Perceptions of traditional ecological and ethnobotanical knowledge and *Nepenthes* conservation among forest-edge communities in Central Kalimantan: An exploratory study

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Research

Abstract

Background: Traditional ecological knowledge is vulnerable to socio-environmental shifts. This exploratory study investigated community perceptions of traditional uses, intergenerational knowledge transmission, and the conservation of pitcher plants (*Nepenthes* spp., locally known as *sempeng* or *sumpeng*) among a purposive sample of forest-edge residents on the periphery of KHDTK Mungku Baru in Central Kalimantan, Indonesia.

Methods: A socio-ecological survey utilizing semi-structured interviews was conducted with 26 local informants. Descriptive qualitative approaches evaluated informant responses across sociodemographic groups.

Results: Overall, Informants recognized *Nepenthes* pitchers as part of local healthcare practices, primarily as a traditional remedy for respiratory complaints like coughs and asthma. Respondents held mixed perceptions of intergenerational transfer, with half noting that youth still retain plant knowledge, whereas others observed that oral transmission within families appears to be limited among younger residents or remained uncertain. Conversely, forest-edge informants expressed favorable perceptions of preserving *Nepenthes* habitats in peat-swamp and heath forest ecosystems, driven by personal observations of ecological threats such as land conversion and forest fires.

Conclusions: Within this exploratory sample, local perceptions reveal a dual trend: there are informant-perceived limitations in intergenerational knowledge transmission among youth, while willingness to support habitat conservation remains strong. Incorporating these community perspectives into local management plans can support participatory conservation of Nepenthes habitats.

Keywords: Biocultural perception; Forest-edge communities; Intergenerational transmission; Nepenthes; Socio-ecology

Background

Indonesia is a critical global hotspot for the diversity and distribution of pitcher plants (*Nepenthes* spp.), a unique genus of carnivorous plants characterized by specialized leaf-tip modifications that form pitfall traps to capture prey and supplement nutrients. These plants occupy highly diverse ecological niches spanning lowland to montane ecosystems, predominantly thriving in nutrient-poor, acidic, and humid environments such as peat-swamp forests, heath forests, secondary forests, and open, degraded landscapes. The spatial distribution and community composition of *Nepenthes* are profoundly governed by microclimatic fluctuations, soil properties, and open-canopy vegetation structures. For instance, recent ecological assessments in Sumatra documented up to 23 *Nepenthes* species across altitudinal gradients, highlighting that several endemic taxa already face severe extinction threats (Mansur *et al*. 2023). Similarly, studies in Bukit Perasak, West Kalimantan, identified co-occurring populations of *Nepenthes gracilis*, *Nepenthes mirabilis*, and the natural hybrid *Nepenthes X neglecta* thriving under specific microclimatic thresholds, emphasizing that the survival of *Nepenthes* is inextricably linked to the localized environmental health of their native habitats, which are increasingly subjected to anthropogenic pressures and climate-induced transformations (Syamswisna & Karmadi 2023).

Beyond their ecological functions, *Nepenthes* species possess profound socio-cultural values embedded within the traditional ecological and ethnobotanical knowledge of local communities. Throughout the Indonesian archipelago, traditional knowledge regarding *Nepenthes*, encompassing localized nomenclature, distinct morphological categories, ecological indicators, and multifaceted utilitarian practices, has been sustained across generations (Handayani *et al*. 2005). Among the Dayak Seberuang community in West Kalimantan, for example, the robust climbing stems of *Nepenthes* are traditionally harvested for durable binding materials and woven handicrafts, while the pitchers serve as organic vessels for traditional culinary preparation (Setiawan *et al*. 2015). Furthermore, the pristine fluid extracted from unopened pitchers is used as a vital emergency water source in deep forests and formulated as an ethnobotanical remedy for respiratory conditions such as acute coughs and asthma, as well as common gastrointestinal distress (Setiawan *et al*. 2015). This sophisticated intersection between botanical utility and culture highlights that *Nepenthes* conservation cannot be effectively evaluated through a purely biophysical lens but must integrate an ethnobotanical framework to capture its complete socio-ecological value.

