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RESEARCH ARTICLE

Taxonomic Studies on the Genus *Arnebia* Forssk. (Boraginaceae) in India

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ABSTRACT: The genus *Arnebia* Forssk. in India is taxonomically studied based on field surveys, collection of live plants, consultation of herbarium and literature. The genus is represented in India by 10 taxa including 8 species and 2 varieties *viz.*, *Arnebia bhattacharyyae* K. Ambrish & S.K. Srivast., *A. benthamii* (Wall. ex G. Don) I.M. Johnst., *A. euchroma* (Royle) I.M. Johnst., *A. guttata* Bunge, *A. hispidissima* (Sieber ex Lehm.) A.DC., *A. linearifolia* A.DC., *A. griffithii* Boiss., *A. nandadeviensis* K. Chandra Sek. & R.S. Rawal , *A. euchroma* var. *grandis* (Bornm.) Kazmi and *A. guttata* var. *thomsonii* (C.B. Clarke) Kazmi, distributed in Jammu & Kashmir, Himachal Pradesh and Uttarakhand in North-West Himalaya to Uttar Pradesh, Punjab and Rajasthan in India. Dichotomous keys to all the species in India along with taxonomic description, distribution, illustrations and images of most of the species including type and their economic importance are provided.

KEY WORDS: *Arnebia,* Boraginaceae, India, Taxonomic Studies.

INTRODUCTION

Arnebia Forssk. (Boraginaceae), an economically important genus was established by Pher Forsskal in 1775. It comprises *c.* 25 species (Mabberley, 2008). The genus is known to occur worldwide from North Africa, Trans Caucasus, Syria, Iraq, Iran, Afghanistan, Pakistan, China and India (Hooker, 1883; Johnston, 1952; Kazmi, 1971; Nasir, 1989; Aswal and Mehrotra, 1994; Zhu *et al*., 1995).

Clarke (1883) presented the first systematic account of Indian Borageineae in *Hookers Flora of British India,* in which he recorded only 4 species under the genus *Arnebia.* Later, Johnston in 1924 reviewed the *Old World Genera of Boraginaceae* and published his observations on some genera and species in his sporadic publication. Further, he differentiated two closely related genera *Arnebia* and *Lithospermum* mainly based on pollen morphology and listed 18 species of *Arnebia* from the Old World. Kazmi (1970) in his account *Revision of the Boraginaceae of W. Pakistan and Kashmir* recorded 13 species of *Arnebia* from the region. Besides, the genus was taxonomically studied by several earlier workers (Popov, 1953; Reidl, 1967; Stewart, 1972; Nasir, 1989; Zhu *et al*., 1995; Chandra Sekar, K. *et al*., 2009; Kumar and Srivastava, 2010 & 2012; Shukla *et al.,* 2011).

In India, no comprehensive systematic study was carried out so far on the family Boraginaceae and genus *Arnebia* as well. Since the distribution of most of the *Arnebia* spp. are confined to Himalayas, which is evident from the survey and herbarium collections, the genus has been critically studied in the field and in herbaria viz. Botanical Survey of India, Dehradun (BSD), Botanical Survey of India, Calcutta (CAL) and Forest Research Institute, Dehradun (DD). The present study reveals that the genus *Arnebia* comprises 10 taxa (8 species and 2 varieties) in India. Of these, two are endemic to Himalayan region of India.

TAXONOMIC TREATMENT

Arnebia Forssk., Fl. Aegypt.-Arab. 62. 1775.

Annual or perennial, bristly or pubescent herbs with purplish or reddish dye stained tap root. Stems erect to prostrate, branched or unbranched, hairy with tuberculate bases. Leaves sessile, alternate. Inflorescence usually in terminal, simple or branched bracteate cymes or thyrse. Flowers usually tubular or funnel-shaped, yellow to purple, mauve or blue. Calyx 5-parted to base, shorter than the corolla tube. Corolla funnel form, hairy outside; tube straight or slightly curved; throat glabrous without faucal appendages; limb usually shorter than tube. Anthers oblong or so; filaments short. Style simple or bifid; stigmas capitate, 2-4 rarely 1; gynobase flat or pyramidal; ovary 4-lobed. Nutlets 1-4, oblique-ovate or ovoid, broad at base, rough, tuberculate.

