

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

Nawal Shrestha

Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal; email: nawalshrestha@gmail.com

## 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-foliolate (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 tri-foliolate 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 Bajrabarahi 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

- 1a. Leaves pedatisect, plants usually monoecious, spadix strongly curved near the base .....6. *A. tortuosum*  
 1b. Leaves whorled, plants usually dioecious, spadix straight.....2  
 2a. Leaflets less than 10, appendage with lobulated base.....3  
 2b. Leaflets more than 10, appendage without lobulated base.....4  
 3a. Spadix shorter than the spathe, tip rounded.....4. *A. nepenthoides*  
 3b. Spadix longer than the spathe, tip pointed.....5  
 4a. Tip of spadix clavate, leaves oblong lanceolate.....1. *A. concinnum*  
 4b. Tip of spadix rounded, leaves linear lanceolate.....3. *A. erubescens*  
 5a. Median leaf rhomboidally orbicular, nerves reticulate.  
 .....5. *A. propinquum*  
 5b. Median leaf broadly ovate, nerves parallel .....2. *A. costatum*

**1. *Arisaema concinnum*** Schott, Bonplandia (Hanover) 7:27 (1859). Hook.f., Fl. Brit. India 6:505 (1893). Hara in Enum. Fl. Pl. Nepal 1: 89 (1978). Malla *et al.*, Fl. Kath. Valley: 706 (1986). Noltie, Fl. Bhutan 3(1): 148 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 13 (2000).

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

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

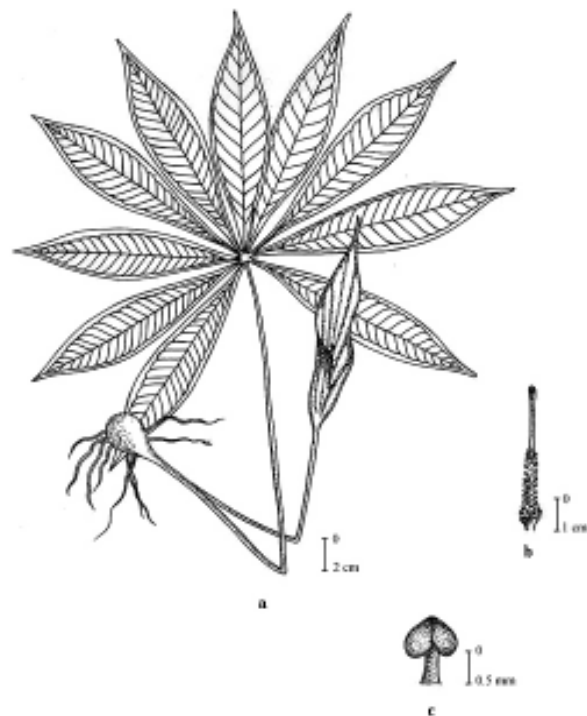
*Arisaema concinnum* var. *alienatum* (Schott) Engler, tom. cit.: 178 (1920).

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 knobby 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).

*Specimens examined:* **Western Nepal:** Dolpa, 2820 m, 21 Jun 1987, N.K. Bhattarai and M.N. Subedi 87/169 (KATH). **Central Nepal:** Makwanpur, Daman, 2400 m, 5 Jun 1972, T.B. Shrestha 17203 (KATH). Rasuwa, 2500 m, 24 Jun 1986, N.K. Bhattarai 86/494 (KATH); Rasuwa, Lama Hotel, 2712 m, 5 Aug 1985, H. Van *et al.* N161 (KATH). Kathmandu, Shivapuri, 2000 m, 24 May 1973, M.M. Amatya 14696 (KATH); Kathmandu, Shivapuri, 2000 m, 24 May 1973, M.M. Amatya 14696 (KATH). Dolakha, 2450 m, 31 Oct 1977, K.R. Rajbhandari and B. Roy 1067 (KATH).

*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).

