

Karyomorphological Analysis of *Arisaema sabyadricum* (Section: *Tortuosa*): an Endemic Aroid from Western Ghats of India

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ABSTRACT

Genus *Arisaema* Mart. comprises ca. 170 species in the world. In India, it is represented by about 43 species. *Arisaema sabyadricum* S. R. Yadav, K. S. Patil & Bachulkar consists of one variety, viz. *A. sabyadricum* var. *ghaticum* Sardesai, S.P.Gaikwad & S.R. Yadav under the section *Tortuosa*, so far known from Maharashtra state. The present paper describes mitotic counts and karyotype analysis of the species and its variety. *A. sabyadricum* var. *sabyadricum* and *A. sabyadricum* var. *ghaticum* both showed $2n = 28$. The karyotype exhibited 1b category of Stebbins asymmetry classes. These two taxa also showed difference in their karyotypic formulae. *Arisaema sabyadricum* var. *sabyadricum* displayed $6sm + 22m$ chromosomes while *A. sabyadricum* var. *ghaticum* showed $2sm + 26m$ chromosomes.

KEY WORDS

Arisaema sabyadricum var. *sabyadricum*, *A. sabyadricum* var. *ghaticum*, India, karyotype, mitosis, section *Tortuosa*.

INTRODUCTION

The genus *Arisaema* (Araceae) comprises 150 to 170 species of tuberous and rhizomatous herbs distributed in temperate to tropical areas; East Asia, Africa and West-North America (Murata, 2011; Mabberly, 2008). In India, it is represented by about 43 species and 9 varieties (Sardesai, 2006; Karthikeyan *et al.*, 1989). Infrageneric classification has been attempted by Murata (1991, 1984); Hara (1971) and Gusman & Gusman (2002). Recently Murata (2011) classified *Arisaema* into 14 sections of which section *Tortuosa* is characterized by 1) tuberous stem 2) appendages without neuter flowers 3) leaves pedate or radiate and 4) spadix appendages gradually tapered to the apex, usually filiform, exerted from spathe, recurved or sigmoidally curved. Section *Tortuosa* of the genus *Arisaema* comprises 7 species viz. *A. jethompsonii* Thiyugaraj & P. Daniel; *A. muricaudatum* Sivdasan; *A. murrayi* (Graham) Hook; *A. neglectum* Schott; *A. sabyadricum* S. R. Yadav, K. S. Patil & Bachulkar; *A. sivasanii* S.R. Yadav, Patil & Janarth. and *A. tortuosum* (Wall) Schott. Section

