The utilization of purwodadi botanical garden as a source of research and biological education media

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Abstract
Purwodadi Botanic Garden (KRP) has great potential as an ex-situ conservation center as well as a natural laboratory for supporting biological research and education, yet its utilization as a learning resource remains limited and is often dominated by recreational purposes. This study aims to explore the collection of lowland dry flora in KRP as a medium for biology education based on outdoor learning. The research employed a descriptive approach through student internship activities conducted in May–July 2025, including species identification, morphological and ecological observations, recording of adaptive traits, and documentation of the collections. Data analysis was complemented by literature studies and linked to the Biology Curriculum of UIN Sunan Kalijaga. The results showed that KRP manages more than 11,000 specimens from approximately 2,472 plant species that can be studied across 28 branches of biological sciences, such as morphology, ecology, ethnobotany, and orchidology. These collections offer significant opportunities for the development of teaching modules, field practices, and student research, while also highlighting the relevance of KRP as an applied learning resource. Direct observations further revealed various adaptive traits of lowland dry plants, such as thick leaves, succulent stems, and stilt roots, which serve as concrete examples in ecological and physiological studies. Therefore, this research emphasizes that KRP not only plays an essential role in conservation but can also be effectively utilized as an educational medium to enhance conceptual understanding, learning motivation, and environmental conservation awareness among students.

Keywords: biology education; ex-situ conservation; learning; Purwodadi Botanic Garden

1. Introduction
Botanical gardens fulfill multidimensional roles that extend far beyond recreational purposes. As centers for conservation, research, and education, they have become essential to both biodiversity preservation and scientific advancement. Their role is particularly significant within the framework of sustainable development, where conservation, research, and environmental education are integrated to balance economic needs with nature conservation, especially in regions designated as Biosphere Reserves (Apriliani et al., 2024; Irawanto, 2024).

The contribution of botanical gardens to global conservation has been well established. To date, at least 105,634 plant species are maintained in botanical gardens worldwide, representing approximately 30% of global plant diversity and including more than 41% of threatened species (Mounce et al., 2017). This underscores the fundamental role of botanical gardens in ex situ conservation, which is crucial for preventing species extinction. Over time, the research focus of botanical gardens has shifted from traditional taxonomy toward conservation biology and genetics (Irawanto, 2024).

In addition to their conservation function, botanical gardens serve as important centers for biodiversity and environmental studies. Research activities conducted within these institutions encompass investigations of vegetation diversity, spatial analyses of collection distribution, and comprehensive plant inventories. The outcomes of these studies not only contribute to scientific knowledge but also support sustainable conservation and the utilization of natural resources (Apriliani et al., 2024; Irawanto, 2024).

However, the use of botanical gardens by the public remains predominantly tourism-oriented. Since their inception, botanical gardens have fulfilled multiple functions, initially serving as medicinal gardens for medical students and later evolving into public educational facilities, thereby positioning themselves as important instruments for learning (Chen et al., 2018; Irawanto, 2024). Nevertheless, recent studies indicate that several obstacles continue to hinder the optimal utilization of botanical

gardens as "natural laboratories" in formal education, particularly due to financial constraints and maintenance challenges (Putri et al., 2025).

Enhancing the educational role of botanical gardens is essential to bridging this gap. One effective strategy is the implementation of internship programs, which provide students with opportunities to gain direct field experience. Such programs enable students to connect classroom theory with practical applications, while also deepening their understanding of the significance of botanical gardens in conservation and research (Apriliani et al., 2024; Irawanto, 2024). Furthermore, to ensure a more structured learning process, there is an urgent need for reliable and practical educational resources, including comprehensive learning guides (Angio, 2020).