Key to the species

1a. Annual herb; corolla tube with distinct annulus at base.....2
1b. Perennial herb; corolla tube without distinct annulus at base…..5
2a.Flowers in one sided, spicate cymes; stigma 1……2. ***A. bhattacharyyae***
2b. Flowers in both sided cymes or thyrse; stigmas 2-4……...3

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3a. Calyx lobes obtuse; stigmas 4……..7. ***A. linearifolia***
3b. Calyx lobes acute; stigmas 2……..…….…….4
4a. Stems with densely covered stiff, white trichomes; calyx lobes equal…….…….4. ***A. griffithii***
4b. Stems hispid with white pungent stout trichomes; calyx lobes unequal……..4. ***A. hispidissima***
5a. Inflorescence a thyrse…….……..……6
5b. Inflorescence a cyme……..……..…...……..7
6a. Plants 30-40 cm long; corolla red; tube upto 2 cm long…….…….....…8. ***A. nandadeviensis***
6b. Plants 40-80 cm long; corolla pink or purple; tube more than 2 cm long……....1. ***A. benthamii***
7a. Leaves long, lanceolate, 2.8-14.5 cm long; flowers in terminal, subglobular cymes…….……...2. ***A. euchroma***
7b. Leaves short, oblanceolate, 1-3.5 cm long; flowers yellow in axillary or terminal, simple cymes…·····.....3. ***A. guttata***

1. ***Arnebia benthamii*** (Wall. ex G. Don) I. M. Johnst. in J. Arnold Arbor. 35. 56. 1954; Kazmi in J. Arnold Arbor. 52: 361. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak & Kashmir 581. 1972; U. Dhar & Kachroo, Alpine Fl. Kashmir Himal. 234. 1983; Aswal & B.M. Mehrotra, Fl. Lahaul-Spiti: 440.1994. *Echium benthamii* Wall. ex G. Don, Gen. Syst. 4: 333. 1838. *Macrotomia benthamii* (Wall. ex G. Don) A.DC., Prodr., 10 : 27. 1846; C.B. Clarke in Hook.f., Fl. Brit. India 4: 177. 1883. *Lithospermum benthamii* (Wall. ex G. Don) I. M. Johnst. in J. Arnnold Arbor. 33. 333. 1952. "*Balchar"* (Fig. 1, A. & B.).

Type: India, Badrinath, *Wallich* 931 (Holo: K; Iso: A)

Perennial, erect, hairy herb, 40-80 cm high with stout root stock. Stems simple, fistular, hispid, densely covered with white trichomes of tuberculated base, leafy. Leaves sessile, basal leaves narrowly lanceolate or oblong-lanceolate, 12.5-20.5 × 1.5-2.5 cm, attenuate at base, acute or obtuse at apex, entire on margins, whitish-hairy on both surfaces with spreading trichomes emerging from tuberculate bases; 3-5 nerved; cauline leaves smaller. Inflorescence a long, dense slender thyrse, 15-30 cm long; bracts leafy, linear- lanceolate, up to 5 cm long, densely hairy. Flowers pink or purple to blue. Calyx lobed, linear-lanceolate up to 4.5 cm long. Corolla tubular, tube up to 2.5 cm long, usually shorter the calyx. Stamens short; anthers elongated. Style shortly bifid; stigmas 2, capitate. Nutlets ovoid, tuberculate, 1-2.5 mm long.

Flowering & Fruiting: August - September

Habitat: Grows in alpine meadows at sandy-moist places.

Distribution: INDIA: Jammu & Kashmir, Himachal Pradesh, Uttarakhand; PAKISTAN, NEPAL.

Specimens examined: **INDIA**: Jammu & Kashmir, Sarbal, *B.M. Wadhwa* 84167 (BSD); Gulmarg, 2700-3000 m, *Duthie* 11323 (DD); Murgan La, 3300 m, *A. Meebold* 4222 (CAL); Himachal Pradesh, Pin Valley, Mud-Tharbik, 3900 m, *K. Chandra Sekar* 102927 (BSD); Uttarakhand, Uttarkashi, Harkidun, 27.09.1995, *B. Balodi* 89679 (BSD) ; Chamoli, Khankalia, 29.05.1972, *B.D. Naithani* 48086 (BSD); Kumaon, Shelang, 16.06.1958, *T.A. Rao* 6903 (BSD).

Economic Importance: Roots yields purple dye, which is used as hair tonic; its extract is taken to cure blood pressure.

2. ***Arnebia bhattacharyyae*** K. Ambrish & S.K. Srivast. in J. Jap. Bot. 88: 298-301. 2013 (Fig. 2, A. & B.).

Type: INDIA. Himachal Pradesh, Lahaul, Keylong, 3200 m, 11 August 1979, *U.C.Bhattacharyya* 40757 (Holo: BSD!; Iso: CAL!)