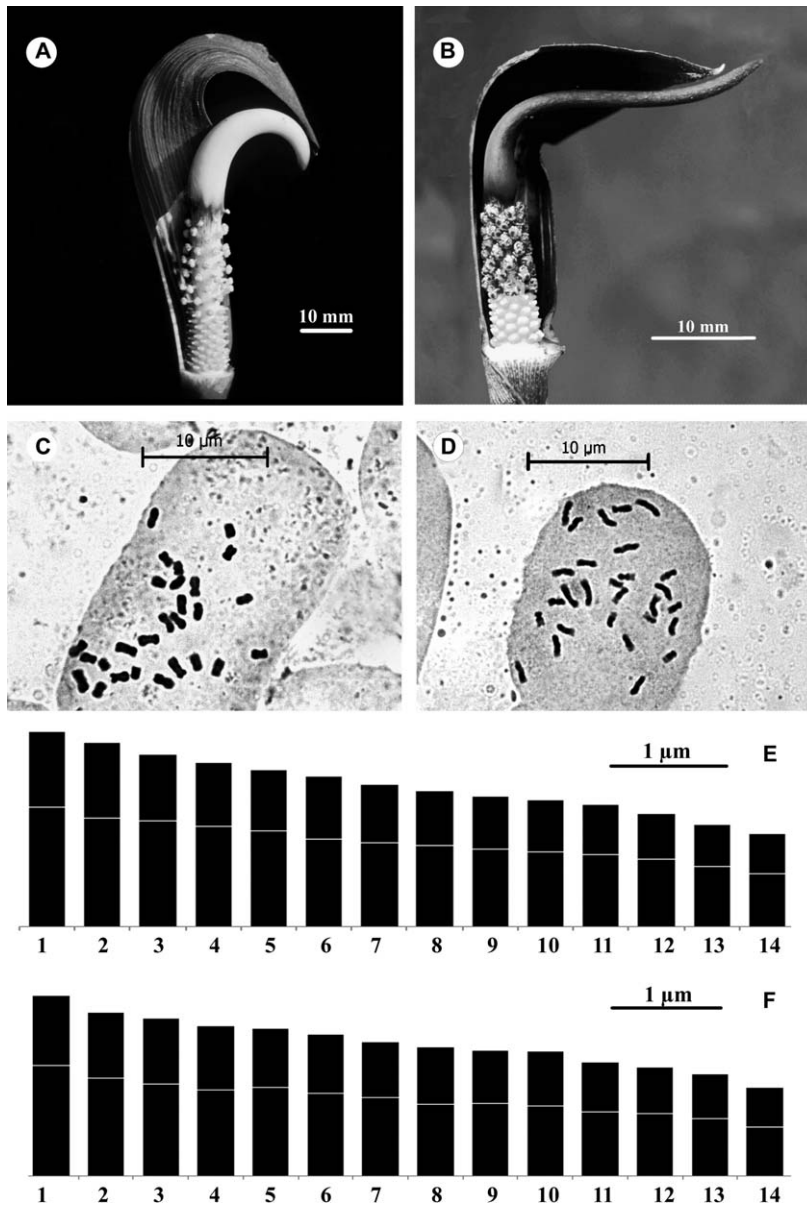


Fig. 1. (A-F) *Arisaema sahyadricum* S. R. Yadav, K. S. Patil & Bachulkar: **A:** Cut open spadix of *Arisaema sahyadricum* var. *sahyadricum*; **B:** Cut open spadix of *Arisaema sahyadricum* var. *ghaticum*; **C:** Somatic plate of *Arisaema sahyadricum* var. *sahyadricum* showing $2n = 28$; **D:** Somatic plate of *Arisaema sahyadricum* var. *ghaticum* showing $2n = 28$; **E:** ideograph of *Arisaema sahyadricum* var. *sahyadricum*; **F:** ideograph of *Arisaema sahyadricum* var. *ghaticum*.

Table 1. Karyotype analysis of *Arisaema sabyadricum* var. *sabyadricum*.

Chromosome pair	Long arm (L) (µm)	Short arm (s) (µm)	Total length c = l + s (µm)	'd' value l - s (µm)	'r' value l/s (µm)	'i' value s/c × 100 (µm)	Centromeric position	Type
I.	1.13 ± 0.18	0.72 ± 0.05	1.85 ± 0.23	0.41	1.57	38.92	sm	A
II.	1.03 ± 0.19	0.72 ± 0.08	1.75 ± 0.27	0.31	1.43	41.14	m	B
III.	1 ± 095.12	0.64 ± 0.12	1.64 ± 0.24	0.36	1.56	39.02	sm	C
IV.	0.95 ± 0.10	0.61 ± 0.07	1.56 ± 0.17	0.34	1.56	39.1	sm	C
V.	0.91 ± 0.13	0.58 ± 0.12	1.49 ± 0.25	0.33	1.57	38.93	sm	C
VI.	0.83 ± 0.14	0.6 ± 0.08	1.43 ± 0.22	0.23	1.38	41.96	m	D
VII.	0.80 ± 0.12	0.55 ± 0.09	1.35 ± 0.21	0.25	1.45	40.74	m	E
VIII.	0.77 ± 0.11	0.52 ± 0.11	1.29 ± 0.22	0.25	1.48	40.31	m	E
IX.	0.74 ± 0.10	0.50 ± 0.06	1.24 ± 0.16	0.24	1.48	40.32	m	E
X.	0.71 ± 0.12	0.49 ± 0.04	1.20 ± 0.16	0.22	1.45	40.83	m	E
XI.	0.68 ± 0.09	0.48 ± 0.06	1.16 ± 0.15	0.2	1.42	41.38	m	E
XII.	0.64 ± 0.09	0.43 ± 0.05	1.07 ± 0.14	0.21	1.49	40.19	m	F
XIII.	0.57 ± 0.11	0.40 ± 0.05	0.97 ± 0.16	0.17	1.43	41.24	m	G
XIV.	0.50 ± 0.13	0.38 ± 0.04	0.88 ± 0.17	0.12	1.32	43.18	m	H

