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Bridging Taxonomic Gaps to Define Conservation Priorities for Sri Lanka's Wild *Oryza* Species

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ABSTRACT

Wild rice species are vital to rice breeding programs as they harbour valuable agronomic traits, including resistance and tolerance to a wide range of biotic and abiotic stresses. However, their natural populations are rapidly declining due to both natural and anthropogenic pressures, creating an urgent need for effective conservation strategies. This study gathered expert opinions on taxonomic gaps and conservation challenges related to Sri Lankan wild rice species from taxonomists, researchers, and conservationists at national and international levels. Data were collected using an online questionnaire developed using Google Forms and shared with university academics, researchers working on Sri Lankan wild rice, and staff from the Rice Research and Development Institute (RRDI), the Plant Genetic Resources Centre (PGRC) and the International Rice Research Institute (IRRI), Philippines. It was also distributed to plant taxonomists, ecologists, and conservationists from Asia, Europe, Australia, Africa, and the Americas. Semi-structured interviews with key stakeholders further enriched the dataset. Results showed strong recognition of the value of wild rice, with 93.8% of respondents rating it as very important, although 61.7% believed the public is largely unaware of its significance. More than half supported integrating wild rice into national biodiversity conservation policies (51.9%) and acknowledged its commercial potential (69.1%). Many respondents viewed the current cultivar-naming system as inadequate (69.1%), emphasized the need for molecular tools to identify desirable traits (69.7%), and highlighted the importance of updating international databases (64.2%). Conservation priorities were strongly supported, with 95% of the participants supported new protected areas and 92% supporting the expansion of existing ones. Overall, the findings underscore the critical need for improved taxonomic resolution, enhanced molecular characterization, strengthened conservation initiatives, and increased public awareness to safeguard Sri Lanka's wild *Oryza* species to ensure the long-term conservation and sustainable use of Sri Lanka's wild *Oryza* genetic resources.

Keywords: Agronomic traits, Conservation, *Oryza*, Protected areas, Sri Lanka, Taxonomy, Wild rice

1. INTRODUCTION

Sri Lanka represents an important secondary center of diversity for rice genetic resources [1]. Five wild species of *Oryza*, *O. nivara* S.D. Sharma (AA genome), *O. rufipogon* Griff (AA genome), *O. eichingeri* Peter (CC genome), *O. rhizomatis* D.A. Vaughan (CC genome) and *O. granulata* Nees (GG genome) are known in Sri Lanka and *O. rhizomatis* is considered endemic to the country[2]. Wild rice species possess several valuable traits, such as bacterial blight resistance in *O. rufipogon* and *O. nivara*[3] blast resistance in *O. rhizomatis*[4] and high biomass production in *O. rufipogon*[5,6] that are useful for cultivated rice plant breeding programmes. Additionally, *O. rufipogon* has contributed genes that enhance

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elongation ability, salinity tolerance, and cold tolerance[7,8]. Importantly, all five Sri Lankan wild rice species have been incorporated into breeding programs to develop varieties resistant to the brown plant hopper[6]. However, as these species are facing various threats, it is essential to take urgent steps to ensure the conservation of these species.

The conservation of wild *Oryza* species in Sri Lanka can be achieved through *in- situ* strategies, such as protecting their natural habitats, and *ex-situ* approaches, including seed storage and maintenance in gene banks and botanical gardens[9]. In Sri Lanka, the Plant Genetic Resources Centre (PGRC) in Gannoruwa serves as the primary institution responsible for ex- situ conservation of wild rice, while the International Rice Research Institute (IRRI) supports these efforts at the global level[10]. Enlargement of existing protected areas or establishing new, small-sized protected areas has been suggested to enhance the effectiveness of *in-situ* conservation [11]. Sajeevan et al. (2023)[12] reported that *O. rhizomatis*, *O. eichengeri* and *O. rufipogon* are considered top priority species for in- situ conservation in Sri Lanka, as most of their population are located outside existing protected areas. Areas with high species richness also require particular attention, as they are currently classified as poorly protected. Nearly half of the known populations occur outside protected zones and are therefore entirely unprotected. For ex-situ conservation, collections of *O. granulata* and *O. rhizomatis* should be expanded, as current accessions held at IRRI and PGRC do not adequately represent all populations reported in recent studies and field surveys, with many existing accessions being outdated[12].

