to native shola forest understories (Reddy *et al.* 2021), its fully ripe, dark-purple fruits are consumed opportunistically as a casual forest snack, primarily by children. Informants noted that consumption is strictly infrequent and limited to completely mature fruits, as unripe green berries are locally avoided due to well-known triterpene toxicity concerns (Suroowan & Mahomoodally 2021). Documenting this dynamic highlights how the Paliyar community interacts opportunistically with altered ecosystems without compromising traditional safety protocols.

Anthropological reasons for intergenerational knowledge erosion

The severe generational knowledge gap separating contemporary Paliyar cohorts (Kruskal—Wallis H-test, $p < 0.001$) is driven by deep sociological transitions and shifting economic patterns within the Kodaikanal region. The deep ethnobotanical literacy preserved exclusively by the Elderly Generation cohort (≥ 56 years, mean = 38.8 species) represents a legacy of an era characterized by complete forest dependency and experiential oral learning. In contrast, the steep decline in plant recognition confirmed among the Younger Generation cohort (18 — 35 years, mean = 11.0 species) is a direct result of rapid socio-economic shifts, proven highly significantly by post-hoc testing (Mann—Whitney U = 0.0, $p<0.001$) and mirroring broader global trends in demographic plant literacy erosion (Kouakou & Kouassi 2021).

These modern shifts drastically reduce the operational field hours youth spend traversing forest paths with elders, breaking down the traditional, vertical transmission pathways of oral knowledge. As wild harvesting transforms from an immediate survival necessity into an occasional, highly opportunistic activity, the practical motivation to maintain pomological systems decline, putting this indigenous biocultural heritage at risk of rapid collapse (Towns *et al.* 2024).

Anthropogenic Pressures and Biocultural Conservation Implications

The biological security of these wild fruit resources faces escalating regional pressures, including rapid tourism infrastructure expansion, overgrazing pressures, and climate -induced shifts in forest fruiting synchrony. To mitigate these ecological threats, conservation models must advance beyond passive preservation into active, integrated biocultural frameworks. Because these fruit resources serve as an active economic safety net supporting 24.2 % of surveyed households through local trade, our findings suggest that establishing community-led germplasm seed banks and elder-guided youth educational walks represents a vital pathway to reconcile local forest restoration with the active protection of endangered indigenous

oral knowledge systems. Priority conservation actions must target narrow regional endemics such as *Elaeocarpus variabilis* Zmarzty and *Berberis tinctoria* Lesch., which collectively function as diagnostic indicators of high-altitude montane shola forest matrices (Sreekumar *et al.* 2020; Prakash & Palani 2024). Although globally categorized as Least Concern (LC) on the IUCN Red List, these specific narrow-endemic taxa remain highly locally vulnerable due to strict shola-habitat restrictions and micro-climatic sensitivity along fragmented mountain ecotones (Reddy *et al.* 2021). Developing targeted micro-habitat protection cells is therefore highly recommended to buffer these keystone pomological resources from ongoing developmental fragmentation and invasive encroachment.

Conclusion

This investigation provides a systematic quantitative baseline of 50 wild and semi-wild fruit species spanning 32 taxonomic families utilized by the indigenous Paliyar tribe across the altitudinal matrices of the Kodaikanal Hills. Non-parametric cohort modeling mathematically validates a severe cross-generational breakdown in traditional oral transmission pathways, demonstrating a highly significant erosion of plant literacy within the Younger Generation (18-35 years) compared to the expert Elderly Generation cohort (≥ 56 years) ($p < 0.001$). structurally, the high representation of edge-dwelling understory shrubs (52.0 %) reflects a strategic foraging adaptation to high-altitude shola forest boundaries, were light restrictions force choice pomological resources to cluster along exposed ecotones.

The biocultural implications of this knowledge degradation are profound for regional tribal autonomy. Beyond satisfying immediate nutritional requirements, these forest resources form the basis of local medicinal practices and function as an active economic safety net, where 24.2 % of surveyed households rely on fruit trade to secure alternative income streams during agricultural deficits. Consequently, regional conservation policies cannot succeed as passive preservation measures. To prevent the collapse of this oral heritage, forest management frameworks must suggest pairing targeted micro-habitat protection cells for narrow endemics-such as *Elaeocarpus variabilis* Zmarzty and *Berberis tinctoria* Lesch. – with community-led initiatives, including elder-guided youth field workshops and local biocultural registries.

Future research must expand past descriptive inventories to execute systematic biochemical evaluations, screening the nutritional densities and antioxidant profiles of the high-altitude fruits under shifting climatic stresses. Furthermore, long-term ecological monitoring plots are urgently required along fragmented forest margins to model the exact harvesting pressures and understory displacement dynamics occurring between native shrub germplasm and aggressive invasive weeds like *Lantana camara* L. Bridging quantitative ethnobotanical indicators with systematic phytochemistry will offer an empirical framework to support local agroforestry domestication initiatives and protect indigenous resource access rights across the Western Ghats corridor.

Declarations

List of abbreviations: WEF – Wild Edible Fruits; UV – Use Value; ICF – Informant Consensus Factor; RFC – Relative Frequency of Citation; UV – Use Value; SNC-MH – Saraswathi Narayanan College Meenakshi Herbarium; ISE – International Society of Ethnobiology; IUCN – International Union for Conservation of Nature; LC – Least Concern.

Declaration of generative AI in scientific writing: The authors declare that generative artificial intelligence (AI) tools were used solely to assist in improving the language, grammar, and clarity of the manuscript. These tools were not used to generate scientific content, interpret results, or draw conclusions. All scientific ideas, data collection, and interpretations remain the sole intellectual contribution of the authors.

Ethics approval and consent to participate: Fieldwork protocols and informant interview procedures were approved by the institutional research ethics committee of Saraswathi Narayanan College. Prior Informed Consent (PIC) was formally obtained orally from all Paliyar community leaders, traditional healers, and individual local informants before conducting semi-structured interviews or plant collection. Fieldwork was carried out in absolute adherence to the International Society of Ethnobiology (ISE) Code of Ethics. This investigation complies fully with the international provisions established under the Nagoya Protocol on Access and Benefit Sharing, ensuring that indigenous biocultural property rights and oral traditional knowledge transmission frameworks are legally and culturally respected.

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Authors contribution: Elizabeth Sahaya Rani P: Investigation, Data curation, Formal analysis writing - original draft. Suresh K: Conceptualization, Methodology, Supervision, Formal analysis (Taxonomic identification of plant specimens) Writing - review & editing. Muthuvel U: Validation. Selvakumar S: Visualization. Krishnamoorthi Raman: Software, Writing - review & editing. Kwang-sun Kim: Writing – review & editing.

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