Table 2. Karyotype analysis of *Arisaema sabyadricum* var. *ghaticum*.

Chromosome pair	Long arm (l) (µm) s	Short arm (s) (µm)	Total length c = l + s (µm)	'd' value l - s (µm)	'r' value l/s (µm)	'i' value s/c × 100 (µm)	Centromeric position	Type
I.	1.14 ± 0.16	0.72 ± 0.04	1.86 ± 0.2	0.42	1.58	38.71	sm	A
II.	1.01 ± 0.08	0.68 ± 0.06	1.69 ± 0.14	0.33	1.49	40.24	m	B
III.	0.94 ± 0.08	0.68 ± 0.05	1.63 ± 0.13	0.27	1.4	41.72	m	B
IV.	0.89 ± 0.11	0.66 ± 0.06	1.55 ± 0.17	0.23	1.35	42.58	m	B
V.	0.91 ± 0.13	0.61 ± 0.08	1.52 ± 0.21	0.3	1.49	40.13	m	B
VI.	0.85 ± 0.08	0.61 ± 0.05	1.46 ± 0.13	0.24	1.39	41.78	m	B
VII.	0.81 ± 0.09	0.57 ± 0.05	1.38 ± 0.14	0.24	1.42	41.3	m	C
VIII.	0.74 ± 0.06	0.59 ± 0.05	1.33 ± 0.11	0.15	1.25	44.36	m	C
IX.	0.72 ± 0.06	0.57 ± 0.05	1.30 ± 0.11	0.2	1.26	44.19	m	C
X.	0.75 ± 0.25	0.55 ± 0.05	1.29 ± 0.3	0.15	1.36	42.31	m	C
XI.	0.66 ± 0.06	0.51 ± 0.04	1.17 ± 0.1	0.15	1.29	43.59	m	D
XII.	0.64 ± 0.04	0.48 ± 0.03	1.12 ± 0.07	0.16	1.33	42.86	m	D
XIII.	0.59 ± 0.06	0.46 ± 0.04	1.05 ± 0.1	0.13	1.28	43.81	m	D
XIV.	0.50 ± 0.03	0.41 ± 0.05	0.91 ± 0.08	0.09	1.22	45.05	m	E

Table 3. Types of chromosome of *Arisaema sabyadicum* var. *sabyadicum*.

Type of chromosome	Description
Type A (Chromosome I):	A pair of very long chromosomes (1.85 μm) with sub-median centromeres sm
Type B (Chromosome II):	One pair of long chromosomes (1.75 μm) with median centromeres m
Type C (Chromosome III to V):	Three pairs of long chromosomes (1.64-1.49 μm) with sub-median centromeres sm
Type D (Chromosome VI to XI):	Six pairs of medium chromosomes (1.43-1.16 μm) with median centromeres m
Type E (Chromosome XII to XIII):	Two pairs of short chromosomes (1.07-0.97 μm) with median centromeres m
Type F (Chromosome XIV):	One pair of very short chromosomes (0.88 μm) with median centromeres m

Tortuosa is distributed in the Indo-Himalayan region (Murata, 2011). *Arisaema sabyadicum* with a variety *A. sabyadicum* var. *ghaticum* are narrowly endemic to Northern Western Ghats of India. The species is not known from a cytological point of view. Mitotic counts and karyotype analysis of the species is presented in the present communication.