Morphological similarities among Sri Lankan wild rice species have been recognized[13], it remains unclear how these gaps are prioritized by different stakeholders such as plant taxonomist, plant breeders, conservation biologists, policy makers, researchers or how they influence broader conservation and research efforts. Therefore, a survey is essential to capture expert consensus on the severity of these gaps, identify areas requiring urgent revision, and assess whether existing taxonomic knowledge is sufficient for effective conservation planning. Such evidence-based insights will ensure that future taxonomic studies are aligned with practical conservation needs and policy development. Identification during the reproductive stage is considerably easier than at the seedling or vegetative stages[13]. This limitation in detailed taxonomic information poses significant challenges for *ex-situ* and *in-situ* conservation planning, as well as for the strategic utilization of wild rice in rice breeding programs, where precise knowledge of genetic resources is essential.

Even though few taxonomic gaps including the Morphological similarities have reported by researchers there are no studies conducted to gather the perspective of taxonomist, researchers and conservationist regarding the priority of the taxonomic gaps and conservation priorities. Thus, this survey conducted among taxonomists, researchers and conservationist also the semi structured interview was done with the farmers and local people aims to gather their insights on conservation priorities and taxonomy gaps, highlighting the critical role of expert knowledge in guiding the preservation and sustainable use of Sri Lanka's wild rice resources.

2. MATERIALS AND METHODOLOGY

2.1 Stake holder identification

The stakeholders relevant to this study are organized into three distinct groups. (i) researchers carried out research on wild rice species in Sri Lanka and other countries. All the researchers carried out research on wild rice species for the last ten years were choose (ii) university and academic staff experts in taxonomy in Sri Lanka and other countries. This information was gathered from the University websites. All the state university in Sri Lanka was considered. (iii) the relevant organizational bodies involved in the conservation of Sri Lankan wild rice species in district, national and international level.

2.2 Data acquisition

Two complementary methodologies were employed in this study an ethno biological survey and semi-structured interviews. An ethno biological survey is a structured approach for documenting traditional knowledge of biological resources, including their uses, cultural significance and management practices within local communities and among experts[14]. Semi-structured interviews are a qualitative data collection method in which the researcher uses a flexible interview guide consisting of open-ended questions[15]. Semi-structured interviews were conducted with farmers and local community members, while the ethno biological survey was used to capture the perceptions 24 taxonomists, 27 researchers, and 30 conservationists, yielding a total of 81 responses. An online questionnaire consisting of 27 questions organized into six sections was developed and distributed to the relevant stakeholders via email.

The survey comprised six sections designed to capture opinion on the conservation priorities and taxonomy gaps of Sri Lankan wild rice species. The sections included: A) Important of Sri Lankan wild rice species, B) current status and threats, C) barriers to conservation and collaboration, D) taxonomic classification and gaps, E) future directions and Priorities, F) in-situ and ex- situ conservation strategies. The section A highlights the importance of wild rice species, the reasons behind their significance, the level of public awareness, and their potential for commercial use. The section B addresses the extent of habitat degradation, existing threats, and associated challenges. The section C discusses issues related to collaboration and management efforts. The section D examines the current taxonomic classification, difficulties in identifying Sri Lankan wild rice species, the value of morphological traits, the need for molecular approaches, limitations in taxonomic resources, the importance of periodically updating IRRI data, and existing taxonomic gaps. The section E emphasizes the role of wild rice in future breeding and food security, while also identifying priority areas to strengthen taxonomic research in Sri Lanka. Finally, the section F evaluates the effectiveness of establishing new protected areas or expanding existing ones, along with the role of ex situ conservation strategies.

We built a "knowledge index" (KI) on questions Q1, Q17 and Q19 to analyses respondents' level of knowledge about the taxonomic gap and conservation priorities of Sri Lankan wild rice species. A composite Knowledge Index (KI) was developed using responses to Questions Q1, Q17, and Q19 to quantify respondents' understanding of taxonomic gaps and conservation priorities of Sri Lankan wild rice species. Each question was scored as 1 for a correct answer and 0 for an incorrect response, following the standard procedure for constructing knowledge indices[16]. Individual knowledge scores were obtained by summing the total number of correct responses for each participant.

