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Oryza coarctata: the name that best reflects the relationships of Porteresia coarctata (Poaceae: Oryzeae)

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Oryza coarctata is a herbaceous species that serves as an important source of germplasm for salt tolerance in rice breeding. Despite biosystematic and phylogenetic studies showing that its closest relatives are other species of *Oryza*, many taxonomists continue to place it in the monospecific genus *Porteresia* because it is morphologically and ecologically distinct from other species of *Oryza*. Such a treatment obscures the reality of its genetic similarities to *Oryza*. The authors strongly recommend returning this species to *Oryza*. This will have the added advantage of ensuring that all those reading about the species will immediately understand its importance to rice breeding.

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Introduction

The binomial system for naming plant species is a valuable tool for conveying information. The question that divides many taxonomists is the nature of the information that should be conveyed. It was Linnaeus' Species plantarum (Linnaeus 1753) that lead to their universal use by botanical taxonomists. In this work Linnaeus combined the convenience of the binomial system with an approach to classification that made it easier for others to determine where a plant belonged in his classification.

Linnaeus' classification relied entirely on morphological characters, so the binomials that he used conveyed information about morphological similarity. As understanding of the reasons that plants can be placed into categories increased, it became generally accepted that species in a genus were more closely related to each other than to species in other genera. "Related to" was understood to mean "genetically related" even though, in most instances, it had to be inferred from morphological and anatomical similarity. Recent years, we have seen development of molecular techniques permitting direct examination of the nucleic acids that provide the genetic blueprint for individual plants and numerical techniques for analyzing these data that reflect explicit assumptions concerning evolution.

In most instances, the new approaches reinforce or suggest minor changes to taxonomic treatments based on heuristic consideration of traditional morphological characters. There are, however, some exceptions. The perennial *Oryza coarctata* Roxb. (2n=4x=48) of the tribe Oryzeae (Poaceae) is a tufted

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herbaceous species that grows in the coastal and tidal regions of India and Myanmar (Watson & Dallwitz 1988). Because of its unique ecological habitats in the mangrove locations and the associated salt tolerance feature, great interest has been aroused in understanding the mechanism of its salt tolerance (Flowers et al. 1990; Farooq et al. 1996; Rangan & Swaminathan 2002). Research programs, that involve hybridization of *O. coarctata* with Asian cultivated rice (*Oryza sativa* L.), *in vitro* propagation of *O. coarctata*, and isolation of stress-induced genes that are tolerant to salt from *O. coarctata*, were extensively conducted as a part of the pre-breeding exploration for rice improvement (Flowers et al. 1990; Sarker et al. 1993; Latha et al. 1998). However, despite its importance as an elite genetic resource and a number of successful studies on its applied potential, the taxonomy of *O. coarctata* is still frequently excluded from *Oryza*, being placed in the monotypic genus *Porteresia*.

Taxonomic history of Oryza coarctata

Oryza coarctata was first described by Roxburgh in 1814. This species, and its inclusion in *Oryza*, was accepted by many taxonomists, including Hooker (1897), Prodoehl (1922), Roschevitz (1931), Chatterjee (1948), and Bor (1960). Griffiths (1851), however, erected the monotypic genus *Sclerophyllum* to accommodate *O. coarctata*. Tateoka (1965) subsequently discovered that this name had already been used by Gaudin in 1821 for a genus in the *Compositae*, therefore, *Sclerophyllum coarctatum* has never been a valid name for *O. coarctata*. He published the name *Porteresia* for the oryzoid taxon, commemorating Dr Roland Portères, a specialist on *Oryza*. Tateoka demonstrated that *O. coarctata* differed from other species of *Oryza* in its leaf anatomy and embryo morphology, two aspects of grasses that had a profound impact on taxonomic interpretation in the family during the 1950s and 1960s. Tateoka (1964) found, for example, that *O. coarctata* was characterized by its large caryopses, with a big embryo relative to the endosperm and with a short petiole-like attachment at the base. He later pointed out that its leaf-blades were coriaceous with prickly tuberculate margins and had a peculiar arrangement of vascular bundles that were not found in any other oryzoid grass (Tateoka 1965). On the basis of these morphological differences, he thereby proposed to remove *O. coarctata* from the genus *Oryza* and erected this species as the monotypic *Porteresia coarctata* (Tateoka 1965).

It is indeed evident that *O. coarctata* and other *Oryza* species differ considerably in their ecological requirements, morphology, and physiology (Table 1). Therefore, the placement of *O. coarctata* in a different genus has been widely accepted by the current taxonomists, plant breeders and geneticists, and conservationists (Chang 1985; Oka 1988; Watson & Dallwitz 1988; Tzvelev 1989; Vaughan 1994; Sarker et al. 1993; Farooq et al. 1996; Pisupati 1999; Rangan & Swaminathan 2002).

Relationships of Oryza coarctata in tribe Oryzeae

Despite the differences just discussed, studies of interspecific hybridization and molecular analyses

Table 1. A comparison of major morpho-physiological differences between *Oryza coarctata* and *Oryza* species.