MATERIAL AND METHODS

The materials for the present investigation were collected from Northern-Western Ghats. The voucher specimens are deposited in the Herbarium of Department of Botany, Shivaji University, Kolhapur (SUK). The tubers were collected and grown in earthen pots in the departmental botanical

garden. Mitosis was studied from healthy water-culture root tips. The root tips of 6–10 mm length were pretreated with saturated solution of Para-dichlorobenzene for 3 to 4 hours at $9 \pm 3^\circ\text{C}$. The root tips were squashed in 2% propionic orcein. The well-spread somatic plates were photographed with a LEICA DM 2000 fluorescent microscope with attached camera at x1000 magnification. Ten well-separated somatic chromosome plates were selected for karyotype analysis by adopting the method of Levan *et al.* (1964). For analysis and comparison of the karyotype, the chromosomes were categorized on the basis of their length and centromeric position. The degree of karyotype asymmetry has been determined as per the categories of Stebbins (1971).

Table 4. Types of chromosome of *Arisaema sabyadicum* var. *ghaticum*.

Type of chromosome	Description
Type A (Chromosome I):	A pair of very long chromosomes (1.86 μm) with sub-median centromeres sm
Type B (Chromosome II to VI):	Five pairs of long chromosomes (1.69-1.46 μm) with median centromeres m
Type C (Chromosome VII to X):	Four pairs of medium chromosomes (1.38-1.29 μm) with sub-median centromeres sm
Type D (Chromosome XI to XIII):	Three pairs of short chromosomes (1.17-1.05 μm) with median centromeres m
Type E (Chromosome XIV):	One pair of very short chromosomes (0.91 μm) with median centromeres m

Table 5. Diagnostic characters of *Arisaema* species in the section *Tortuosa*.

Sr. No.	Name of taxa	Diagnostic features
1.	<i>Arisaema jethompsonii</i> Thiyag. & P. Daniel	Leaflets 5–7, narrowly elliptic, entire to faintly undulate-crenate along the margins. Spathe-limb notched at the base. Spadix included; appendix cylindrical, curved, obtuse and warty at the apex.
2.	<i>A. muricaudatum</i> Sivad.	Leaves 2–3 distinctly pedate-lobed. Spadix appendage sigmoid, erect and resembles the tail of a mouse. (Fig. 2A)
3.	<i>A. murrayi</i> (J. Graham) Hook.	Limb white with purple throat. Appendage tapering from base to apex. (Fig. 2B)
4.	<i>A. neglectum</i> Schott	Plant with single leaf. Spadix below the leaf. (Fig. 2C)
5.	<i>A. sabyadicum</i> S.R. Yadav, K.S. Patil & Bachulkar	Leaves erect. Spathe uniformly reddish-purple. Appendix short, thick, blunt and included in the spathe. (Fig. 1A and 2D)
6.	<i>A. sabyadicum</i> var. <i>ghaticum</i> Sardesai, S.P.Gaikwad & S.R. Yadav	Leaves pendulous initially. Spathe uniformly reddish-purple. Appendix very slender, gradually pointed and protruding from spathe. (Fig. 1B and 2E)
7.	<i>A. sivadasanii</i> S.R. Yadav, Patil & Janarth.	Plant with single leaf. Spadix with short thick appendage which project only slightly out of spathe limb. Late prolonged flowering from August to October. (Fig. 2F)
8.	<i>A. tortuosum</i> (Wall.) Schott	Plant with two leaves. Leaflets 5–18, elliptic-obovate, entire along the margin Spadix above the leaf. Appendix subulate, sigmoid, smooth, straight and acute at apex. (Fig. 2G)