**2. *Arisaema costatum*** (Wall.) Mart. ex Schott, Melet. Bot.: 17 (1832). Hook. f., Fl. Brit. India 6: 501 (1893). Hara in Enum. Fl. Pl. Nepal 1: 89 (1978). Malla *et al.*, Fl. Kath. Valley: 707 (1986). Noltie, Fl. Bhutan 3(1): 154 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 13 (2000).

*Arum costatum* Wall., Tent. Fl. Nepal.: 28, t.19 (1824).

*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 (CE. 1900-2800m). Endemic to Nepal.

*Specimens examined*: **Western Nepal**: Dang, 1200 m, 25 Jul 1981, N.P. Manandhar and D.P. Joshi 6199 (KATH). Pyuthan, Swargadwari, 875m, 20<sup>th</sup> Sep 1988, N.K. Bhattarai and S.R. Baral 88/397 (KATH). **Central Nepal**: Parbat, Ulleri, 2500 m, 21 Jul 1974, D.P. Joshi and T.K. Bhattacharya 74/1842 (KATH). Rasuwa, Sherpagaon, 2250 m, 26 Jun 1986, N.K. Bhattarai 86/507 (KATH). Kathmandu, Budanilkanta, 1400 m, 14 Jun 1969, H. Kanai 281 (KATH). Lalitpur, Phulchowki, 1700 m, 21 May 2001, S. Shrestha (TUCH). Sindhuwa, 2280 m, 5 Jun 1972, H. Kanai, H. Shashi and K. Iwatsuki 1341 (KATH). Sindhupalchowki, Pakhar danda, 1750 m, 7 Jul 1997, P.R. Shakya, K.R. Rajbhandari and H.K. Sainju 1018 (KATH).

*Voucher specimen*: Kanike, 1800 m, 25 May, 1995, S. Jha (TUCH).



**Fig. 2.** *Arisaema costatum* (Wall.) Mart. ex Schott: (a) habit sketch, (b) staminate spadix, (c) stamen (S. Jha).

**3. *Arisaema erubescens*** (Wall.) Schott, Melet. Bot.: 17 (1832). Hook. f., Fl. Brit. India 6:506 (1893). Hara in Enum. Fl. Pl. Nepal 1: 89 (1978). Malla *et al.*, Fl. Kath. Valley: 708 (1986). Noltie, Fl. Bhutan 3(1): 154 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 13 (2000).

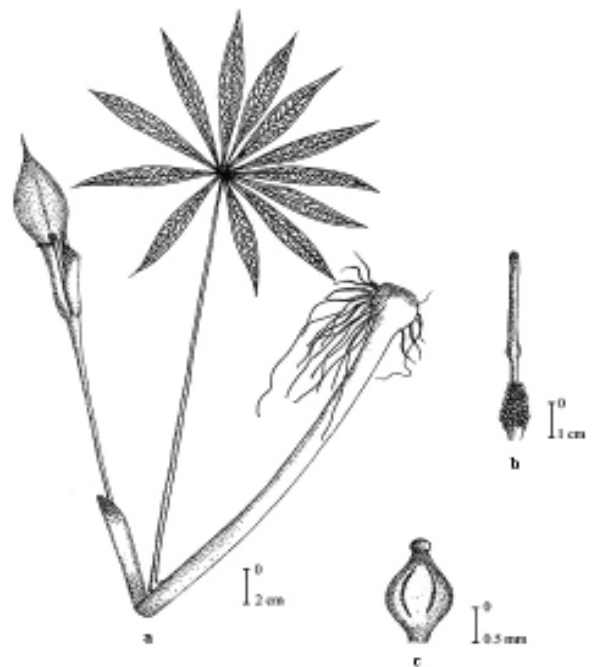
*Arum erubescens* Wall., Pl. Asiat. Rarior. 2: 30, t.135 (1831).

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.