To standardize these scores, a Knowledge Index (KI) was calculated using the formula

$$\text{KI} = \frac{Number\ of\ correct\ responses}{Total\ number\ of\ questions} \text{ x } 100$$

The resulting KI values were expressed as percentages and categorized into three levels based on Bloom's cut-off points: High knowledge: 80–100%, Moderate knowledge: 60–79%, Low knowledge: <60%. Similar to this an "awareness index" (AI) was built on questions Q3, Q6 and Q11 to analyze participants' awareness on degradation, public people awareness and taxonomic classification of Sri Lankan wild rice species. Overall response from conservationist, researchers and taxonomist were analyzed and a pie chart was made to interpret the results.

Semi-structured interviews were carried out to explore the challenges and possible solutions related to taxonomic gaps and conservation priorities of Sri Lankan wild rice species. The respondents included local people, farmers, and community members residing in close proximity to wild rice habitats. This approach was chosen to capture the perspectives of those with direct interactions and experiences with these species. The interview format allowed participants to freely share their knowledge, perceptions, and

insights on issues concerning conservation practices, taxonomic difficulties, and the future management of wild rice resources. The interviews were conducted with 42 participants from the dry, wet, and intermediate zones of Sri Lanka, and each interview lasted approximately 20 minutes.

Data Analysis

Data from the expert opinion survey were entered into Microsoft Excel. Summary statistics were used to analyze the 1–5 Likert-scale questions. Chi- square test was performed to check the significant different among the overall response from taxonomist, conservationist and researchers.

3. RESULTS AND DISCUSSION

Profile of the participants: Participants are with different languages including English, Sinhala and Tamil with males and females with different age group from Sri Lanka and other countries. A total of 145 questionnaires were distributed, and 81 participants responded.

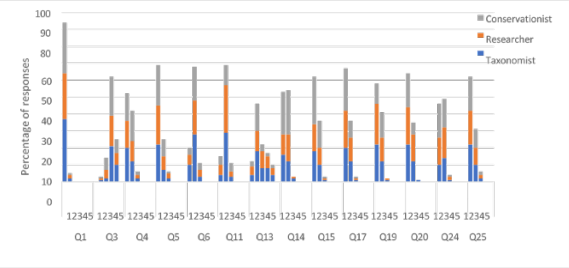

Figure 1. Participants' responses to the Likert scale questions

Results from the "Knowledge Index" (KI) reveal that 72.4% of the respondents (taxonomist, researchers and conservationist) have moderate knowledge on understanding of taxonomy gaps and conservation priorities of Sri Lankan wild rice species. A total of 65.8% of the respondents (taxonomist, researchers and conservationist) scored in the "Medium" category for the "Awareness Index" (AI).

The distribution of responses across the Likert scale for each survey question varied. Questions such as Q1 showed a strong consensus toward higher agreement levels, whereas questions like Q3, Q5, Q19 and Q25 (Awareness, commercial utilization, important in taxonomic diversity and important of expanding protected areas respectively) revealed wider variability with many responses clustered at the lower end of the scale. Q13 (field of taxonomic research) demonstrated the greatest spread, indicating diverse opinions among respondents. Several questions, including Q14, Q15, Q17, Q20, and Q24 (Usefulness of morphological traits, important of molecular research, updating the IRRI accessions, establishment of centralized data base and establishment of new protected areas respectively) displayed very narrow distributions, reflecting strong uniformity in responses. Overall, the plot highlights both the areas of consensus and the questions where perceptions were more divergent (Figure 2).