The Purwodadi Botanical Garden (KRP), located in Pasuruan, East Java, plays a pivotal role in conserving the distinctive flora of Indonesia's dry lowland forests, which are both ecologically unique and of high scientific value. Established on January 30, 1941, KRP was founded to address the urgent need for conserving dry lowland plant species that could not be optimally preserved at the Bogor and Cibodas Botanical Gardens. Since its public opening in 1963, KRP—currently managed by the National Research and Innovation Agency (BRIN)—has continued to develop through collection expansion, facility improvement, and the exchange of genetic resources, with the vision of becoming a leading center for the conservation and research of dry lowland plants in Indonesia (Putri et al., 2023). Covering an area of 85 hectares and housing 183 family-based plant collections, KRP is recognized for its unique and highly valuable assemblage of dry lowland plant species (Sulistiani et al., 2020).

As part of the Indonesian Botanical Gardens network, the Purwodadi Botanical Garden (KRP) carries out key functions that include ex situ conservation, research, education, and the preservation of rare species from dry tropical ecosystems. Beyond its role as a conservation area, KRP also serves as a valuable research resource, providing opportunities for students and researchers to engage directly in field-based studies. Research activities at KRP primarily focus on documenting endangered plant species and exploring their potential applications (Sulistiani et al., 2020; Angio, 2020). Through its conservation and research initiatives, KRP plays a critical role in safeguarding the native flora of Indonesia's dry lowland forests, while simultaneously advancing scientific knowledge, supporting environmental sustainability, and contributing to the well-being of society.

This potential presents significant opportunities for the development of KRP as an outdoor-based biology learning center. According to Saputri et al. (2023), this learning approach has been shown to enhance student motivation and academic achievement at the university level. Similarly, recent studies highlight the important role of botanical gardens as platforms for conservation education, particularly in fostering environmental awareness through direct interaction with plant collections (Apriliani et al., 2024). Despite this, limited research has examined the educational use of botanical gardens in relation to the unique dry lowland plant species conserved at KRP. Further investigations are therefore necessary to address this gap and to optimize KRP's role as a center for experiential biology education, aligned with the theoretical framework of experiential learning (Beard & Wilson, 2018).

Based on this background, the present study focuses on two main questions: (1) how the KRP collection of dry lowland plants can be utilized as a source for biological learning, and (2) how internship-based activities can serve as an effective educational medium. The purpose of this research is to highlight the relevance of KRP as a field-based medium for biology education and to explore the potential of its dry lowland plant collections as teaching materials.