*Specimens examined*: **Western Nepal**: Bajhang, Khaptad, 2500 m, 24 Aug 1990, N.K. Bhattarai 90/1092 (KATH). **Central Nepal**: **Makwanpur**, Daman, 2400 m, 5 Jun 1972, T.B. Shrestha 17202 (KATH); Makwanpur, Simbhanjyang, 2460m, 25 Aug 1960, S.B. Malla 40 (KATH). Kathmandu, Shivapuri, 2424 m, 26 Jun 1995, A. Mishra 32 (TUCH). Lalitpur, Phulchowki, 2100 m, 25 Apr 1969, H. Kanai 111868 (KATH). Dolakha, Jiri, 2300 m, 10 Jun 1997, S. Aryal 2 (TUCH); Dolakha, Jiri, 2300 m, 14 April 1996, N. K. Adhikari 81 (TUCH); Dolakha, Nigale, 2450 m, 8 Jul 1977, K.R. Rajbhandari and B.Roy 1068 (KATH). **Eastern Nepal**: Okhaldhunga, 2840 m, 28 May 1979, N.P. Manandhar and M.K. Adhikari 1870 (KATH).

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



**Fig. 3.** *Arisaema erubescens* (Wall.) Schott: (a) habit sketch, (b) carpellate spadix, (c) carpel (N. Shrestha 108).

**4. *Arisaema nepenthoides*** (Wall.) Mart. ex Schott, Melet. Bot.:17(1832). Hook. f., Fl. Brit. India 6:504 (1893). Hara in Enum. Fl. Pl. Nepal 1: 90 (1978). Malla *et al.*, Fl. Kath. Valley: 709 (1986). Noltie, Fl. Bhutan 3(1): 145 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 14 (2000).

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

*Arisaema ochraceum* auct. non Schott: Lacaïta in J. Linn. Soc. Bot. 43: 483 (1916).

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).

**Specimens examined: Central Nepal:** Parbat, 2667 m, 4 Jun 1985, H. Van and I. S. Cotter N 45 (KATH). Kaski, Odane lekh, 2300 m, 19 Mar 1974, D.P. Joshi and M.M.Amatya 74/1610 (KATH). Kathmandu, Shivapuri, 2100 m, 17 Mar 1966, R. Thapa 4357 (KATH). Lalitpur, Phulchowki, 1600 m, 28 Nov 1994, K. Manandhar (TUCH). Dolakha, 2300 m, 14 April 1996, S.P. Parajuli 16 (TUCH); Dolakha, Jiri, 2450 m, 12 Dec 2005, S. Shrestha and R. Amatya 26 (TUCH). Bagdwar, 2400 m, 26 Mar 1969, H. Kanai 11135 (KATH). Chinsapu, 2730 m, 7 Apr 1967, S.B. Malla 7854 (KATH). Lampokhari, 2940 m, 10 Mar 1993, P.R. Shakya 9653 (KATH). **Eastern Nepal:** Mechi, 2650 m, 7 Apr 1967, D.H. Nicolson 7/1967 (KATH).

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

**5. *Arisaema propinquum*** Schott, Oesterr. Bot. Wochenbl. 7:333 (1857). Hook. f., Fl. Brit. India 6: 501 (1893). Hara in Enum. Fl. Pl. Nepal 1: 90 (1978). Malla *et al.*, Fl. Kath. Valley: 709 (1986). Noltie, Fl. Bhutan 3(1): 153 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 14 (2000).

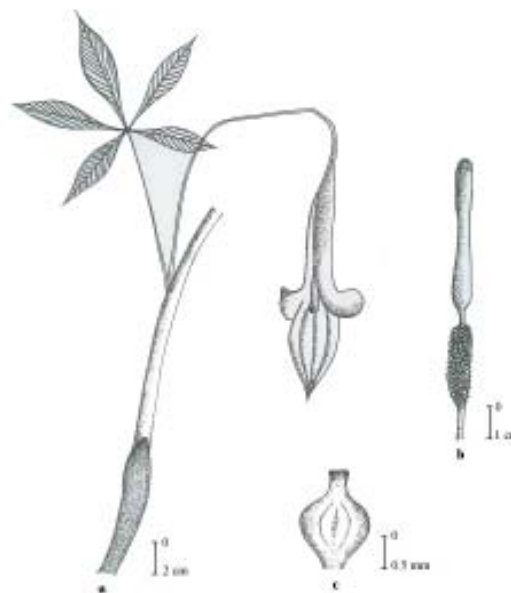
*Arisaema wallichianum* Hook. f., Fl. Brit. India 6:500 (1893).