Traditionally, this ecological knowledge is acquired through direct environmental immersion and transmitted vertically through oral channels within familial units. Elders, parents, and experienced forest foragers play pivotal roles in transmitting information on plant nomenclature, habitat identification, phenotypic indicators, and processing methods. This biophysical enculturation typically occurs during joint livelihood activities, such as subsistence farming, agroforestry management, non-timber forest product harvesting, and forest navigation (Mashizi & Escobedo 2025). However, modern socio-spatial transformations, including shifts in agrarian livelihoods, rural-to-urban migration, the introduction of formal Westernized education, intensive land-use conversion, and regional biodiversity loss, exert unprecedented disruptive pressures on these intergenerational transmission networks. Ethnobotanical frameworks suggest that while traditional learning relies heavily on place-based practices, acute social and spatial changes often isolate younger generations from their ecological landscapes, potentially contributing to shifts in the transmission of traditional knowledge (Ouma 2022). Consequently, systematic documentation of this vulnerable botanical heritage is urgently needed before it loses its holistic socio-ecological context.

Crucially, the distribution of traditional ecological knowledge within a community is rarely homogeneous; it is heavily differentiated by internal sociodemographic variables. Factors such as chronological age, gender-defined societal roles, occupational exposure, duration of residency, and frequency of forest interactions generate distinct variations in ethnobotanical proficiency. While older generations possess extensive historical-ecological memory due to prolonged environmental exposure, younger generations exhibit highly variable knowledge retention, heavily dependent on the stability of their respective family transmission structures. Furthermore, distinct gender divisions of labor and spatial usage shape different domains of plant interaction without necessarily implying a hierarchy in overall knowledge depth. Therefore, analyzing informant characteristics requires a nuanced approach that avoids simplistic age- or gender-based generalizations, thereby allowing researchers to frame ethnobotanical knowledge as a dynamic, emergent outcome of interactions among individuals, family units, occupations, and their changing environments (Villamor & van Noordwijk 2016).

The Special Purpose Forest Area (*Kawasan Hutan dengan Tujuan Khusus* / KHDTK) of Mungku Baru in Central Kalimantan offers an ideal socio-ecological landscape for investigating this contemporary biocultural dynamic. The forest-edge communities residing on the periphery of this conservation zone, predominantly from the indigenous Dayak community (specifically the Dayak Ngaju), have long-standing lived experiences with local *Nepenthes* populations and identify them by

specific vernacular terms such as *kantong semar*, *sempeng*, and *sumpeng*. Despite this intimate relationship, the community's traditional knowledge systems, particularly regarding localized nomenclature, morphological attributes, habitat seasonality, socio-cultural benefits, and historical shifts in plant abundance, remain relatively under-documented in formal academic literature (Despriando *et al*. 2026). There is a critical knowledge gap regarding how this heritage is transmitted across generations amidst escalating external pressures, and how the community's internal sociodemographic variations influence their perceptions toward habitat threats, agricultural encroachment, and active conservation engagement.

To address these deficiencies, this study comprehensively evaluates the socio-ecological paradox of *Nepenthes* interaction within the KHDTK Mungku Baru through three integrated analytical approaches. First, this research aims to describe the depth of local community knowledge regarding the vernacular nomenclature, morphological traits, habitat typologies, seasonality, and ethnobotanical uses of *Nepenthes*. Second, the study is designed to analyze the mechanisms of intergenerational knowledge transmission and dissect its distribution trends across distinct age and gender cohorts. Finally, the investigation seeks to elucidate the local community's perceptions of ecological population declines, drivers of habitat degradation such as forest fires and land conversion, and their overall willingness to support community-based conservation frameworks. Ultimately, this systematic documentation provides the essential baseline data needed to bridge the gap between biocultural preservation and formal environmental management, paving the way for inclusive, community-led conservation strategies for threatened *Nepenthes* habitats in Central Kalimantan.

Materials and Methods

Study area

The research was conducted among forest-edge communities living adjacent to KHDTK Mungku Baru, situated within Rakumpit Sub-district, Palangka Raya City, Central Kalimantan Province, Indonesia (Fig. 1). Geographically, the core sampling site and field interaction area within KHDTK Mungku Baru are centered around coordinates 1°38'53'' S and 113°42'01'' E (decimal: -1.648056°, 113.700278°). The KHDTK Mungku Baru landscape features tropical lowland peat-swamp and heath forest ecosystems, characterized by acidic soil (pH 5.6-6.3), high relative humidity (79.0-87.5%), and mean daily temperatures of 25.1-32.1°C, thereby providing a natural habitat for *Nepenthes* (Mariaty & Purnama 2023).



