Systematic study of six species of *Arisaema* Mart. (Araceae) of Nepal

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**Abstract**

The genus *Arisaema* is represented by sixteen species in Nepal. They are distributed in sub-tropical, temperate to sub-alpine regions at an elevation ranging from 300 to 4000 m asl. The present study includes six representative species of *Arisaema* occurring in Nepal. The aim is to investigate the interrelationship between the taxa on the basis of morphological and anatomical evidence. The work is based on the herbarium specimens deposited at TUCH and KATH as well as personal collections of the author.

**Key-words**: endemic species, revision, spadix, spathe, taxonomy.

**Introduction**

The word *Arisaema* is derived from two Greek words ‘aris’ and ‘haima’ in reference to the red spotted leaves of some species. It is commonly known by the name Jack-in-the-pulpit and Cobra Lily. The plants are generally terrestrial herbs and sometimes growing in wetland. *Arisaema* was previously known as *Arum*. Three Nepalese species under the generic name *Arum* was reported by Wallich (1824). Later, Martius (1831) established the genus *Arisaema* based on those three Himalayan species described previously under the genus *Arum* (*A. nepenthoides*, *A. costatum* and *A. speciosum*) (cited in Croat 2000).

There are approximately 150 species of *Arisaema* in the world. They are chiefly concentrated in Temperate Asia, North America, Mexico and Africa (Renner et al. 2004). Sixteen species of *Arisaema* have been reported from Nepal, out of which three species (*A. costatum*, *A. exappendiculatum* and *A. vexillatum*) are endemic to Nepal (Hara et al. 1978; Shrestha and Joshi 1996; Press et al. 2000). The former two species occur in Eastern and Central Nepal and the latter species has been reported from Sankhuwasabha district of Eastern Nepal at an altitude of 3,400 m asl. Except some cytotaxonomical and anatomical studies (Rajbhandari 1997), there is no thorough taxonomic revision of the genus *Arisaema* in Nepal. The genus represents a unique assemblage of various economically important species having both ornamental as well as medicinal values. With the advancement of molecular systematics, phylogenetic relationships have also been assessed within Araceae through the use of rbcL, matK sequences (Judd et al. 1999; Cabrera et al. 2008). Family Araceae is considered monophyletic based on morphology and cpDNA sequences. The family may be a fairly early divergent lineage within monocots and probably is sister to the remaining families of Alismatales (Judd et al. 1999).

In the present study, an attempt has been made to study the taxonomy of six representative species of *Arisaema* occurring in Nepal. The aim is to investigate the interrelationship between taxa on the basis of morphological and anatomical evidence. The identification of *Arisaema* is mainly based on leaf morphology. The leaves are either pedatisect, whorled or tri-foliate (Noltie 1994). Thus, on the basis of leaf morphology, three groups of *Arisaema* can be distinguished. Species like *A. concinnum*, *A. erubescens* and *A. nepenthoides* have whorled leaves, consisting of more than 3 leaflets. Similarly, species like *A. flavum* and *A. tortuosum* have pedatisect leaves. The third group of *Arisaema* consisting of trifoliate leaves include *A. costatum* and *A. propinquum*. The present study has included representative taxa from all the three groups of *Arisaema* thus almost covering the range of morphological variability within the species occurring in Nepal.

**Materials and Methods**

Plants belonging to the genus *Arisaema* were collected from different parts of Nepal (mainly Langtang National Park, and Bajabarahi area of central Nepal). The voucher specimens were pressed, dried and mounted to standard herbarium sheets. The voucher specimens were deposited at Tribhuvan University Central Herbarium (TUCH). Standard literatures were consulted to confirm identify of the collected specimens (Hooker 1894; Polunin and Stainton 1984; Noltie 1994). Morphological and anatomical studies were carried out based on the specimens collected by the author as well as those housed in the herbaria (TUCH, KATH). For anatomical study, parts of leaves, stem, and petiole from the herbarium specimen were taken and boiled in water for few minutes. The softened parts were sectioned and the finer sections were subjected to dehydration using alcohol series. Safranin and Light Green were used for staining. The dehydrated material was mounted with DPX. Temporary slides were prepared for the stomatal studies.

Key characters were used to assess the relationships among
the representative members of the genus *Arisaema* through hierarchical cluster analysis using SPSS for window program (version 11.5). The character state of each character was coded as 0, 1 or 2 before analysis.

**Results**

**TAXONOMIC TREATMENT**

*Arisaema* Mart.