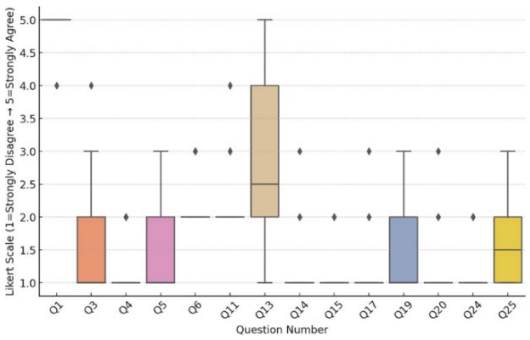

Figure 2. Visualization of results from Likert-scale questions. The graph shows box-plots representing interquartile ranges of participants' answers to Likert-scale questions

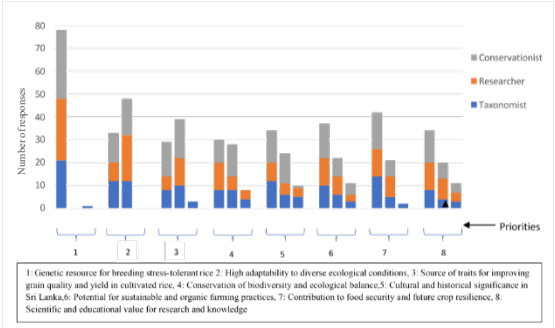

Figure 3. Participants' responses to the top three priorities for the importance of Sri Lankan wild rice species (Question 2)

Genetic resource for breeding stress-tolerant rice, contribution to food security and potential for sustainable and organic farming practices were reported as the top three priorities for the importance of Sri Lankan wild rice species

(Figure 3). Wild species of rice provide a wide range of favourable characters and is a valuable reservoir of genetic resources[17]. Moreover, improving rice varieties by incorporating desirable traits from wild relatives may lead to advance in rice breeding, as the wild species of rice seems to harbour significantly higher genetic a phenotypic diversity than the cultivated rice[18].

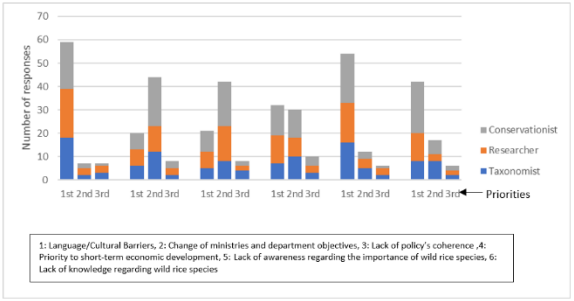

Figure 4. Participants' responses to the top three challenges that hamper collaboration among Sri Lankan wild rice in Sri Lanka (Question 9)

The top three challenges identified were lack of awareness about the importance of wild rice species, insufficient knowledge regarding these species, and Language/Cultural Barriers (Figure 4). Public awareness plays a crucial role in conservation, as local communities, farmers, and stakeholders who understand the ecological and economic value of wild rice. Awareness can be increased through targeted educational programs, community workshops, inclusion of wild rice topics in school curricula, awareness campaigns, and citizen science initiatives that engage the public in monitoring and protecting wild rice habitats[19,20].

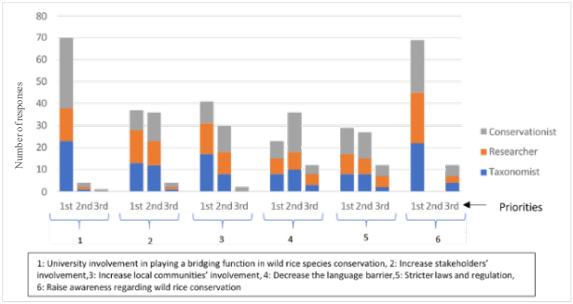

Figure 5. Participants responses to the top three management actions of Sri Lankan wild rice species in Sri Lanka (Question 10).

The top three management actions were identified as University involvement, raising awareness regarding wild rice conservation and increasing stake holders' involvement (Figure 5). Engaging communities and stakeholders through education, workshops, and participatory programs can strengthen conservation efforts and promote sustainable use of wild rice resources.

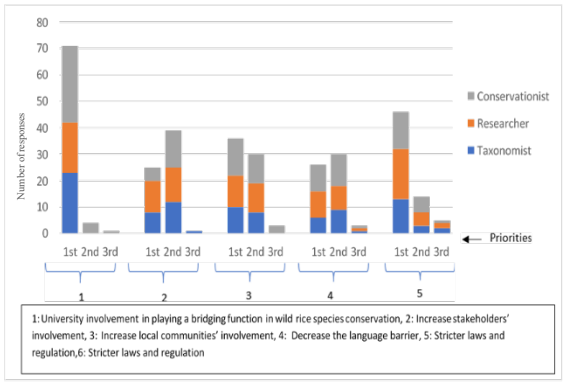

Figure 6. Participants' responses to the resources lacking for taxonomic work of Sri Lankan wild rice species in Sri Lanka (Question 16).