2. Methods

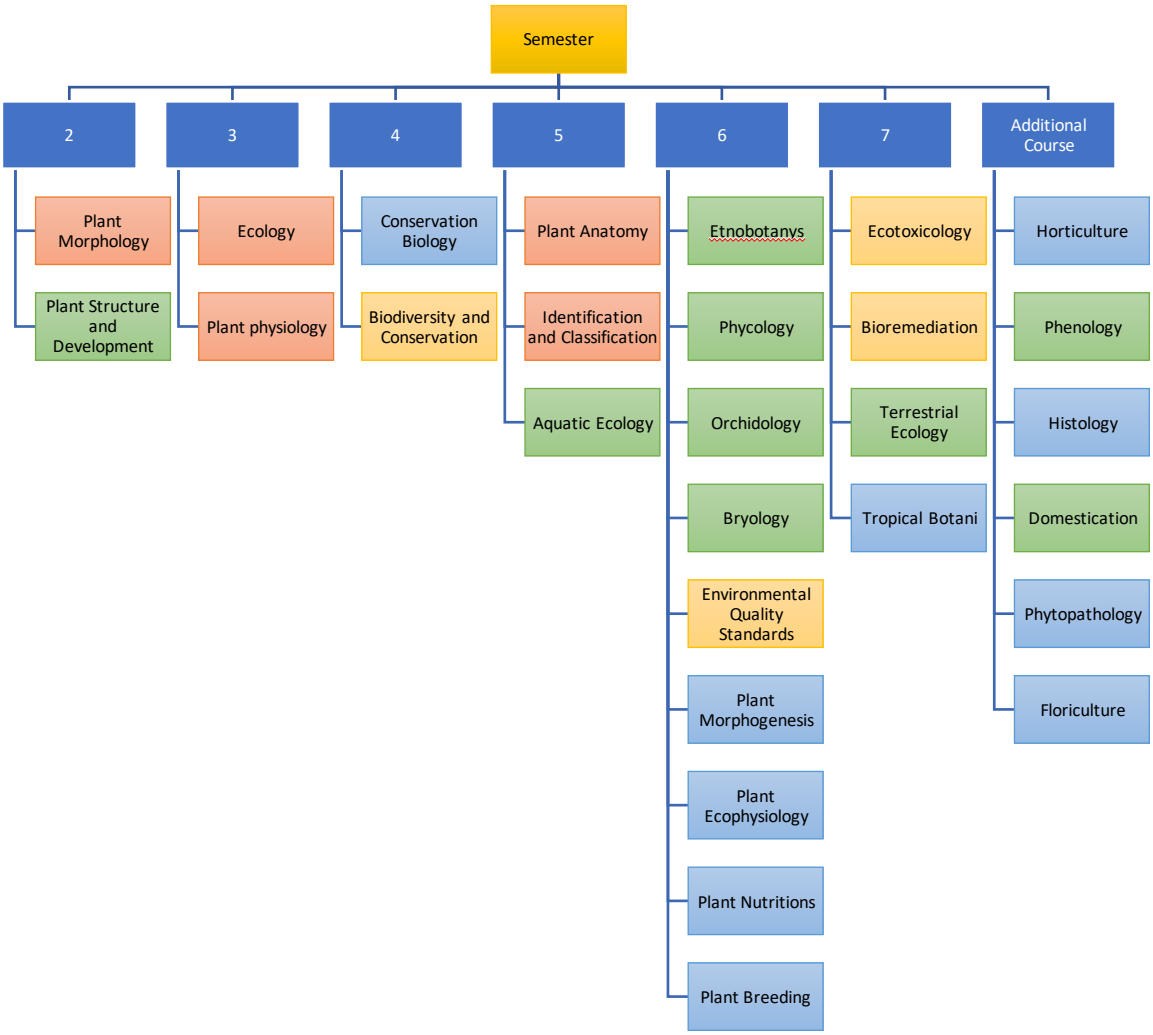
This study employed a descriptive-experimental approach based on internship experiences, conducted at the Purwodadi Botanical Garden (KRP), Pasuruan District, East Java, between May and July 2025. The research focused on the collection of dry lowland plants, observed in terms of their morphology, ecology, and potential as resources for biological research and educational media. The research procedures included species identification using floras and interpretive signboards; morphological observations of roots, stems, leaves, flowers, and fruits; documentation of adaptive characteristics; field notes; and visual documentation through photographs and sketches. The instruments used comprised observation sheets, cameras/phones, simple measuring tools, plant identification books, and writing devices (notebooks and laptops). Data analysis was conducted using relevant literature and online resources, including the Biology Study Programme curriculum of UIN

Sunan Kalijaga (https://biologi.uin-suka.ac.id/id/page/kurikulum), as a reference for developing biology learning materials. The analysis was presented in a qualitative descriptive form, through narrative explanations and tabular data, to illustrate the potential of KRP's plant collections as biological learning resources.

3. Results and Discussion

The Purwodadi Botanical Garden (KRP) serves as an important center for the conservation of Indonesia's biodiversity, particularly the dry lowland flora of East Java, Southeast Nusa Tenggara, Sulawesi, and Maluku. KRP functions as a natural laboratory that offers extensive opportunities for biological research and education. Its diverse plant collections provide a basis for the study of multiple biological disciplines. According to the Biology Study Programme curriculum of UIN Sunan Kalijaga Yogyakarta, at least 28 branches of biology can be explored using the collections available at KRP (Table 1).

Table 1. Curriculum Structure of the Biology Study Program



: Major Branches of Biology
: Specialized Branches of Biology
: Interdisciplinary Branches of Biology
: Future Branches of Biology

KRP manages more than 11,000 living specimens representing approximately 2,000 species cultivated across six habitat types. Its diverse plant collections provide opportunities for studying

multiple branches of biology, including morphology, anatomy, ecology, physiology, conservation, and ethnobotany. Through direct observation, students and researchers can examine plant adaptations to dry environments—such as thickened leaves, succulent stems, and elongated root systems—while simultaneously enhancing biology education through modules, worksheets, and field-based practices. This broad potential positions KRP not only as a conservation center but also as a valuable medium for biological education. Nevertheless, its utilization for student learning and academic research remains relatively limited to date.