Rootstock a subglobose corm or cylindrical rhizome. Leaves usually appearing with flowers, 1-2 (-3), erect; petiole longer than blade; blade medium to dark green, sometimes glaucous adaxially, palmately or pedately (radiately) divided, not peltate, leaflet elliptic to broadly ovate or oblanceolate, base rounded to obtuse or attenuate, apex obtuse or acute to acuminate; primary lateral veins of each leaflet pinnate. Inflorescences: peduncle erect, nearly equal to leaves [to very short], apex not swollen; spathe variously coloured or striped, distal part open at maturity, exposing tip to ½ or more of spadix appendage; spadix more or less cylindrical, surmount by sterile appendage of variable shape. Flowers unisexual, staminate and pistillate on same or different spadix; pistillate flowers congested; staminate flowers usually scattered, distal to pistillate flowers when both are present; perianth absent. Fruits not embedded in spadix, glossy orange to bright red. Seeds 1-6, mucilage sometimes present (not present in *Arisaema triphyllum*). X =13, 14.

**Key to the Species**

1. Leaves pedatissect, plants usually monoecious, spadix strongly curved near the base ........................................6. *A. tortuosum*
   
2. Leaflets less than 10, appendage with lobulated base...........3
   
   3a. Spadix shorter than the spathe, tip rounded....................5
   
   3b. Spadix longer than the spathe, tip pointed..........................5
   
   4a. Tip of spadix clavate, leaves oblanceolate........1. *A. concinnum*
   
   4b. Tip of spadix rounded, leaves linear lanceolate.....3. *A. erubescens*
   
5a. Median leaf rhomboidally orbicular, nerves reticulate.

   5b. Median leaf broadly ovate, nerves parallel ..........2. *A. costatum*


   *Arisaema alienatum* Schott, tom. cit.: 26 (1859).

   *Arisaema affine* Schott, tom. cit.: 27 (1859).

   *Arisaema concinnum* var. *alienatum* (Schott) Engler, tom. cit.: 178 (1920).

Herb upto 60 cm. Rootstock globose. Stem erect, succulent with brownish chequering. Leaf 1, radiate, leaflets 10-11, linear to narrowly oblanceolate, abruptly acuminate, sessile, 6-9 x 1.5 cm. Spathe blade ovate, scarcely wider than tube, not auriculated at base, narrowed into a long tail margin, green; tube elongate, green with broad whitish stripes. Spadix shorter than the spathe, just exceeding the tube, appendage very slender, constricted below the knobly apex, erect, tip clavate truncate. Dioecious. Synandria dense, ± sessile, yellowish, 4-loculed, locules opening by apical pores. Fruiting peduncle erect. Fl. May-Jul. & Fr. Aug.-Sep. (Fig. 1).

**Distribution**: Nepal (CE. 1600-2400 m), Himalaya (Punjab to Arunachal Pradesh), NE India (Meghalaya), Myanmar, China (Xizang).


**Voucher specimen**: Lalitpur, Bajrabarahi, 1350 m, 22 May 2005, N. Shrestha 107 (TUCH).

**Fig. 1. Arisaema concinnum** Schott: (a) habit sketch, (b) staminate spadix, (c) stamen (N. Shrestha 107).


*Arisaema wallichianum* auct. non Hook.f.: Engler, Pfl.-reich IV-23F, Ht. 73: 175 (1920).

Herb. Rootstock globose. Stem erect, green. Leaf 2, trifoliate, sessile with closely set parallel nerves, dark green, 5-13 × 12-25 cm, lateral leaflets dimidiate cordate, median broadly ovate, acuminate. Spathe dark maroon, glossy, limb of spathe oblong lanceolate narrowed into a long filiform tip, tube elongate, dull purple with white stripes. Spadix longer than the spathe, appendage forming a dilated lobulated base and then tapering into a long filiform tail. Dioecious. Fl. Jun.-Jul. & Fr. Aug.-Sep. (Fig. 2).

**Distribution**: Nepal (C. 1900-2600m), Sikkim.


**Voucher specimen**: Rasuwa, Thulo Syabru, 2000 m, 4 June 2005, N. Shrestha 108 (TUCH).


Herb upto 40 cm. Rootstock globose. Stem erect, purplish white with dark brown streaks. Leaf 1, radiate, leaflets 10-12, linear lanceolate, acuminate, sessile, margin undulate, 4-10 × 0.5-1.2 cm. Spathe cylindric, pinkish, limb ovate lanceolate, tapering into a filiform tip; tube infundibular, faint green. Spadix shorter than the spathe just exceeding the tube, 4.5-5 cm, appendage stout erect subcylindric from an elongated ovoid base, tip rounded. Dioecious. Fl. May-Jul. & Fr. Aug.-Sep. (Fig. 3).