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

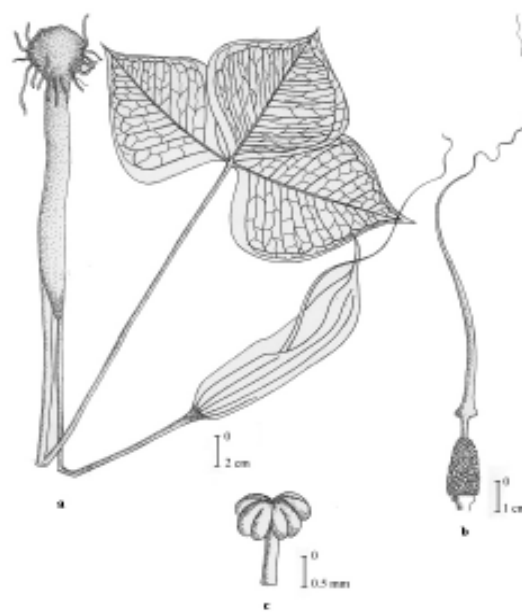
*Arisaema sikkimense* Stapf ex Chatterjee in Bull. Bot. Soc. Bengal 3:18 (1949).

*Arisaema costatum* var. *sikkimense* (Stapf) Hara in J. Jap. Bot. 36:76 (1961).

Herb upto 1 m. Rootstock sub globose. Leaves 2, trifoliate, 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



**Fig. 4. *Arisaema nepenthoides*** (Wall.) Mart. ex Schott: (a) habit sketch, (b) carpellate spadix, (c) carpel (M.S. Subedi K26).



**Fig. 5. *Arisaema propinquum*** Schott: (a) habit sketch, (b) staminate spadix, (c) stamen (N. Shrestha 112).

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).

**Specimens examined: Western Nepal:** Dailekh, Mabu pass, 2172 m, 6 Jul 1979, K.R. Rajbhandari and B. Roy 2897 (KATH). **Central Nepal:** Dolpa, Maure pass, 3450 m, 28 Jun 1987, N.K. Bhattarai and M.N. Subedi 87/243 (KATH). Myagdi, Ghodepani, 2750 m, 22 Jun 1975, D.P. Joshi and T.K. Bhattacharya 75/2892 (KATH). Lalitpur, Phulchowki, 2450 m, 23 May 1967, D.H. Nicolson 3361 (KATH).

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

**6. *Arisaema tortuosum*** (Wall.) Schott, Melet. Bot.: 17 (1832). Hook. f., Fl. Brit. India 6: 502 (1893). Hara in Enum. Fl. Pl. Nepal 1: 90 (1978). Fl. Kath. Valley: 710 (1986). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 14 (2000).

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 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 tortuosum* var. *curvatum*** (Roxb.) Engl., Pflanzenr. (Engler) IV-23F (Ht. 73): 191 (1920). Hara in Enum. Fl. Pl. Nepal 1: 91 (1978). Noltie, Fl. Bhutan 3(1): 147 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 14 (2000).

*Arum curvatum* Roxb. [Hort. Bengal.:65 (1814), nom. nud.], Fl. Ind. ed. 2,3: 506 (1832).