RESULTS

Somatic chromosome complements in both taxa of *Arisaema sabyadicum* is $2n = 28$ (Figs. 1e and d). Chromosomes of *A. sabyadicum* var. *sabyadicum* can be classified in 6 different types (Tables 1 and 3) while that of *A. sabyadicum* var. *ghaticum* can be classified in 5 different types (Tables 2 and 4) on the basis of chromosome length and types of chromosomes. Chromosome length varied from $1.85 \mu\text{m}$ to $0.88 \mu\text{m}$ in *A. sabyadicum* var. *sabyadicum* whereas it ranged between $1.86 \mu\text{m}$ to $0.91 \mu\text{m}$ in *A. sabyadicum* var. *ghaticum*. Mean chromosome length was found to be $1.34 \mu\text{m}$ in *A. sabyadicum* var. *sabyadicum* and $1.38 \mu\text{m}$ in *A. sabyadicum* var. *ghaticum*. Total chromosome length of the haploid set was 18.88 in *A. sabyadicum* var. *sabyadicum* while 19.26 in *A. sabyadicum* var. *ghaticum*.

Gradient index (GI) 47.57 and 48.92, symmetric index (SI) 67.67 and 72.58 and total form percentage (TF %) 40.36 and 42.06 were found in *A. sabyadicum* var. *sabyadicum* and *A. sabyadicum* var. *ghaticum* respectively. Karyotype 1b category of Stebbins (1971) was found in both the taxa. The karyotype formula $8sm + 20m$ were found in *A. sabyadicum* var. *sabyadicum* while $2sm + 26m$ in *A. sabyadicum* var. *ghaticum*.

DISCUSSION

The somatic chromosome complements ($2n = 26, 28$ and 56) have been reported for the section (Murata, 2011). Somatic complement with $2n = 28$ was observed in populations of all the species (Table 6), but aneuploidy with $2n = 26$ has been reported in *A. tortuosum* (Table 6), and tetraploids $2n = 4x = 56$ in *A. murrayi*, *A.*

Table 6. Cytological parameters of *Arisaema* species in the section *Tortuosa*.

Sr. No	Name	Somatic chromosome complements		Total Gradient Symmetry index		Asymmetric classes of Stebbins		Karyotype formula	References
		chromosomes	factors	index	index	Stebbins	Stebbins		
1.	<i>A. jethbompsonii</i> hiyag. & P. Daniel	-	-	-	-	-	-	-	-
2.	<i>A. muricaudatum</i> Sivad.	-	-	-	-	-	-	-	-
3.	<i>A. murrayi</i> (J. Graham) Hook.	28	44	47	78	1a	2H ^m + 4H1 ^m + 8J ^m + 10I2 ^m + 4J ^m	Asana and Sutaria (1935); Patil (1995); Patil and Dixit (1995).	
4.	<i>A. neglectum</i> Schott	56	43	54	78	1a	28J ^m + 28J1 ^m	Patil (1995); Patil and Dixit (1995).	
		28	42	62	72	1a	6I2 ^m + 18J ^m + 4J1 ^m	Patil (1995); Patil and Dixit (1995).	
		56	43	49	77	1b	4I ^m + 12I2 ^m + 28J ^m + 12J ^m	Patil (1995); Patil and Dixit (1995).	
5.	<i>Arisaema. Sabyadricum</i> var. <i>sabyadricum</i> S.R. Yadav, K.S. Patil & Bachulkar	28	42	45	73	1a	2G2 ^m + 2H ^m + 6H1 ^m + 8I ^m + 8I2 ^m + 2J ^m	Patil (1995); Patil and Dixit (1995).	
		28	40.36	47.57	67.67	1b	6sm + 22 m	Present communication	
6.	<i>A. sabyadricum</i> var. <i>ghaticum</i> Sardesai, S.P. Gaikwad & S.R. Yadav	28	42.06	48.92	72.58	1b	2sm + 26 m	Present communication	
7.	<i>A. sivadasanii</i> S.R. Yadav, Patil & Janarth.	28	43	59	75	1a	6H1 ^m + 10I ^m + 12I2 ^m	Patil (1995); Patil and Dixit (1995).	