3.1. Plant Morphology

Plant morphology, as a fundamental branch of science, plays a crucial role in defining plant characteristics. It encompasses the study of the external form and structure of plant organs, including roots, stems, leaves, flowers, fruits, and seeds. Such information provides essential support for further research, particularly in species identification and classification. Morphological observations also serve as concrete phenotypic data for genetic studies and experiments. Moreover, morphological traits often become reference models for understanding reproductive biology, including the differentiation between domesticated and wild types (Nasution, N.H. & Nasution, I.W., 2024).

Plant morphology is closely linked to physiology, as it reflects the cycles and adaptive patterns of plant life. For instance, the morphology of xerophytic plants such as cacti, in which leaves are modified into spines, demonstrates an adaptive strategy to minimize water loss through evaporation. Similarly, aquatic plants (hydrophytes) with high transpiration rates, such as *Nymphaea* (lotus), exhibit morphological adaptations—such as narrow or specialized leaf structures—that help maintain water balance (Handayani, 2020).

The plant collections at the Purwodadi Botanical Gardens (KRP) provide significant opportunities for morphological studies. One notable example is research on the morphological diversity of sorus positions in the Polypodiaceae family. The study aimed to identify variations in sorus form and position, as well as their correlation with other morphological characteristics. Findings revealed that members of the Polypodiaceae exhibit diverse sorus types, including circular, garland-shaped, coenosorus, and acrostichoid forms. These structures occur in distinct positions, often aligned with the leaf veins, and may be arranged regularly, irregularly, or in clusters (Utami, 2015).

Another morphological investigation was conducted on the vegetative organs of the Pandanaceae family by Rachma (2013). This study examined the kinship relationships among members of the Pandanaceae collection at KRP based on the morphometric characteristics of their vegetative organs. The results highlighted several distinctive traits of the family, such as the presence of prop roots (tunjang roots) in certain species, aerial roots in others, and stiff, strap-shaped leaves with thorny margins arranged spirally. In addition, members of the Pandanaceae produce small, unisexual flowers, and are generally dioecious (Rachma, 2013).

Morphometric analyses and observations of the drupaceous Ficus collection at KRP have yielded not only morphometric data but also insights into their correlations and potential applications in ethnobotanical studies. For example, the leaves and stems of Hedruthyea were reported to contain chemical compounds with potential medicinal properties, including antimalarial, antidiabetic, antibacterial, and anticancer activities (Angio, 2022).

Morphological studies of various plant taxa conducted at the Purwodadi Botanical Gardens (KRP) have made significant contributions to the advancement of botanical sciences, particularly in supporting collective efforts in taxonomy and plant conservation. Observable data derived from the KRP collections—such as those of the *Polypodiaceae*, *Pandanaceae*, and *Orchidaceae* families—serve as valuable references for understanding interspecific relationships within plant families. Furthermore, morphological investigations provide a robust foundation for subsequent studies in classification, genetics, and even plant breeding.

The Purwodadi Botanical Gardens (KRP) function as a natural laboratory that provides substantial benefits for both university students and the wider public. The diversity of its plant collections enables visitors to directly examine morphological characteristics across a range of taxa, including both wild types and domesticated varieties. Field-based activities such as species identification, phenotype documentation, and morphological structure recording can be conducted on site, offering valuable hands-on experience. Consequently, the KRP serves as an essential and inclusive learning platform—

not only for the academic community but also for the broader public interested in exploring and applying knowledge of Indonesia's biodiversity.

3.2. Ecology

According to Burnie (2000) and Indriyanto (2006), ecology encompasses the study of populations, communities, ecosystems, hierarchical levels of life, trophic interactions, energy and matter flows, as well as biogeochemical cycles. This discipline provides a fundamental framework for understanding the complexity of interactions between organisms and their environments. Moreover, ecology highlights the importance of equitable and sustainable resource management by integrating social, economic, and ecological considerations. It also plays a critical role in addressing global environmental challenges such as pollution and climate change, while contributing to human well-being through a deeper understanding of biodiversity and ecosystem health.