**Distribution**: Nepal (C. 1900-2600m), Sikkim.


**Voucher specimen**: Rasuwa, Thulo Syabru, 2000 m, 4 June 2005, N. Shrestha 108 (TUCH).

*Arum nepenthoides* Wall., Tent. Fl. Napal.: 26, t. 18 (1824).


Herb. Rootstock sub-globose. Stem erect, succulent, dull yellowish with dark streaks. Leaves usually 2, subopposite, palmate, leaflets 5, oblanceolate, sessile, abruptly acuminate to very acute, base cuneate, dark green, 6-9 × 1.5 cm. Peduncle usually exceeding leaves. Spathe tube cylindric, dull yellowish clouded with dark streaks, blade arching over spadix, elliptic ovate, base of limb dilated into 2 broad rounded auricles, auricles spotted with dark brown patches. Appendix cylindric, apex rounded, base truncate, just exceeding the spathe tube, smooth, pinkish. Fruiting peduncle erect. Dioecious. Fl. Mar.-Apr. & Fr. May-Aug. (Fig. 4).

**Distribution**: Nepal (WCE. 2500-3800m), Himalaya (Kashmir to Bhutan), NE India (W. Bengal), China (Xizang).


**Voucher specimen**: Deurali, 2500 m, 14 April 1996, M.S. Subedi, K26 (TUCH).


*Arisaema intermedium* var. *propinquum* (Schott) Engler in DC., Monogr. Phan. 2:541 (1879).


Herb upto 1 m. Rootstock sub globose. Leaves 2, trifoliolate, leaflets subsessile, margin blackish; central leaflet rhomboidally orbicular, acuminate, base cuneate; lateral leaflet asymmetrical ovate, finely acuminate, base cuneate, 10-12 × 9-10 cm. Petiole with dark longitudinal stripes. Spathe dark brownish-purple; tube elongate, cylindric with broad yellowish or greenish stripes; limb oblong lanceolate, acute, caudate acuminate. Appendix forming a dilated lobulated base and then tapering into a very long filiform tail, dark purplish, smooth. Synandria shortly stalked, cream to yellowish, composed of 3 anthers opening by a horse-shoe shaped slit. Fl. May-Jun. & Fr. Jul.-Sep. (Fig. 5).

**Distribution**: Nepal (WCE. 2500-3800m), Himalaya (Kashmir to Bhutan), NE India (W.Bengal), China (Xizang).


**Voucher specimen**: Rasuwa, Cholangpati, 2700 m, 6 Jun 2005, N.Shrestha 112 (TUCH).

Monoecious. Bulb depressed globose. Leaves 2, pedately 7-13 foliate, leaflets variable in shape, oblong to lanceolate, apex acuminate, base cuneate, shortly petiolulate, lateral veins many, outer leaflets smaller, petiole elongate. Peduncle longer than the leaf. Spathe green, tube cylindric, blade ovate or oblong ovate, shortly acute, 7.5-10.5 cm long and 2.2-3.5 cm broad. Spadix unisexual, anthers 2-3, longitudinally dehiscent; appendage elongate, sigmoidally curved in the lower part, and almost upright in the upper part.

Key to the infraspecific category

1a. Leaves linear lanceolate, leaflets 6-8…………………A. tortuosum var. curvatum

1b. Leaves ovate lanceolate, leaflets 9-12…………………A. tortuosum var. tortuosum


Arisaema curvatum (Roxb.) Kunth, Enum. Pl. 3: 20 (1841).

Herb upto 50 cm. Rootstock sub-globose. Leaves 2-3, pedate, dull above, dark green. Leaflets 6-8; central leaflet narrowly to broadly elliptic to oblong-elliptic, shortly acuminate, base rounded to cuneate; lateral linear lanceolate. Peduncle usually exceeding leaves. Spathe shortly acuminate, pale green; limb ovate, acuminate, tube narrow. Appendix sigmoidally ascending, gradually tapering from sessile base to very acute apex, greatly exceeding spathe, smooth, green. Synandria widely spread, stalked, cream to orange, composed of 2-3 anthers. Monoecious. Fruiting peduncle erect. Fl. May-Jun. & Fr. Jul.-Sep. (Fig, 6).

Distribution: Nepal (C. 1500-2500m), Himalaya (Himachal Pradesh to Sikkim), NE India (Meghalaya)


Voucher specimen: Lamjung, Sindure, 1500 m, 9 Jul 2002, B. Adhikari 194 (TUCH).