Figure 1. Location map of KHDTK Mungku Baru in Rakumpit Sub-district, Palangka Raya, Central Kalimantan, Indonesia (1°38'53'' S, 113°42'01'' E). Map created by the authors using Google Maps.

Research approach and design

This study employed a qualitative-descriptive approach, integrated with an ethnobotanical survey design, to examine traditional ecological knowledge and conservation perceptions regarding *Nepenthes* among forest-edge communities. The qualitative framework captured nuanced community experiences, localized nomenclature, morphological recognition,

habitat typologies, utilization practices, intergenerational transmission dynamics, perceived population shifts, and conservation attitudes. To complement qualitative insights, basic descriptive statistics (counts, percentages, means, medians, and ranges) were used to summarize informant sociodemographic characteristics and thematic response distributions. The design did not seek to test causal relationships but aimed to characterize the socio-ecological interactions between local inhabitants and their surrounding forest landscape (Gonçalves-Souza *et al*. 2022).

Specimen collection and botanical verification

While the local ethnobotanical knowledge documented in this study applies to a broad folk category (*sempeng*/*sumpeng*) that likely encompasses multiple locally occurring *Nepenthes* species, botanical specimens were collected to verify presence within the study site. The specific voucher collected on June 21, 2026, by M. R. F. Pratama, I. Afitah, and H. Fauzia was identified as *Nepenthes ampullaria* Jack (Family: Nepenthaceae). Rather than focusing exclusively on a single botanical taxon, this investigation uses *N. ampullaria* as a representative voucher to confirm the genus's presence in the peat-swamp ecosystem, while the documented traditional uses and vernacular nomenclature reflect the broader folk taxonomy recognized by local communities. Taxonomic determination and verification were conducted by the Herbarium of the *Unit Pelaksana Teknis* (UPT) Laboratorium Herbal Materia Medica Batu, East Java, Indonesia, which serves as the official authority for flora determination. Based on the Certificate of Determination No. 000.9.3/2499/102.20/2026 issued on June 24, 2026, the collected sample was officially confirmed as *Nepenthes ampullaria* Jack, assigned specimen/voucher number 2499/102.20/2026, and permanently deposited in the Herbarium of UPT Laboratorium Herbal Materia Medica Batu.

Informant selection

Informants were selected using a non-probability purposive sampling method based on three primary inclusion criteria: permanent residency in forest-edge settlements peripheral to KHDTK Mungku Baru; direct daily interaction with adjacent forest habitats through agricultural, foraging, or non-timber forest product harvesting activities; and documented personal experience or cultural knowledge regarding the recognition, collection, or utilization of *Nepenthes* (Fig. 2). Ethnicity variables were excluded from the analysis as ethnic self-identification was not explicitly captured in the survey instrument.



Figure 2. The field research team, together with key local informants, conducted a survey in the disturbed habitat surrounding KHDTK Mungku Baru. Photo credit: H. Fauzia. Written informed consent for the publication of photos was obtained from all identifiable individuals.

Data collection techniques and instrumentation

Data were collected through semi-structured interviews using a standardized guide comprising 18 open-ended questions across the factual, conceptual, procedural, contextual, and normative domains (provided in Supplementary Material 1). Primary inquiry topics focused on botanical recognition and vernacular nomenclature of the broad folk category of pitcher plants (*Nepenthes* spp.). This included recording local names such as *sempeng*, *sumpeng*, *pasah kameloh*, and *sepay*, which are rooted in the dialects of the indigenous Dayak communities native to the study location and generally refer to multiple pitcher plant species recognized across these groups, as well as morphological traits used for field identification. The protocol evaluated ecological knowledge regarding habitat preferences across peat swamps, heath forests, secondary growth, and agricultural edges, as well as microclimatic conditions and seasonality. Traditional utilization was investigated through healthcare practices, such as using fluid from an unopened pitcher for coughs, asthma, and gastrointestinal distress, as well

as structural applications, such as stem-binding materials and ornamental uses. Additionally, interviews explored intergenerational transmission pathways by comparing familial networks with formal education and assessing perceived knowledge retention among youth. Finally, conservation perceptions were examined by gathering data on historical population trends, ecological threat drivers such as forest fires and land conversion, harvest norms, and local willingness to participate in community-based conservation initiatives (DeJonckheere & Vaughn 2019).