University involvement in playing a bridging function in wild rice conservation, increasing stakeholders' involvement and stricter laws and regulations were recorded as the resources lacking work of Sri Lankan wild rice species (Figure 6). Enhancing university participation can facilitate research-based conservation strategies, while stakeholder collaboration ensures coordinated efforts. Strengthening legal frameworks is also essential to provide effective protection and long-term sustainability of wild rice populations.

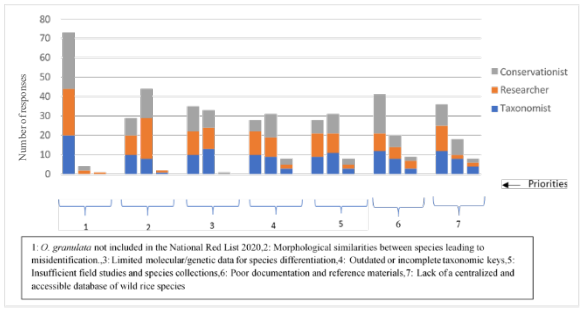

Figure 7. Participants' responses to the main taxonomic gaps of Sri Lankan wild rice species in Sri Lanka (Question 18)

Limited molecular data, morphological similarities between species and errors in the national red list were recorded as taxonomic gaps of Sri Lankan wild rice species (Figure 7). Researchers should be encouraged to conduct

further studies on molecular characterization and morphological identification of Sri Lankan wild rice species, as such research is critical for informing effective conservation and breeding strategies.

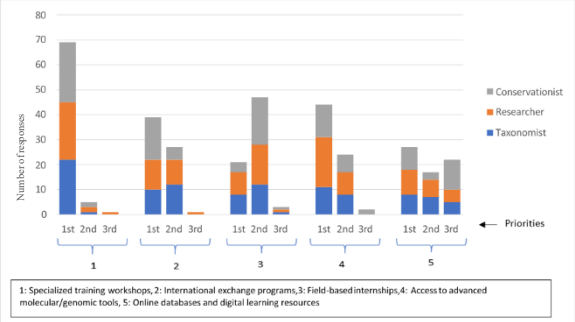

Figure 8. Participants' responses to the form of capacity building most useful for the future taxonomist in Sri Lanka (Question 22)

International exchange program, field-based internship and access to advanced genomic tools were recorded as the top useful for the future taxonomist (Figure 8). International exchanges provide exposure to global best practices and collaborative research opportunities, while field internships allow hands-on experience in species identification, habitat assessment, and conservation techniques. Access to advanced genomic tools further enables detailed molecular characterization, helping to resolve taxonomic ambiguities and support breeding and conservation programs.

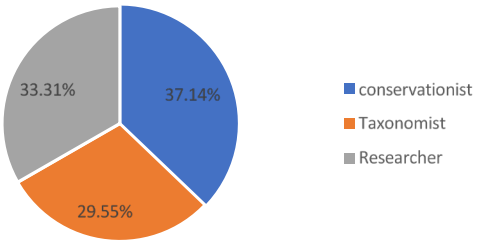

Figure 9. Distribution of overall response from conservationists, taxonomists and researchers

A total of 2,636 responses were recorded across the three expert groups. Of these, Conservationists contributed the highest proportion, accounting for 37.14% (n=979) of all responses, followed by Researchers with 33.31% (n= 878) and Taxonomist with 29.55% (n=779). The distribution of responses differed significantly among the three groups, as confirmed by Chi- square goodness-of-fit test ($\chi^2 = 22.76$, df = 2, $p < 0.001$). The accompanying pie chart visually demonstrates this imbalance, highlighting the greater representation of conservationists relative to taxonomists and researchers (Figure 9).