Fig. 6. Arisaema tortuosum var. curvatum (Roxb.) Engl.: (a) habit sketch, (b) spadix, (c) stamen, (d) carpel (B. Adhikari 194).

Fig. 7. Arisaema tortuosum (Wall.) Schott var. tortuosum: (a) habit sketch, (b) spadix, (c) stamen (S. Thapa 1).
**Arisaema propinquum**

These taxa resemble each other in multiple distant relationships with leaves. Similarly, **Arisaema helleborifolium** Schott, Synops. Aroid.:29 (1856).

**Arisaema tortuosum** var. **helleborifolium** (Schott) Engler in DC., Monogr. Phan. 2: 545 (1879).

Herb. Stem mottled with purple. Leaves 2, pedately compound; leaflets 9-12, unequal, most of them stalked, ovate lanceolate, long pointed. Spathe green, finely ribed; tube narrow, mouth contracted; limb broad, ending in a long pointed tip. Spadix prolonged into a far-protruding tail-like appendage, curved near the base, then turning upwards. Male and female flowers usually on the same plant but in very unequal numbers. Anthers white or pale yellow. Fl. May-Jun. & Fr. Jul.-Sep. (Fig. 8).

**Distribution**: Nepal (WCE. 1300-2900m), Himalaya (Punjab to Bhutan), NE India (Meghalaya, Manipur), N. Myanmar, W. China.


**Voucher specimen**: Kathmandu, Balaju, 1300m, May 2003, S. Thapa 1 (TUCH).

**Hierarchical Cluster Analysis**

Hierarchial cluster analysis, based on morphological data, revealed greater affinities between **A. costatum** and **A. propinquum**. These taxa resemble each other in multiple characters including trifoliate leaves, and morphology and color of spathe. These two taxa which possess trifoliate leaves are distantly related with **A. tortuosum** which possesses pedatisect leaves. Similarly, **A. erubescens** and **A. concinnum** were found to be much closely related. **A. nepenthoides** shares only few common characters and was thus distantly related with each of these species.

**Discussion**

The genus **Arisaema** is represented by sixteen species in Nepal, including 3 endemic species, viz **A. costatum**, **A. exappendiculatum** and **A. vexillum**. They generally occur in the subtropical and temperate to subalpine regions at an elevation ranging from 300 to 4000 m asl. The morphological variation within the species is well marked. Arrangement of leaflets is basically of three types: trifoliate, pedatisect and whorled. Trifoliate leaf is found in species like **A. costatum**, **A. propinquum**, **A. griffithii** and **A. utile**. Similarly **A. tortuosum** and **A. flavum** have pedatisect leaves. Likewise, leaves of **A. concinnum**, **A. consanguineum**, **A. nepenthoides** and **A. erubescens** are whorled.

Venation varies from parallel to pinnate. **A. costatum** has closely set parallel veins which differ from all its congeners. Rootstock or corm is either globose or subglobose.

Majority of the species are dioecious with male and female flowers occurring in different plants. Few are, however, monoecious for example **A. tortuosum**. In monoecious species, staminate flowers lie on the upper portion of the spadix and pistillate flowers on the lower portion beneath the staminate flowers. It has been found that smaller plants produce only staminate flowers and larger plants produce either staminate or pistillate flowers simultaneously or pistillate flowers only. The inflorescence is surrounded by a large leaf-like bract (a spathe) which is variously coloured. The shape and striation of spathe differs from species to species. In **A. concinnum** and **A. erubescens**, blade of the spathe is ovate whereas in **A. costatum** and **A. propinquum** the shape is oblong lanceolate. Similarly, in **A. nepenthoides**, the base of the limb is dilated into 2 broad rounded auricles. Spadix is shorter than the spathe in **A. erubescens**, **A. nepenthoides** and **A. concinnum**. In some species, the appendage of the spadix extends beyond the spathe (**A. tortuosum**) and continues as a long filiform tail (**A. propinquum** and **A. costatum**). **A. tortuosum** possesses a remarkable sigmoidally ascending spadix tip. The inflorescence usually produces a strong odour (sweet to noxious) and often heat. The gynoecium matures before the androecium, and when the flowers are unisexual, the carpellate mature before the stamine, leading to outcrossing (Takasu 1987). In **Arisaema**, small (generally
young) plants are staminate and larger (older plants) are carpellate, again leading to out crossing.

The anatomical differences within the species are not clearly defined. In all the studied species, the leaf anatomy revealed similar pattern. The stomata are of paracytic type and they are more or less of same size. The distribution of stomata was much higher in *A. propinquum* compared to other species. The species, as such, is not easy to distinguish on the basis of anatomical details alone.

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**References**