Data analysis

Informant sociodemographic data were evaluated using descriptive statistics to calculate key summary metrics. Qualitative interview transcripts and field notes underwent thematic analysis through systematic data immersion, initial coding, category grouping, and thematic synthesis. The coding framework applied was emergent, meaning that analytical categories were derived directly from the informants' narratives rather than being forced into predetermined theoretical constructs. In instances where an informant provided multiple responses to a single open-ended question (e.g., listing multiple habitat types, overlapping medicinal uses, or multiple drivers of environmental threats), their answers were coded into all applicable categories, with multiple responses permitted. Conversely, incomplete, ambiguous, or off-topic responses were excluded from specific thematic denominators to preserve data integrity. Consequently, the denominators used to calculate response percentages reflect only the number of valid responses or the specific subset of informants relevant to each thematic question, rather than the total sample size across all variables. Six major analytical themes were established: vernacular nomenclature and identification, habitat and seasonal ecology, traditional functional utilization, intergenerational knowledge pathways, perceptions of environmental change and threats, and conservation awareness and management attitudes (Dahal 2025). Response frequencies and percentages were calculated to contextualize trends in qualitative data without asserting population-wide statistical generalizations. Sub-group comparisons across age cohorts and gender roles were conducted purely descriptively due to sample size constraints and demographic imbalances among informants.

Data trustworthiness and ethical considerations

Data trustworthiness was ensured through informant triangulation, cross-checking responses across interconnected interview questions, and auditing field interview records. Incomplete or ambiguous responses were excluded from thematic interpretations to preserve data integrity. Ethical guidelines for human research were strictly upheld by obtaining verbal informed consent from all participants after a detailed explanation of the study objectives and by maintaining individual confidentiality throughout data handling. Formal ethical clearance for this study was granted by the Research Ethics Committee of Universitas Muhammadiyah Palangkaraya on June 18, 2026 (No. 143e/PTM63.R7/LP2M/KEP/2026). Local healthcare claims regarding pitcher fluid were analyzed strictly in terms of ethnobotanical heritage rather than validated clinical efficacy.

Results

Informant demographics

A total of 26 local inhabitants in the vicinity of KHDTK Mungku Baru participated in the study (Table 1). Valid age data were obtained for 26 informants, ranging from 17 to 75 years, with a mean of 48.7 years and a median of 49.0 years. The 45–59 age group constituted the largest cohort at 46.2% (n=12), while the 30–44 and ≥60 age groups comprised 20.0% (n=5) each, and the 17–29 age group represented 12.0% (n =3). By gender, 80.8% of informants were male (n=21) and 19.2% were female (n=5). Male informants predominantly engaged in subsistence farming, rubber tapping, and non-timber forest product collection, whereas female informants primarily managed domestic households, attended school, or maintained long-term village residency. Survey protocols did not record self-identified ethnic backgrounds, precluding cross-ethnic comparative analyses.

Table 1. Informant sociodemographic characteristics

Sociodemographic Characteristic	Category	Count (n)	Percentage (%)
Age Group (years)	17–29	3	11.5
	30–44	5	19.2
	45–59	12	46.2
	≥60	6	23.1
	Total	**26**	**100.0**
Gender	Male	21	80.8
	Female	5	19.2
	Total	**26**	**100.0**

Local recognition and vernacular nomenclature

All informants (100%) recognized the broad folk category of pitcher plants (*Nepenthes* spp.) upon visual presentation, primarily identifying them by the specialized pitfall pitcher attached to the leaf tip, trailing stems, elongated leaves, and trumpet-like or speckled pitcher morphology. Vernacular nomenclature was highly consistent, with 92.3% of informants (n=24) identifying the plant as *sempeng* or *sumpeng*, alongside localized variants such as *pasah kameloh*, *pasat kameloh*, and *sepay*, which are rooted in the dialects and naming traditions of the indigenous Dayak communities residing in the study location. Informants aged 45-59 and >60 years articulated vernacular names spontaneously and linked them to specific forest locations, whereas younger informants frequently cited parental instruction as their naming source. Nomenclature showed no clear differentiation between genders.

