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ISOETES PANTII (ISOETACEAE: PTERIDOPHYTA) – A REVIEW

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ABSTRACT

The taxon, *Isoetes pantii* H.K. Goswami & B.S. Arya discovered in 1970, possess genetically inherent features of development of three types of morphologically distinct microspores, (monolete, alete and trilete) as well as large megaspores within one and the same microsporangium, a feature never known, even today, in any species of the genus *Isoetes*. Follow up studies on morphological, chromosomal and biochemical approaches published on different species of *Isoetes* in Central India over four decades have repeatedly confirmed these findings and we strongly reestablish here the integrity of the species as a unique taxon of the genus. *Isoetes pantii* is also the only species to possess 2n= 36, 48 chromosomes and related plant populations in the Narsinghgarh area (Madhya Pradesh, India) have shown 2n=60 and 2n=72 chromosomes indicating thereby that the new line of chromosome evolution of n=12 series have probably evolved through this species as already suggested elsewhere.

Keywords: Chromosome evolution, Heterosporous sporangia, *Isoetes pantii*, Polymorphic microspores.

INTRODUCTION

More than 40 years ago a unique plant population of *Isoetes* L. (quillwort) was discovered in a pond in Narsinghgarh (Central India) which characteristically possessed heterosporous microsporangia. These heterosporous microsporangia had three kinds of microspores, monolete, alete and trilete, a feature never recorded in any species of the genus *Isoetes* (Goswami and Arya, 1968). As far as known, even till today, there has been no genuine record of occurrence of three different kinds of microspores being produced within one and the same microsporangium. Additionally, the development of large megaspores within the same microsporangia was taken as another significant discovery at that time. This was very cautiously observed that plants of other two species growing intermixed, viz. *I. sampatkumaranii* Rao and *I. coromandelina* L.f. never showed such an occurrence of megaspores and microspores in one and the same sporangium. Based on comparison of all morphological details of spore morphology, ligule and labium we had named this species as *Isoetes pantii* (Goswami and Arya, 1970). Since then by following up studies on multidisciplinary approaches (morphological, biochemical, chromosomal, anatomical etc.) on these species and some other species of different areas in India and abroad, we have been able to ascertain this to be a taxon originated by natural hybridization. *Isoetes* × *pantii* is the product of natural hybridization in between I. *coromandelina* × *I. sampathkumaranii* (Goswami & Bhu, 2000; Goswami, 2001). Infact, there is no species in the world which is such a rich assemblage of features of great and rare evolutionary significance as is *Isoetes* × *pantii*. This and related species of hybridization segregates studied over four decades have been exhibiting (Goswami, 1975a, b) a new series of chromosome evolution based on n=12 (2n= 36, 48, 60 chromosomes; Bhu and Goswami, 1990; Goswami, 2011).

This paper, based on series of comparative observations, apart from highlighting major features of rare significance of *Isoetes pantii*, also refutes a few recent publications (Fraser-Jenkins, 1997, 2008) designed to demolish the district identity of this taxon. This criticism of nomenclature has been based on gross morphology of various "similar looking" taxa without understanding and caring for cognizance of detailed spore morphology, variable ligule and labium structural details and chromosome numbers (Goswami, 2010). This anticipated merger of Indian species of Isoetes by Fraser - Jenkins (1997, 2008) is also strongly opposed by Sharma and Purohit (2011). The modern taxonomy and nomenclature has to be based on many parameters which must include biochemical, molecular and as far as possible genomic DNA comparisons on certain loci. Merging of species on the basis of a few simple morphological observations (looking similar) cannot be and should not be acceptable to modern taxonomy. (Fig.1)

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Fig. 1. Bisexual plants of *Isoetes pantii* (Voucher specimen HKG/ 2000-Bionature) Plants measured 45 ± 2cms

MATERIAL AND METHODS

Plant Collections

The author (HKG) has been working on *Isoetes* populations from Central India for over four decades and as many as seven species of Isoetes, viz. *I. sampathkumaranii, I. panchananni, I. indica, I. coromandelina, I. dixitei, I. pantii and I. fuschii* have been repeatedly studied by various morphological, chromosomal, biochemical, embryological and anatomical approaches and several such studies have been reviewed (Goswami & Arya, 1968, 1970; Goswami, 1996, 2004; Goswami & Kumar, 2006) and are being followed up on comparative genomic DNA studies (Bajpai & Goswami, 2002; Bajpai & al., 2004b). This short note chiefly concerns with the evolutionary significance of microsporangia of *I. pantii.* Detailed diagnosis of this species (Fig.1) is presented here in order to reemphasize that this taxon is unique and maintains its individual status because *I. pantii* is totally a different one, not comparable to any living or fossil species of the genus except the height of plants (24 - 60cm) which in no way, can be a deciding factor for the diagnosis of the species.