Characters	*O. coarctata*	*Oryza* species
Culm	Erect	Erect to scrambling
Leaf blades	Narrowly linear	Liner or lanceolate
	Leathery	Not leathery
	Margins tuberculate	Margins not tuberculate
	Vascular bundles prominent	Main vascular bundles prominent
Caryopses	Large (>1 cm).	0.2-0.9 cm
Embryo	Large relative to endosperm	Small relative to endosperm
Seed		
- germination	Recalcitrant	Orthodox
- longevity	Short	Long

have demonstrated that *O. coarctata* is closely related to other species of *Oryza*. Data from interspecific hybridization have demonstrated that "*Porteresia*" is so far the only related genus in the tribe Oryzeae that can be successfully crossed with *Oryza* species with relative ease (Sarker et al. 1993; Farooq et al. 1996), indicating a close biosystematic relationship of "*P. coarctata*" with *Oryza* species. Such close affinities between "*P. coarctata*" and *Oryza* species were also documented in recent molecular marker (AFLP and ISSR) studies by different authors, although they did not give a proper explanation to their results in the papers (Aggarwal et al. 1999; Joshi et al. 2000).

A molecular phylogenetic study of a selected set of species in the tribe Oryzeae by sequence analysis of internal transcribed spacer (ITS) of nuclear ribosomal DNA revealed that "*P. coarctata*" had a close affinity to *O. brachyantha* and *O. granulata* complex of *Oryza* (Xie et al. 2000). A phylogenetic tree constructed based on the analysis of total chloroplast DNA restriction fragments from 20 species of Oryzeae and three species of other tribes in Poaceae (as outgroups) demonstrated evidently a three-cluster pattern of the included Oryzeae species, where all *Oryza* species and "*P. coarctata*" were included in a distinct group, and all *Leersia* species and species from six other related genera of the Oryzeae were separated into two independent groups (Zhang & Second 1989). In another study, the phylogeny of 23 *Oryza* species and one representative each from four related genera of Oryzeae (including "*P. coarctata*") was reconstructed by sequence analysis of two nuclear genes (*Adh1* and *Adh2*) and one chloroplast gene (*mat*K) (Ge et al. 1999). In the generated gene trees, "*P. coarctata*" was consistently embedded within the diagnosably monophyletic *Oryza* clade and left other related genera separated from *Oryza* species (Ge et al. 1999). This study further proposed that the tetraploid "*P. coarctata*" and *O. schlechteri*, another morphologically and ecologically significantly differentiated species of *Oryza*, shared the HHKK genomes that are closely related to the HHJJ genomes of the *O. ridleyi* complex. Our recent phylogenetic study based on the chloroplast gene (*mat*K) sequences from 26 species, representing 11 genera of the tribe Oryzeae and three outgroup species, demonstrated the monophyletic origin of this tribe. It is noteworthy that the *mat*K gene could further distinguish the Oryzeae species as two monophyletic lineages, with the first lineage consisting of species of *Oryza* and *Leersia*, where "*P. coarctata*" was embedded within *Oryza*, and another lineage including the remaining related genera of Oryzeae (Ge et al. 2002). This finding was strongly supported by the sequence data of recent studies on the mitochondrial NAD intron (Guo & Ge 2004).

All the recent hybridization and molecular studies carried out independently by different authors have consistently confirmed a close biosystematic and phylogenetic relationship of *O. coarctata* with species in *Oryza*, although significant morphological differences are found between *O. coarctata* and *Oryza* species. The significant morphological differentiation of *O. coarctata* from other species in the genus *Oryza* provides an excellent example of divergent evolution of closely related taxa. *Oryza coarctata* appears to be closely related to *O. brachyantha*, *O. granulata*, and *O. schlectheri*, but all of these species possess substantial morphological differences. This divergent evolution can most likely be explained by the adaptive evolution of species in different ecological environments. *Oryza coarctata* occurs in coastal and saline areas, *O. brachyantha* on seasonally inundated areas of open habitats, *O. granulata* mainly in forests, bamboo woods, and grassy slopes of upland ecosystem, and *O. schlectheri* was found in undisturbed forests and on land slopes with sufficient moisture (Vaughan 1994). These types of ecological habitats are completely different from those occupied by other *Oryza* species. Species of *Oryza* are usually found in swampy lowlands, lagoon, and along rivers with fresh water. The adaptation to such unique environments has resulted different morphological features of e.g. *O. coarctata* and *O. schlectheri* from other *Oryza* species in the evolutionary process.

Taxonomic treatment

In conclusion, we strongly recommend the retention of *O. coarctata* in *Oryza*, a treatment that reflects both its phylogenetic position as revealed by cladistic analyses of molecular data and its ability to hybridize with other species of *Oryza*.

Oryza coarctata Roxb.

Hort. Beng. 87 (1814); Fl. Ind. ed. 2, II: 206 (1832).

Sclerophyllum coarctatum (Roxb.) Griff., Not. III: 8 (1851).

Porteresia coarctata Tateoka, Bull. Nat. Mus. Tokyo 8(3): 405 (1965).

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References

Aggarwal, R. K., Brar, D. S., Nandi, S., Huang, N., & Khush, G. S. 1999. Phylogenetic relationships among *Oryza* species revealed by AFLP markers. – Theor. Appl. Genet. 98: 1320-1328.