Habitat knowledge and seasonal occurrence

Informants identified *Nepenthes* populations across secondary forests, shrublands, old agricultural fallows, roadside verges, peat swamps, burned lands, and orchard margins (Fig. 3). Preferred substrates were described as moist, waterlogged, sandy, or peaty soils. Regarding seasonality, 69.2% of informants (n=18) reported year-round presence without seasonal restriction, 23.1% (n=6) associated peak visibility with the rainy season due to enhanced pitcher fluid accumulation, and 7.7% (n=2) were uncertain. Older informants described a broader range of micro-habitats than younger cohorts, while male informants detailed habitats in relation to land clearing and forest navigation.



Figure 3. A cluster of lower pitchers of *Nepenthes ampullaria* Jack recorded on the forest floor within the KHDTK Mungku Baru peat-swamp ecosystem. Photo credit: H. Fauzia.

Traditional utilization and medicinal practices

Informants documented multifaceted utilitarian values, including traditional medicine, ornamental yard planting, emergency drinking water, stem-binding materials that replace rattan, and commercial sale (Table 2). Regarding healthcare, 46.2% of informants (n=12) were aware of medicinal applications, and 30.8% (n=8) reported direct personal use or observation of this general folk category of pitcher plants rather than a specific botanical species. Primary therapeutic indications targeted respiratory ailments (coughs and asthma), gastrointestinal distress, and musculoskeletal pain. The predominant administration method involved extracting and drinking uncontaminated fluid directly from young, unopened pitchers (closed pitchers), explicitly avoiding mature, open pitchers due to insect contamination (Miguel *et al*. 2018). As noted by a 47-year-old male informant: "*We learned about this from our parents when we went into the forest; if someone at home has a severe cough or asthma, we take the closed liquid from young pitcher plants to drink as a traditional remedy*." Medicinal awareness was concentrated among older informants aged 45-59 and >60 years (n=9 out of 18) compared to younger cohorts (n=2 out of 8).

Table 2. Informant knowledge and experience regarding medicinal utilization of *Nepenthes* spp. (n = 26).

Medicinal Utilization Dimension	Response Category	Count (n)	Percentage (%)
General Awareness	Aware of or heard about medicinal uses	12	46.2
	Unaware / Never heard about medicinal uses	14	53.8
Direct Experience	Personally used or witnessed usage	8	30.8
	No personal use or never witnessed usage	18	69.2

Sources and intergenerational knowledge transmission

Familial elders (parents, grandparents, and senior relatives) represented the primary knowledge source for at least 88.5% of informants (n=23), with secondary sources including formal schooling, literature, and community figures. Knowledge acquisition occurred through place-based immersion as children accompanied their parents to agricultural fields or forests. Regarding youth retention, 50.0% of informants (n=13) perceived that younger generations retain *Nepenthes* knowledge; 38.5% (n=10) reported limited or declining retention due to shifting modern lifestyles and reduced forest exposure; and 11.5% (n =3) remained uncertain (Table 3). Experiential transmission was exemplified by a 17-year-old informant who demonstrated detailed extraction of medicinal fluid, learned directly from parental guidance.

Table 3. Informant perception of youth knowledge retention.

Informant Perception	Count (n)	Percentage (%)
Youth still possess knowledge	13	50.0
Knowledge is limited or declining	10	38.5
Uncertain / Cannot determine	3	11.5
Total	**26**	**100.0**

Perceptions of population changes and ecological threats

When evaluating historical population dynamics, 65.4% of informants (n=17) were uncertain whether local *Nepenthes* abundance had changed, 26.9% (n=7) reported a noticeable population decline, and 7.7% (n=2) perceived stable or abundant populations (Table 4). As expressed by a 23-year-old male informant: *"I am not really sure if the number of pitcher plants around here has decreased or stayed the same. We rarely go deep into the swamp forest nowadays, so it is hard to tell whether their population has actually changed over the years."* Informants citing declines (based on a relevant denominator of n=7, where multiple responses were permitted) attributed them to anthropogenic disturbance, including land clearing, forest fires, agricultural expansion, mining, and wetland drainage. Male informants more frequently specified industrial land conversion and fire history, reflecting their daily spatial interactions with forest boundaries.

Table 4. Informant perception of *Nepenthes* population trends.