The Purwodadi Botanical Garden (KRP) can be regarded as an artificial ecosystem that closely resembles the natural conditions of dry tropical ecosystems. Through its diverse plant collections originating from various tropical regions, particularly dry lowlands, KRP represents broad ecological diversity. As an artificial ecosystem, KRP facilitates an understanding of the complex interactions between plants and their physical environments, including soil, light, climate, and water availability (Irawanto, 2024). These characteristics make KRP an ideal site for studying the responses of dry tropical plants to environmental stresses, especially variations in light intensity and drought conditions (Sulistiani et al., 2020).

The study of ecology at KRP encompasses various interspecific interactions. For example, plants compete for essential resources such as nutrients, water, and light, while also establishing symbiotic relationships with soil microorganisms. Moreover, KRP illustrates predator–prey dynamics, as seen in the presence of insectivorous plants that utilize insects as supplementary nutrient sources. These plant types enable research on ecological adaptation strategies that are rarely addressed in conventional classroom-based learning (Burnie, 2000; Indriyanto, 2006).

Various studies conducted at KRP highlight its potential as an open ecological laboratory. Research on parasitic infestations demonstrates real parasitism between pests and host plants (Solikin, 2022). Investigations of tree canopy structure and its influence on hydrological performance reveal plant interactions with abiotic environmental factors such as rainfall and water distribution (Darmayanti & Fiqa, 2021). Furthermore, studies on odonata diversity confirm the close linkages between flora and fauna in shaping ecological networks (Khafi et al., 2024), while research on leaf decomposition rates in pond ecosystems illustrates the role of microorganisms in organic matter cycling (Idaheryana et al., 2025). Collectively, these findings affirm that KRP functions not only as a conservation center but also as an effective site for studying diverse ecological processes.

As an open laboratory, KRP provides opportunities for direct observation of ecosystem dynamics. Researchers and students can investigate the distribution of endemic species, plant responses to drought, and the interactions between plants, wildlife, and pollinators within the garden (Sulistiani et al., 2020). In addition to advancing biodiversity conservation and management, ecological observations at KRP are significant in providing real-world insights into species–environment relationships (Edwards & Jackson, 2019).

From an educational perspective, KRP holds strategic value as a medium for ecological learning. The life cycles of plants, food chains, and adaptive strategies of diverse collections can be directly observed by students (Saputri et al., 2023). Such field-based activities help to clarify ecological concepts that often remain abstract when taught solely in classroom settings (Putri et al., 2025). Thus, beyond its research functions, KRP also serves as an interactive, relevant, and applied ecological learning facility (Angio, 2020).

3.3. Ethnobotany

Ethnobotany is the study of plant utilization within the cultural context of human communities, encompassing purposes such as food, medicine, traditional ceremonies, cosmetics, and timber resources (Ramadhan et al., 2017). Based on the collections of the Purwodadi Botanical Garden (KRP), a number of species with high ethnobotanical value have been documented. In the food category, *Artocarpus altilis* (breadfruit) has long been used as an alternative carbohydrate source. KRP also conserves various

local fruit trees, such as *Diospyros blancoi* (bisbul), *Mangifera indica* and *Mangifera odorata* (mango), *Citrus maxima* (grapefruit), *Psidium guajava* L. (guava), *Annona squamosa* (sugar apple), *Syzygium cumini* L. (jamblang), and *Dimocarpus longan* Lour. (longan). This collection reflects KRP's role in preserving local germplasm that is increasingly rare in community landscapes.