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

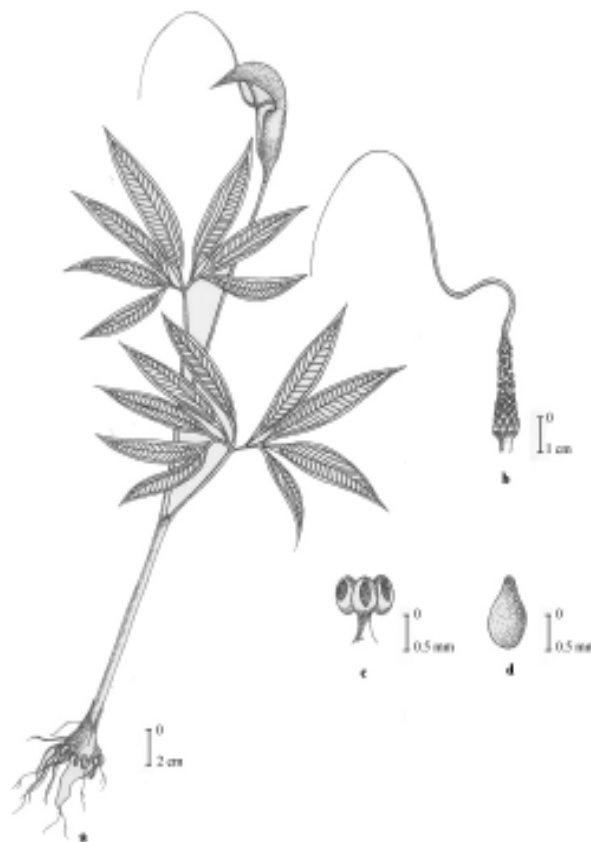
Herb upto 50 cm. Rootstock sub-globose. Leaves 2-3, pedate, dull above, dark green. Leaflets 6-8; central leaflet narrowly to broadly elliptic to oblong-elliptic, shortly acuminate, base rounded to cuneate; lateral linear lanceolate. Peduncle usually exceeding leaves. Spathe shortly acuminate, pale green; 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)

**Specimens examined:** **Western Nepal:** Dadeldhura, Anarkholilekh, 2250 m, 30 May 2005, K. Bhatta 23 (TUCH). **Central Nepal:** Tanahun, 400 m, 8 Apr 1996, P. Pandit 165 (TUCH). Lamjung, Sindure, 1500 m, 9 Jul 2002, B. Adhikari 194 (TUCH). Lalitpur, Hattiban, 1400m, 5 May 2001, M.R. Aryal 7 (TUCH); Lalitpur, Bajrabarahi, 1400 m, 10 Jun 2001, N. Maharjan 7 (TUCH).

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

***Arisaema tortuosum*** (Wall.) Schott, Melet. Bot.: 17 (1832) var. ***tortuosum*** Hara in Enum. Fl. Pl. Nepal 1: 91 (1978). Noltie, Fl. Bhutan 3(1): 147 (1994). Press *et al.*, Ann. Check. Fl. Pl. Nepal: 14 (2000).



**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).

*Arum tortuosum* Wall., Pl. Asiat. Rarior. 2: 10, t. 114 (1831).

*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 ribbed; 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. 7).

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

**Specimens examined:** **Western Nepal:** Kalikot, 2000 m, 14 Jun 1979, K.R. Rajbhandari and B. Roy 3252 (KATH). Rolpa, 1430 m, 1 Sep 1982, N.P. Manandhar and N.K. Bhattacharya 8655 (KATH). Dang, 1200 m, 25 Jul 1981, N.P. Manandhar and D.P. Joshi 6204 (KATH). **Central Nepal:** Gorkha, 2250 m, 5 Jun 1983, P.R. Shakya *et al.* 7761 (KATH). Kathmandu, Hattiban, 1400 m, 23 May 2001, P. Adhikari 15 (TUCH). Lalitpur, Phulchowki, 1600 m, 23 Jun 2001, G.P. Sharma G60 (TUCH). Dolakha, 2300 m, 8 Jul 1977, K.R. Rajbhandari and B.Roy 1088 (KATH).

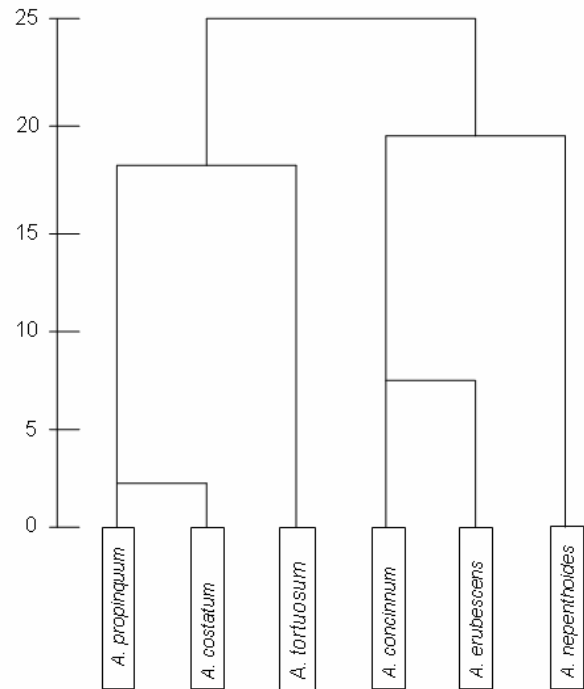
**Voucher specimen:** Kathmandu, Balaju, 1300m, May 2003, S. Thapa 1 (TUCH).