Diagnosis

Isoetes × pantii H.K. Goswami & B.S. Arya, in J. Indian Bot. Soc. 49: 30. 1970 publ. 1971, (Pro sp.) *I. coromandelina* auct. non L.f. 1982; Fraser - Jenk., New Sp. Syndr. Indian Pteridol. 153. 1997.

Plants 24 - 60cm; mature leaves 22 - 58cm long, unequal; corm three lobed, one lobe smaller than others making corm often tilted; ligule 1 - 3 × 2 - 5mm, cordate, spongy, with long attenuating middle flap, serrate margins, shrivels down on mature sporangia; labium large, much broader (4 - 7mm) than long (3 - 4mm) remains as a thick flap on mature sporangia; velum absent, but seen as rudimentary in very young sporangia; heterosporangiate, megasporangia round to oval 4 - 16mm long and 2 - 5mm broad at the upper part, containing 180 - 500 trimorphic, round tuberculate heteromorphic megaspores large megaspores, 370 - 560μm, medium 240 - 360μm and small megaspores measure 120 - 200μm in diam; microsporangia 0 - 4 per plant, contain more than 70,000 (seventy thousand) microspores, 12 - 46μm, trimorphic, round alete, bilateral monolete and triangular to globular trilete along with, several large megaspores with reticulate exine of variable shapes and sizes ranging 165 - 180μm in diam.

Chromosome number: sex chromosomes present, 2n=48 and some plants with 2n=36; B-chromosome (1 - 2), always present.

Distribution : Narsinghgarh and Rampura in Madhya Pradesh

Specimens examined: Collections of HKG - made in 1975, 1986, 1990, 1998; 2001, 2005; numbered as - Bionature-HKG/ voucher specimens: Bionature Collections, Society of Bionaturalists, Bhopal, M.P.

OBSERVATIONS

General considerations

Pfeiffer (1922) laid the foundation of species diagnosis on the basis of ornamentation of outer coat of the megaspores (exine ornamentation). Accordingly we know five categories of spore ornamentation,viz. *Tuberculatae, Cristateae, Echinatae, Reticulatae* and *Laevis* (Pfeiffer, 1922; Srivastava & al., 1993, Shukla & al., 2005). In most of the species microsporangia are not commonly found but each and every fertile *Isoetes* plant has a megasporangium hence megaspore morphology including colour shape and size, tritadiate mark and nature of pyramidal areas on proximal face etc. have been most reliable and widely used diagnostic features for species differentiation (Pant & Srivastava, 1982; Fuchs-Eckert, 1992). In the entire *Isoetes* flora, *I. pantii* H.K. Goswami & B.S. Arya (Fig.1) has been the only species, as far as known, which has consistently shown, following unique features extensively explored over four decades and which have not been known in any species of the otherwise cosmopolitan genus *Isoetes* which has almost more than 200 species from various continents (Takamiya & al., 1994; Kim & al., 2010 a,b; Takamiya, 2001; Liu & al, 2004).

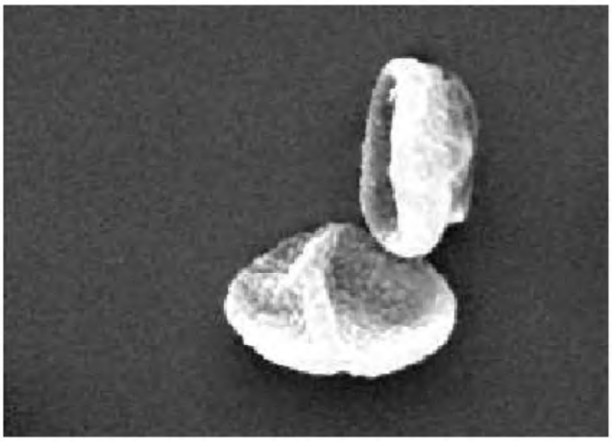

Fig. 2. A light microscopic glycerine mount of microspores in microsporangia. A bar near round alete microspore measures 10μm.

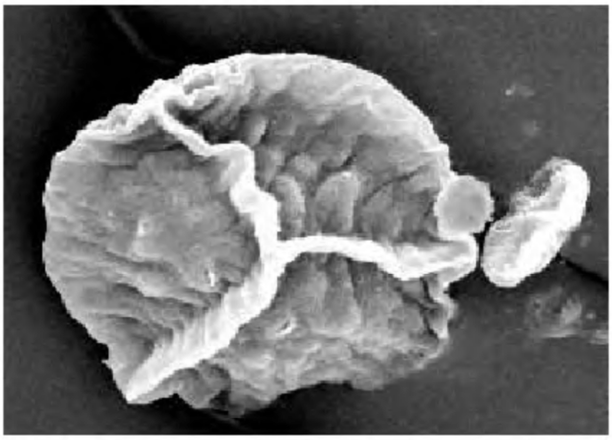

Fig. 3. A SEM of megaspore and attached monolete microspore from the microsporangium