The ethnobotanical resources at KRP also include plants of high timber value, such as *Tectona grandis, Aquilaria filaria, Dracontomelon dao, Agathis borneensis*, and *Canarium asperum*. These species are not only crucial as building materials but also serve as important economic assets in their native regions. Notably, *Tectona grandis* contributes beyond timber use, as its flowers are incorporated into batik motifs, symbolically intertwined with other patterns to represent local cultural identity (Mahrani et al., 2025). In addition, KRP houses collections of plants used in traditional ceremonies and rituals, including *Cananga odorata* (ylang), *Jasminum sambac* (jasmine), *Piper betle* (betel), and *Plumeria* sp. (frangipani). The presence of these culturally significant species underscores the role of KRP as a conservation repository supporting the preservation of cultural and spiritual values in Indonesian society.

KRP also maintains a wide array of plants utilized in cosmetics and traditional medicine. Examples include *Stelechocarpus burahol* (burahol), jasmine, and ylang, which are used as natural bases for perfumes and cosmetics. Medicinal plants conserved in the garden include Tinospora crispa (brotowali), *Piper betle* (betel), *Arcangelisia flava* (yellow root), *Coleus amboinicus* (Indian borage), *Styrax benzoin* (frankincense), *Cinnamomum verum* (cinnamon), and *Strychnos lucida*. These collections demonstrate that KRP functions not only as a center for botanical conservation but also as a living repository for ethnobotanical research. Furthermore, they support the preservation of traditional knowledge, biodiversity conservation, and the exploration of plant-based economic opportunities for local communities.

3.4. Orchidology

Orchidology, derived from orchid and logos/logi (science), refers to the scientific study of orchids, encompassing their morphology, biodiversity, and taxonomy. This field also covers the understanding of cultivation patterns and techniques, species-specific habitat requirements, internal and external factors affecting growth, as well as the management of pests and diseases.Within the context of internship-based learning at the Purwodadi Botanical Garden (KRP), students gain valuable opportunities to develop essential field skills in botanical studies. These include species identification through morphological observation, orchid care, watering and fertilization techniques, light management, and pest–disease control. Students are also trained in inventory and documentation skills, such as scientific name verification, plant label inspection, updating collection databases, photographing, and preparing morphological descriptions. The collected data are then compiled into scientific reports or articles. Thus, internship programs at KRP not only provide hands-on practical experience but also generate academic outputs that contribute to botanical research and education.

In addition to student-oriented learning, orchidological research has also been actively conducted at KRP. Renjana & Hendrawati (2019), for example, carried out an inventory of orchid collections as a reference for study visits. Their research recorded 670 orchid specimens, representing 48 genera and 124 species. Among these, *Dendrobium* was the most dominant genus (28 species), followed by *Coelogyne* (10 species), *Bulbophyllum* (9 species), and *Eria* (6 species). Notable collections include *Cymbidium finlaysonianum* (64 specimens), *Paphiopedilum glaucophyllum* (31 specimens), *Coelogyne asperata* (27 specimens), and *Spathoglottis plicata* (23 specimens). Some orchids, such as *Paphiopedilum glaucophyllum*, hold significant conservation value as they are endemic to Java and categorized as rare in Indonesia. These findings confirm that the orchid collection of KRP not only supports botanical research but also holds strategic importance in education and biodiversity conservation.

Further studies in KRP's orchidology include research by Yulia (2009), who evaluated the flowering times of orchid species from 2007–2008. The study revealed species-specific flowering durations and highlighted seasonal patterns, with *Paphiopedilum glaucophyllum* exhibiting the longest flowering time and many species showing peak flowering in July. Another notable study by Ulfa (2016) investigated the floral color composition of *Dendrobium* orchids in the KRP collection. The research focused on color variations as significant morphological traits in breeding and aesthetics. Observations

emphasized the visual attributes of sepals, petals, and the labellum, which are primary diagnostic features in Orchidaceae morphology. Although the study primarily examined floral color, supplementary data on flower size and shape were also recorded, contributing to the understanding of varietal differences and quality assessment (Ulfa, 2016).

3.5. Biodiversity and Conservation

The scope of biodiversity and conservation science encompasses the variation of life at the genetic, species, and ecosystem levels. This field also addresses various threats to biodiversity sustainability, including deforestation, habitat fragmentation, and the impacts of climate change. In response, conservation efforts are increasingly crucial, involving management strategies for conservation areas, community participation, and policy support at both national and international scales (Leksono, 2015).