Perceived Population Trend	Count (n)	Percentage (%)
Declining or reduced abundance	7	26.9
Relatively constant or abundant	2	7.7
Uncertain / Do not know	17	65.4
Total	**26**	**100.0**

Community attitudes toward conservation and governance

Informants expressed strong positive attitudes toward protecting *Nepenthes*, citing its morphological uniqueness, therapeutic value, ornamental appeal, economic potential, and status as a regional icon (Rizki *et al*. 2025; 2021). However, 100% of informants reported an absence of formal customary rules (*adat*), village regulations, or harvest quotas governing *Nepenthes* collection. To bridge this management gap, community members proposed training in cultivation, sustainable harvesting methods that preserve parent plants, and clear identification of medicinal versus ornamental varieties (Fig. 4).



Figure 4. Community discussion and spatial orientation session with local stakeholders in Mungku Baru Village. Photo credit: H. Fauzia. Written informed consent for the publication of photos was obtained from all participants.

Discussion

Within this exploratory study, the purposive sample was composed predominantly of middle-aged informants aged 45–59 years (46.2%) and male respondents (80.8%). This demographic pattern reflects long-term spatial interaction with adjacent forest, agricultural, and peat-swamp landscapes, enabling older foragers and farmers to accumulate historical-ecological memory regarding plant distribution and habitat shifts. However, chronological age does not solely dictate the depth of knowledge, as certain younger informants also demonstrated specialized awareness of medicinal fluid collection, acquired directly through parental instruction. This dynamic aligns with ethnobotanical assessments in natural-resource-dependent communities, where plant proficiency is shaped interactively by age, occupational exposure, frequency of environmental immersion, and the structural integrity of familial learning pathways (Beltrán-Rodríguez *et al*. 2014).

The higher representation of male informants in this study reflects gendered labor divisions in forest-edge settlements, where men more frequently engage in land clearing, timber extraction, and deep-forest navigation. In this sample, male respondents tended to articulate detailed observations regarding land-use conversion and remote habitats, whereas female informants primarily contextualized *Nepenthes* within domestic healthcare and family well-being, such as administering pitcher fluid for respiratory and gastrointestinal complaints. As demonstrated in comparative ethnobotanical literature, gendered variations in botanical knowledge stem from differentiated social spheres, daily responsibilities, and spatial movement rather than innate differences in cognitive capacity (da Costa *et al*. 2021). Furthermore, because survey instruments did not record self-identified ethnicity, cross-ethnic comparative analysis was omitted to avoid unjustified cultural generalizations.

Within this purposive sample of forest-edge residents selected for their known forest interactions, visual recognition of *Nepenthes* was complete (100%), with high consensus on vernacular nomenclature (92.3% citing *sempeng* or *sumpeng*). While these figures should not be interpreted as prevalence estimates for the broader regional population, they confirm that *Nepenthes* remains culturally embedded in the local ecological vocabulary of those actively interacting with the forest. The

documented linguistic variants, including *pasah kameloh*, *pasat kameloh*, and *sepay*, illustrate localized phonetic adaptations and familial naming traditions. Similar vernacular diversity has been documented among Dayak Sampit communities, who employ the term *tabeko* based on teapot-like pitcher morphology (Idamansyah & Ayatusa'adah 2021). Local recognition relies predominantly on prominent macro-morphological markers, such as terminal leaf pitchers, climbing vining stems, and colorful peristomes, rather than microscopic or floral taxonomic traits. This practical, utility-driven folk classification mirrors observations in the Mandor Nature Reserve, where community members recognized pitcher plants broadly but rarely distinguished individual species (Mansur *et al*. 2020).

Community observations of habitat preferences across peat swamps, heath forests, secondary shrublands, and agricultural margins align broadly with the ecological spectrum of *Nepenthes* in nutrient-poor, acidic, and high-humidity tropical environments (Gaume *et al*. 2016). While 69.2% of informants noted year-round availability, 23.1% associated peak pitcher development with the rainy season, highlighting how localized hydrology influences plant detection. Integrating local habitat mapping with formal botanical inventories presents a pragmatic strategy for future species-level conservation around KHDTK Mungku Baru.

Mungku Baru residents recognize *Nepenthes* as a multi-purpose bioresource with health, aesthetic, structural, and commercial value. The use of climbing stems as durable binding substitutes for rattan and the collection of juvenile plants for ornamental yard gardens mirror ethnobotanical practices reported among the Dayak Seberuang in West Kalimantan (Setiawan *et al*. 2015). However, the commercial extraction of wild specimens poses ecological risks if market demand escalates without ex situ nursery propagation (Khuraijam & Roy 2015).