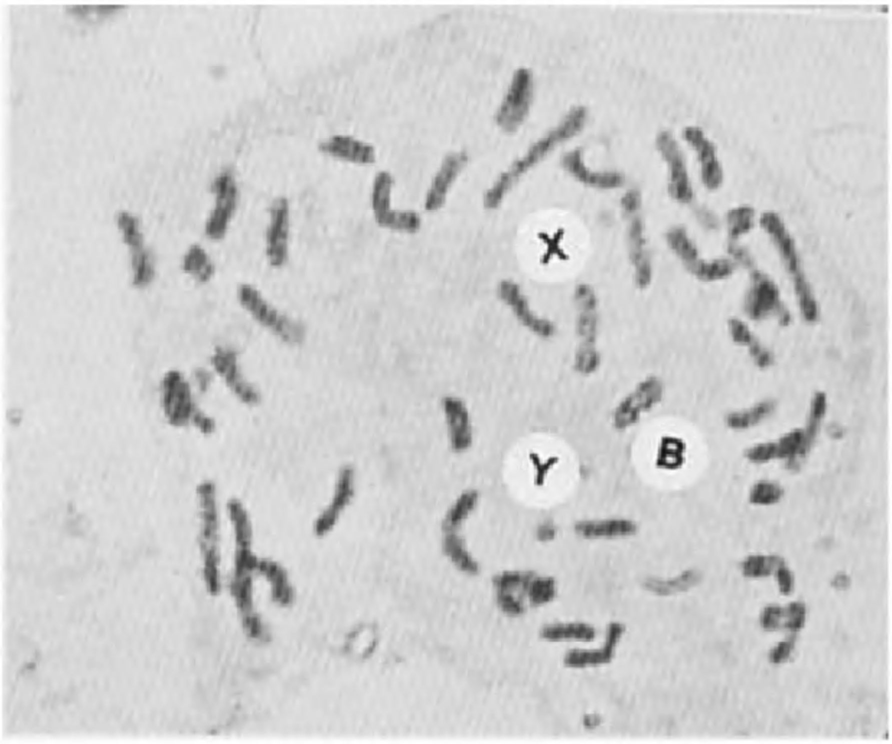

Fig. 4. Mitotic chromosomes (2n=48) from bisexual plants of Isoetes × pantii (After Goswami,1986, 2011)

(i) Features inside the microsporangia:

1) Three kinds of microspores (alete, monolete and trilete; Fig. 2) developing inside one and the same microsporangium. Microspores germinate to produce microgametophytes.

2) The same microsporangium also possesses large trilete megaspores (Fig. 3) which have reticulate exine with folds (not tuberculate, as are the megaspores of the megasporangium of the same plant).

3) Some of these megaspores possess abnormal or very large perispore flanges within which fine tubules and or spines extend of variable shapes and sizes making these abnormal spores directly comparable to spores of fossil lycopods (Goswami, 1975 a,b; Goswami and Goswami, 1986; Goswami, 2004 a)

4) Both kinds of megaspores germinate within the heterosporous sporangium and megagametophyte shows extended archegonium coming out of the gametophytic tissue (exoscopic; Goswami, 2004 a).

5) Spermatozoids have been observed to be multiflagellate as expected but some biflagellate spermatozoids with bifid flagella have also been photographed (Goswami, 2004a)

(ii) Chromosome evolution:

Population cytogenetic studies have shown the evolution of new basic chromosome number i.e., n=12 and we have discovered plants with 2n 36 and 48 chromosomes; 2n=48 with X, Y and B (Fig. 4) chromosomes appears to be a stable chromosome number Bhu & Goswami, 1990; Liu & al, 2004; Bir & Verma, 2010; Goswami, 1975a,b, 2011

DISCUSSION

Needless to mention, *Isoetes* × *pantii* is a species of extremely rare genic combinations exhibiting highly unusual and most fascinating characteristic features in bisexual plants observed since 1966 till to date. The species typically possesses evolution of new chromosomes (Goswami, 1975a,b, 2005a, b, 2011; Bhu and Goswami, 1990) with variable counts in natural populations over these years. However, most bisexual plants possess 2n =48 chromosomes with B, X and Y chromosomes (Fig. 4; Goswami, 2011). So, on all biochemical including preliminary genomic DNA approaches, spore morphological comparisons (polymorphic megaspores inside the megasporangia with round tubercles; polymorphic microspores developing inside the microsporangia) and other rare adjuvant features mentioned herein and published for more than four decades, we dare declare that *Isoetes* × *pantii* is not comparable with any living or fossil species of the genus. Elsewhere, attempts are being made to place this unique taxon at a different special morphological status.

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