Table 6. Continued.		Somatic chromosome complements factors			Asymmetric classes of Stebbins			Karyotype formula		References
Sr. No	Name	Total factors	Gradient index	Symmetry index	1b	412 ^m + 20j ^m + 32j1 ^m	412 ^m + 20j ^m + 32j1 ^m			
8.	<i>A. tortuosum</i> (Wall.) Schott	56	49	75	-	-	-	-	Patil (1995); Patil and Dixit (1995); Ramachandran (1978); Murata (2011).	
		26	-	-	-	-	-	-	Sharma (1970).	
		28	-	-	-	-	-	-	Subramanian and Munian (1988); Murata and Iijima (1983); Mehra and Sachdeva (1976c).	

neglectum and *A. tortuosum*. Total factor percentage, gradient index and symmetrical index varied from species to species in the section (Table 6). This variability was also found in different ploidy level within same species (Table 6). Total factor percentage, gradient index and symmetry index were found different as compared to the previous report in *A. sahyadricum* (Table 6). Species of the section *Tortuosa* showed 1a and 1b category of Stebbins asymmetric classes. Previously 1a and 1b categories have been reported in different ploidy levels in *A. murrayi* (Table 6). Patil (1995) reported karyotype of *A. sahyadricum* under 1a category while it falls under 1b category of Stebbins classification in the present investigation. Previously only m-type of chromosomes were reported for section *Tortuosa*, but sm-type of chromosomes have been found in *A. sahyadricum* and *A. sahyadricum* var. *ghaticum* in present investigation (Table 6). This may be due to great condensation of chromosomes in karyotypic studies of previous workers (Table 5).

Morphologically all the species of section *Tortuosa* are distinct (Fig. 2 and Table 5). A basic chromosome number (x) = 14, m and sm-types of chromosomes and highly symmetric karyotype 1a and 1b categories of Stebbins have been found to be karyological characteristic features of the section *Tortuosa*.

Arisaema sahyadricum var. *sahyadricum* (Figs. 1A and 2D) and *A. sahyadricum* var. *ghaticum* (Figs. 1B and 2E) are quite distinct in morphology (Table 5). Cytologically both taxa could be differentiated by karyotype formula with 6sm + 22m chromosomes in *A. sahyadricum* var. *sahyadricum* and 2sm + 26m in *A. sahyadricum* var. *ghaticum*.

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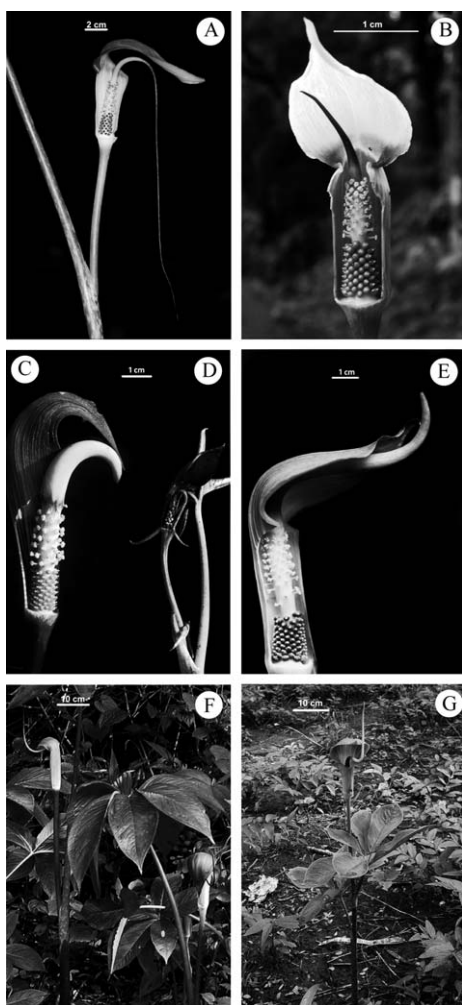


Fig. 2. (A–G) Spadices of *Arisaema* species belongs to section *Tortuosa*: **A:** *Arisaema muricaudatum*; **B:** *A. murrayi*; **C:** *A. sabyadricum* var. *sabyadricum*; **D:** *A. sabyadricum* var. *ghaticum*; **E:** *A. sivadasanii*; **F:** *A. neglectum*; **G:** *A. tortuosum*.

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