Ethnomedicinal applications focus on drinking fluid extracted from young, unopened pitchers to treat respiratory conditions such as coughs and asthma, as well as gastrointestinal and musculoskeletal distress. Selective harvesting of sealed pitchers demonstrates an intuitive community understanding of fluid hygiene by avoiding mature, open pitchers that are susceptible to insect decomposition and environmental contamination. While laboratory evaluations of a different botanical species, *Nepenthes mirabilis*, have isolated bioactive constituents with *in vitro* anti-inflammatory properties (Thao *et al*. 2016), this pharmacological evidence strictly concerns a distinct species from our verified *N. ampullaria* specimen and serves solely as comparative context for the genus's bioactivity, rather than validating the clinical efficacy of the local application. Variations in preparation methods, unstandardized dosages, and the absence of clinical safety evaluations underscore the necessity for systematic bioactivity-guided screening and phytochemical profiling before endorsing pitcher fluid for therapeutic applications.

Vertical transmission within familial units (>88% from parents and grandparents) serves as the primary mechanism for preserving *Nepenthes* heritage. Knowledge acquisition occurs through place-based experiential learning during subsistence agricultural work and non-timber forest product harvesting (Ouma 2022). While half of the informants believed youth still retain knowledge, 38.5% reported perceived limitations in knowledge retention among youth, attributing these to modern socio-economic shifts, formal schooling that excludes local flora, and reduced youth participation in forest activities. Global synthesis studies emphasize that local ecological knowledge is increasingly vulnerable to socio-spatial transformations, urbanization, and market integration (Aswani *et al*. 2018). Preserving this biocultural legacy requires embedding traditional ecological knowledge into local school curricula and community-led conservation programs.

Notably, a substantial majority of informants (65.4%) expressed uncertainty about long-term trends in *Nepenthes* populations. This high degree of uncertainty is a key finding in its own right, demonstrating a significant gap in systematic local ecological monitoring. Among the minority of informants (26.9%) who perceived a noticeable decline in *Nepenthes* abundance, these reports represent strictly informant-reported perceptions and local observations, rather than independently verified ecological metrics. These informants attributed the perceived declines to land conversion, recurring forest fires, agricultural expansion, and wetland drainage. While these represent subjective community observations of environmental threats, they align with independently demonstrated ecological threat assessments documented across Kalimantan (Utari *et al.* 2023). Crucially, 100% of informants reported no formal customary regulations or harvest quotas governing *Nepenthes* collection. Given that *Nepenthes* species are internationally regulated under CITES Appendix II (Robinson & Roberts 2024), this regulatory vacuum poses a conservation risk should commercial exploitation increase.

Despite the absence of formal harvest rules, community attitudes toward conservation remain highly positive, motivated by the plant's aesthetic uniqueness, cultural identity, and perceived medicinal value. Informants expressed explicit interest in receiving technical training on cultivation, sustainable harvesting techniques that safeguard parent plants, and species

identification. Operationalizing this conservation awareness through community-based mapping discussions, community-managed nurseries, and local harvest agreements provides an inclusive framework for protecting both *Nepenthes* populations and traditional ecological and ethnobotanical knowledge in KHDTK Mungku Baru (Aswani *et al*. 2018).

Limitations of the study

Several methodological limitations should be considered when interpreting the findings of this exploratory study. First, the reliance on a non-probability purposive sampling method, coupled with a small sample size (n=26) and demographic imbalances, such as a high proportion of male informants and a predominance of middle-aged cohorts, limits the generalizability of the results to the broader regional population. Second, the data rely primarily on self-reported perceptions and qualitative recall, which may be subject to subjective bias. Third, the cross-sectional design lacks a longitudinal assessment of intergenerational knowledge transmission, limiting the ability to track temporal changes in youth knowledge retention. Finally, the absence of systematic ecological population monitoring means that reported historical trends and perceptions of habitat threats reflect subjective community observations rather than independently verified quantitative ecological metrics.