Bor, N. L. 1960. The grasses of Burma, Ceylon, India and Pakistan (Excluding Bambuseae). – Pergamon Press, Oxford.

Chang, T. T. 1985. Crop history and genetic conservation: Rice – a case study. – Iowa State J. Res. 59: 425-455.

Chatterjee, D. 1948. A modified key and enumeration of the species of *Oryza* L. – Indian J. Agri. Sci. 18(3): 185-192.

Farooq, S., Iqbal, N., Shah, T. M. & Asghar, M. 1996. Problems and prospects for utilizing *Porteresia coarctata* in rice breeding programs. – Cereal Rer. Commun. 24 (1): 41-47.

Flowers, T. J., Flowers, S. A., Hajibagheri, M. A. & Yeo, A. R. 1990. Salt tolerance in the halophytic wild rice, *Porteresa coarctata* Tateoka. – New Phytologist 114: 675-684.

Ge, S., Sang, T., Lu, B. R. & Hong, D. Y. 1999. Phylogeny of rice genomes with emphasis on origins of allotetraploid species. – Proc. Natl. Acad. Sci. USA 96: 14400-14405.

– , Li, A., Lu, B.-R., Zhang, S. Z. & Hong, D. Y. 2002. A phylogeny of the rice tribe Oryzaeae based on *mat*K sequence data. – Amer. J. Bot. 89: 1967-1972.

Guo, Y. L. & Ge, S. 2004. The utility of mitochondrial *nad*1 in phylogenetic study of Oryzeae with reference to the systematic position of *Porteresia*. – Acta Phytotaxon. Sinica 42: 333-344.

Griffiths, W. 1851. Notulae ad plantas asiaticas 3: 8. – Calcutta.

Hooker, J. D. 1897. Gramineae. – Flora of British India. Vol. VIII, CLXXIII. Reeve, London.

Joshi, S. P., Gupta, V. S., Aggarwal, R. K., Ranjekar, P. K. & Brar, D. S. 2000. Genetic diversity and phylogenetic relationship as revealed by inter simple sequence repeat (ISSR) polymorphism in the genus *Oryza*. – Theor. Appl. Genet. 100: 1311-1320.

Latha, R., Ajith, A., Srinivasa, R. C., Eganathan, P. & Balakrishna, P. 1998. In vitro propagation of salt-tolerant wild rice relative, *Porteresia coarctata* Tateoka. – J. Plant Growth Regul. 17 (4): 231-235.

Linnaeus, C. 1753. Species Plantarum. Vol. I. – Stockholm.

Oka, H. I. 1988. Origin of cultivated rice. – Japan Scientific Societies Press, Tokyo.

Pisupati, B. 1999. Determining genetic diversity among *Porteresia coarctata* Tateoka accessions using morphological, isozyme and RAPD markers. – J. Plant Biochem. Biot. 8 (1): 21-24.

Prodoehl, A. 1922. Oryzeae monographice describuntur. – Bot. Arch. 1: 211-256.

Rangan, L. & Swaminathan, M. S. 2002. Protein changes in response to salt stress in *Porteresia coarctata* Tateoka. – J. Plant Biochem. Biot. 11 (1): 49-52.

Roschevicz, R. J. 1931. A contribution to the study of rice. – Tr. Prikl. Bot. Genet. Selek. 27: 3-133.

Sarker, R. H., Samad, M. A., Seraj, Z. I., Hoque, M. I. & Islam, A. S. 1993. Pollen-tube growth in crosses between *Porteresia coarctata* and *Oryza sativa*. – Euphytica 69: 129-134.

Tateoka, T. 1964. Notes on some grasses. XVI. Embryo structure of the genus *Oryza* in relation to the systematics. – Amer. J. Bot. 51: 539-543.

– 1965. *Porteresia*, a new genus of Gramineae. – Bull. Nat. Mus. Tokyo 8(3): 405-406.

Tzvelev, N. N. 1989. The system of grasses (Poaceae) and their evolution. – Bot. Rev. 55: 141-204.

Vaughan D. A. 1994. The wild relatives of rice: a genetic resources handbook. – International Rice Research Institute, IRRI, Los Baños, Philippines.

Watson, L. & Dallwitz, M. J. 1988. Grass Genera of The World: Illustrations of Characters, Descriptions, Classification, Interactive Identification, Information Retrieval. – Res. School of Biol. Sci., Australian Nat. Univ., Canberra.

Xie, Z. W., Zhou, Y., Lu, B.-R. & Hong, D. Y. 2000. Molecular Phylogenetics of the genus *Oryza* L. (Poaceae): Evidence from the sequences of the internal transcribed spacer (ITS) of nuclear ribosomal DNA. – Proc. The 4th Annual Intern. Conf. Computational Molecular Biology, Tokyo, Japan, April 8 - 11, 2000, pp. 186-187.

Zhang, S. H. & Second, G. 1989. Phylogenetic analysis of the tribe Oryzeae: Total chloroplast DNA restriction fragment analysis (A preliminary report). – Rice Genetics Newsletter 6: 76-80.