#### HIERARCHICAL CLUSTER ANALYSIS

Hierarchical 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 possess 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. vexillatum*. 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.



**Fig. 8.** Dendrogram showing interrelationship between six species of *Arisaema*.

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 staminate, 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.

## Acknowledgements

The author is grateful to Prof. Dr. Krishna Kumar Shrestha, Prof. Dr. Ram Prasad Chaudhary, Ms. Sangeeta Rajbhandary and Mr. Bhaskar Adhikari for their support and guidance during the work. The author is also thankful to Dr. Suresh K. Ghimire for constructive suggestions. Thanks are also due to Dr. Mahesh Kumar Adhikari, Department of Plant Resources, for permission to examine herbarium specimens deposited at KATH.

## References

- Cabrera L.I., Salazar G.A., Chase M.W., Mayo S.J., Bogner J. and Dávila P. 2008. Phylogenetic relationships of aroids and duckweeds (Araceae) inferred from coding and noncoding plastid DNA. *American Journal of Botany* 95: 1153–1165
- Croat T.B. 2000. History and Current Status of Systematic Research with Araceae. [online] URL: [http://www.aroid.org/literature/croat/history/literature/lit\\_m.php](http://www.aroid.org/literature/croat/history/literature/lit_m.php) (assessed 25 Nov. 2009).
- Hara H., Stearn W.T. and Williams L.H.J. 1978. *An Enumeration of Flowering Plants of Nepal* Vol 1. British Museum (Natural History), London, UK.
- Hooker J.D. 1894. *Flora of British India* Vol. VI. L. Reeve and Co. Ltd., Ashford, Kent, UK.
- Judd W.S., Campbell C.S., Kellogg E.A. and Stevens P.F. 1999. *Plant Systematics- A Phylogenetic Approach*. Sinauer Associates Inc., Sunderland, Massachusetts, USA.
- Martius K.F.P. von. 1831. ber die Art der Befruchtung bei einigen Aroideen und, ber die Charakteristik mehrerer Gattungen dieser Familie. *Flora* 14 (2): 449–460.
- Noltie H.J. 1994. *Flora of Bhutan* Vol 3 Part 1. Royal Botanic Garden, Edinburgh, UK.
- Polunin O. and Stainton A. 1984. *Flowers of the Himalaya*. Oxford University Press, New Delhi.
- Press J.R., Shrestha K.K. and Sutton D.A. 2000. *Annotated Checklist of the Flowering Plants of Nepal*. The Natural History Museum, London, UK.
- Rajbhandari T.K. 1997. *Cytotaxonomical Studies in the Genus Arisaema Mart. and its Allies of Nepal*. Ph.D. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.
- Renner S.S., Zhang, L. and Murata, J. 2004. A chloroplast phylogeny of *Arisaema* (Araceae) illustrates Tertiary floristic links between Asia, North America and East Africa. *American Journal of Botany* 91(6): 881–888.
- Shrestha T.B. and Joshi R.M. 1996. *Rare, Endemic and Endangered Plants of Nepal*. WWF Nepal Program, Kathmandu, Nepal.
- Takasu H. 1987. Life history studies on *Arisaema* (Araceae) I. Growth and reproductive biology of *Arisaema urashima* Hara. *Plant Species Biology* 2(1,2): 29–56.
- Wallich N. 1824. *Tentamen Florae Nepalensis Illustratae*. London, UK.