Conclusion

This study demonstrates that forest-edge communities peripheral to KHDTK Mungku Baru possess strong traditional ecological knowledge of *Nepenthes*, recognizing its distinct pitcher morphology, peat-swamp and heath forest habitat preferences, and diverse utilitarian values spanning medicinal drinking fluid for respiratory complaints, ornamental planting, structural stem bindings, and economic trade. Intergenerational knowledge transfer is primarily driven by vertical transmission within familial units during place-based forest activities; while older cohorts hold broader historical-ecological experience, knowledge retention varies among youth, and gender differences reflect distinct daily spatial activities rather than cognitive capacity. Despite experiencing informant-perceived limitations in intergenerational knowledge transmission and facing habitat threats from land conversion and fires amidst an informant-reported lack of customary harvest rules, community members maintain favorable attitudes toward conservation, as evidenced by local proposals for plant cultivation and sustainable harvesting. Ultimately, integrating this enduring local knowledge into formal collaborative spatial documentation, ex-situ cultivation, local harvest governance, and youth-oriented environmental education is essential to safeguard both threatened *Nepenthes* populations and traditional ecological and ethnobotanical knowledge in Central Kalimantan. Furthermore, as this study represents non-commercial documentation of traditional knowledge and does not involve the extraction of genetic resources for commercial research and development, it complies with local institutional ethics frameworks and does not trigger formal commercial benefit-sharing mechanisms under the Nagoya Protocol.

Declarations

List of abbreviations: KHDTK - *Kawasan Hutan dengan Tujuan Khusus* (Special Purpose Forest Area); CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Ethics approval and consent to participate: The study adhered to ethical and legal guidelines for research involving human participants and traditional ecological knowledge. Formal ethical clearance was granted by the Research Ethics Committee of Universitas Muhammadiyah Palangkaraya on June 18, 2026 (Approval No. 143e/PTM63.R7/LP2M/KEP/2026). Verbal informed consent was obtained from all informants prior to interviews, following a clear explanation of the research objectives and assurances of confidentiality.

Consent for publication: Written informed consent for the publication of identifiable photographs (Fig. 2 and Fig. 4) was obtained from all participants.

Availability of data and materials: The qualitative datasets and survey records generated during the current study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare no competing interests.

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Supplementary Material 1
Semi-Structured Interview Guide

Section 1: Botanical Recognition and Vernacular Nomenclature

1. How do you and your family locally name the pitcher plant (e.g., *sempeng, sumpeng, pasah kameloh, sepay*), and are these terms specific to the Dayak community in this village?
2. What are the main physical features (morphological traits) you look for to recognize and identify this plant in the wild?
3. Do you recognize different variations or types of this plant? If so, how do you distinguish them from one another?

Section 2: Ecological Knowledge and Habitat Preferences

4. In what types of environments or habitats (e.g., peat swamps, heath forests, secondary forests, or agricultural edges) do you usually find this plant growing?
5. What are the typical soil and moisture conditions in the areas where this plant thrives?
6. Can you find this plant all year round, or is it more abundant during specific seasons? Why do you think that is?

Section 3: Traditional Functional Utilization

7. What are the traditional uses of this plant within your family or community?
8. How is the plant utilized for healthcare or traditional medicine (e.g., treating coughs, asthma, or stomachaches)?
9. Which specific parts of the plant are used for medicine (e.g., the fluid from unopened pitchers), and how is it prepared or consumed?
10. Aside from medicinal uses, are there other practical applications for this plant, such as using the stems for binding materials, crafts, or collecting it as an ornamental plant?

Section 4: Intergenerational Knowledge Pathways

11. Who originally taught you about this plant, its name, where to find it, and how to use it?
12. How is knowledge about this plant currently being passed down to your children or the younger generation in your family?
13. In your observation, do the youth in this village still retain knowledge about this plant and its traditional uses? Why or why not?
14. Do you feel that modern lifestyles or formal schooling have affected how much the younger generation learns about local forest plants compared to traditional familial teaching?

Section 5: Perceptions of Environmental Change

15. Based on your personal observations over the years, is the population of this plant in the surrounding forests increasing, decreasing, or remaining stable?
16. What do you perceive as the main threats driving changes to this plant's habitat (e.g., forest fires, land conversion, agricultural expansion)?

Section 6: Conservation Attitudes

17. Are there any local customary rules (*adat*), village regulations, or harvesting norms that limit how much of this plant can be collected from the wild?
18. How would you feel about participating in community-based initiatives or training to protect this plant, such as learning sustainable harvesting methods or cultivating it locally?