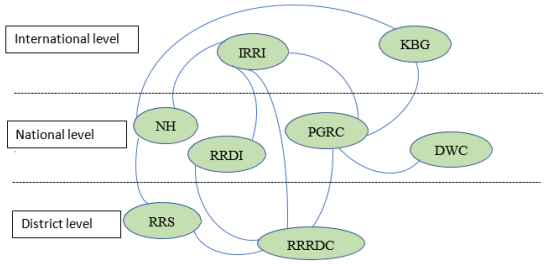

Figure 10. Collaboration network between different organization involved in the conservation of Sri Lankan wild rice species at district, national and international. RRS – Rice Research Station, RRRDC – Regional Rice Research Development Centre, RRDI – Rice Research and Development Institute, NH-National Herbarium, PGRC- Plant Genetic Resource Centre, DWC –Department of Wildlife Conservation, IRRI-International Rice Research Institute, KBG-Kew Botanical Garden.

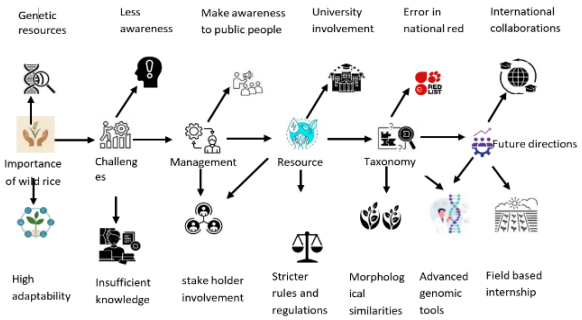

Figure 11. Graphical illustration showing the stake holder opinion about the challenges, management actions, taxonomy gap and future direction towards conservation of Sri Lankan wild rice species

Semi-structured interview: Interview respondents indicated that *O. nivara* has been traditionally used in cultivation, and in some communities, it is also believed to hold devotional or cultural significance. From the farmers' perspective, however, *O. nivara* is often regarded as a troublesome weed in paddy fields. Farmers reported that they regularly remove the species prior to cultivation in order to prevent

competition with cultivated rice. In many cases, they resort to burning the plants as a control measure, aiming to stop its further spread and minimize negative impacts on rice yields. They also suggested that the seed shattering tendency in *O. nivara* limits its suitability for commercial cultivation. Out of 42 participants 32% could specify at least one species of Sri Lankan wild rice species; the species mentioned more often include *O. nivara* and *O. rhizomatis*, which is named by the local name Uru wee. But none of them are familiar with *O. rufipogon*, *O. granulata* and *O. eichengeri*. This may be attributed to the fact that this species typically inhabits undisturbed areas, particularly shaded forests and sites near water bodies.

A coordinated network of national, local, and international organizations plays a crucial role in conserving Sri Lankan wild *Oryza* species through both *in-situ* and *ex-situ* strategies. National institutions such as the Plant Genetic Resources Centre (PGRC) and the Rice Research and Development Institute (RRDI) secure genetic diversity by maintaining wild-rice accessions in gene banks, supporting long-term preservation and breeding research. *In-situ* efforts are largely linked to protected areas managed by the Forest and Wildlife authorities, although only about 23% of wild-rice populations currently fall within these zones[12], highlighting the need for expanded habitat protection. International collaboration, particularly with the International Rice Research Institute (IRRI), provides added security through genetic backup and global research integration. Collectively, this multi-level network enhances the *in-situ* and *ex-situ* conservation and future utilization potential of Sri Lanka's wild *Oryza* resources.

4. CONCLUSION

This study identifies key conservation priorities and taxonomic gaps in Sri Lankan wild rice species, which represent important genetic reservoirs for crop improvement and food security. Despite their recognized value, awareness remains limited and is largely confined to a few well-known taxa, particularly *Oryza nivara* and *Oryza rhizomatis*. The findings reveal significant challenges in taxonomy, conservation, and coordination, including inadequate identification resources, limited molecular studies, and weak collaborative frameworks. Expert opinions underscore the urgency of addressing taxonomic gaps through capacity building, modern molecular approaches, and strengthened conservation strategies. Effective safeguarding of Sri Lanka's wild rice diversity requires integrated scientific research, stakeholder collaboration, and community participation, supported by national and regional research institutions and herbaria to ensure long-term conservation and sustainable management.

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