As one of the world's megabiodiversity countries, Indonesia faces considerable pressure on the sustainability of its biological resources. These pressures stem largely from infrastructure development, agricultural and plantation expansion, and the consequences of global climate change (Jainuddin, 2023). Within this context, the Purwodadi Botanical Garden (KRP), as part of the national ex-situ conservation system, plays a strategic role in the inventory, documentation, and protection of endangered plant species. Research at KRP has explored the functional characteristics of plant collections, including trade-off analyses between morphological traits and physiological performance (Chen & Sun, 2018).

Located in East Java, KRP has a vital responsibility in conserving the flora of the unique and highly valuable dry lowland forest ecosystem. Since its public opening in 1963, KRP has made substantial progress through the expansion of species collections, the development of research and visitor facilities, and active involvement in the exchange of genetic resources. With its vision of becoming a center of excellence for dry lowland plant conservation and research in Indonesia, KRP continues to strengthen its role through initiatives that integrate biodiversity conservation, scientific advancement, and the promotion of community welfare (Putri et al., 2023).

According to recent data, KRP maintains more than 11,000 specimens representing approximately 2,472 species, distributed across six environmental zones categorized by taxonomic affinity and ecological traits (Sulistiani et al., 2020). Among these, Zones IV and VI host the greatest species diversity and individual abundance, indicating high conservation intensity and successful acclimatization and propagation (Apriliani et al., 2024). Such distribution patterns reflect adaptive conservation strategies tailored to the taxonomic requirements and reproductive potential of the species collected (Smith, 2019).

Several of KRP's flagship collections hold significant ecological and research value. Nymphaea lotus demonstrates protogynous pollination with specialized pollinators (Hirthe & Porembski, 2003), while Ceiba pentandra plays an important ecological role through nocturnal pollination by bats (Nathan et al., 2005). Meanwhile, Paphiopedilum species are rare orchids with unique floral morphologies and prolonged blooming periods, yet are vulnerable to overexploitation, thus necessitating conservation-focused population studies (Zhang et al., 2021; Romadlon et al., 2021). These species exemplify the dual role of KRP's collections as subjects of high scientific relevance and contributors to ecosystem function.

KRP serves as an open-air laboratory that facilitates public education and community engagement. Thematic gardens, such as aquatic and orchid gardens, function as interactive learning spaces for understanding the value of ecological restoration and natural resource management, including phytoremediation processes by aquatic plants (Irawanto, 2024). Active community involvement in these programs fosters a sense of social ownership and strengthens ecological awareness, reinforcing KRP's role as not only a botanical institution but also a catalyst for sustainable social transformation (Edwards & Jackson, 2019).

KRP has advanced digital transformation initiatives, notably through the Makoyana platform, which provides open access to plant collection data (Apriyanto, 2022). The platform includes detailed information on species, conservation status, morphology, geographical distribution, and photographic documentation. Digitization enhances research accessibility while fostering national and international collaboration in biodiversity conservation (Asaniyah, 2017; Edwards & Jackson, 2019). Such technology-driven resources are critical for evidence-based policy development and for positioning botanical gardens as central nodes in biodiversity information networks. By adopting adaptive and

participatory conservation approaches, KRP contributes simultaneously to environmental protection and to the integration of social, economic, and educational benefits for ecosystem and community sustainability.

4. Conclusion

The plant collection at the Purwodadi Botanical Garden (KRP) offers an extensive scope for scientific inquiry, encompassing at least 28 branches of biological sciences. Among these, research in plant morphology, ecology, ethnobotany, orchidology, and conservation biology has been the most prominent, contributing significantly to the advancement of botanical and ecological knowledge. Beyond conserving diverse species characteristic of the unique dry lowland ecosystem, KRP also functions as an open-air laboratory that supports conservation-oriented research and educational initiatives addressing contemporary environmental challenges. Through this integrated role, KRP combines long-term research, education, and empirical practice, thereby establishing itself not only as a conservation center but also as a vital medium for contextual biology learning.

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