Annual, decumbent, strigose herb, 50-70 cm tall. Stems loosely branched above the base, fistulous, covered with spreading, stiff, white trichomes, 1.5-2 mm long, arising from tuberculate bases. Leaves sessile, alternate to sub opposite; basal leaves unequal, oblong-lanceolate to oblanceolate, 2.5-5.2 × 0.5-1.5 cm, attenuate to subrounded at base, acute-acuminate at apex, entire on margins, both surfaces and margins covered with spreading or thick 1.5-2 mm long, white trichomes, emerging from thick, white, tuberculate bases; cauline leaves usually reduced upwards, narrower and shorter than basal leaves. Inflorescence 10-30 cm long, in branched, terminal or subterminal spicate cymes; bracts linear to linear- lanceolate, up to 1 cm long. Flowers sessile, one sided, tubular, yellow, *c.* 1.2 cm long. Calyx 5-lobed; lobes equal, linear-lanceolate, 7-9 mm long, densely hispid, covering usually 2/3 corolla. Corolla yellow, tubular, 8-10 mm long; limb 2.5-3.5 mm across, obtusely 5-lobed. Stamens exserted; anthers small, ovoid, attached at lower half of corolla lobes. Style filiform, 2.5-3.5 mm long; stigma 1, capitate. Nutlets obliquely ovoid, *c.*1 mm long, obtuse at tip, brown, tuberculate.

Flowering & Fruiting: July to September.

Habitat: Grows on open dry sandy slopes along wasteland in temperate zone at an altitude between 3100-3200 m.

Distribution: INDIA: (Himachal Pradesh, Lahaul & Spiti).

Specimens examined: **INDIA**: Himachal Pradesh, Lahaul, Keylong, 3200 m, 11 August 1979, *U.C. Bhattacharyya* 40757 (BSD).

3. ***Arnebia euchroma*** (Royle ex Benth.) I.M. Johnst. in Contr. Gray Herb. 73: 49. 1924; Riedl in Rech.f., Fl. Iranica 48:164.1967; Kazmi in J. Arnold Arbor. 52: 486. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak. & Kashmir 482. 1972; U. Dhar & Kachroo, Alpine Fl. Kashmir Himal. 234. 1983; Aswal & B.N. Mehrotra, Fl. Lahaul-Spiti: 441.1994. *Lithospermum euchromon* Royal ex Benth. in Royle, Ill. Bot. Himal. Mounts. 1: 305.

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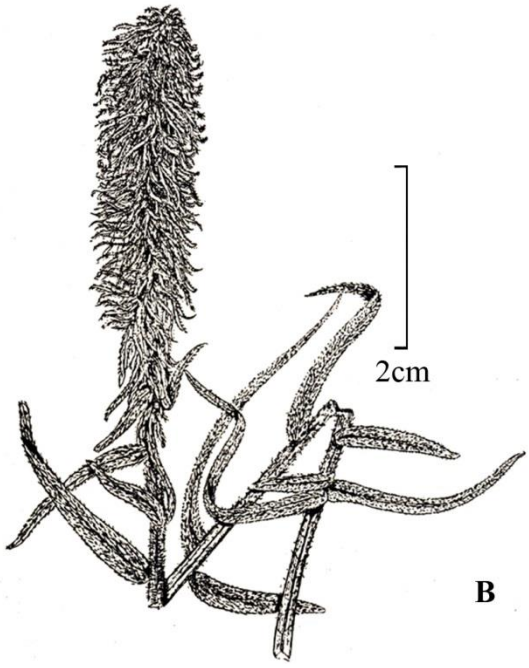
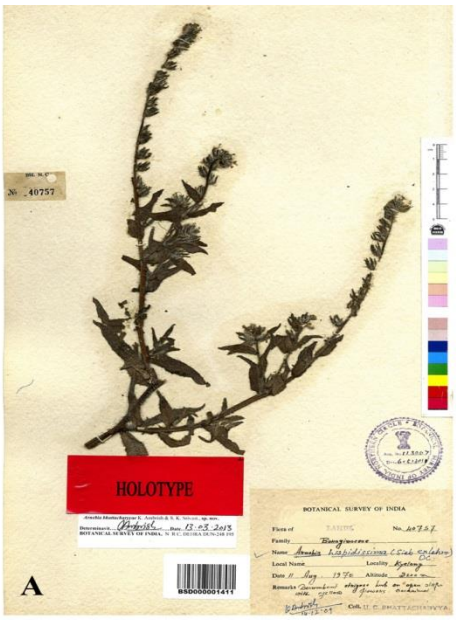


Fig. 1. *Arnebia benthamii* (Wall. ex G. Don) I. M. Jhonst. A. Photo (R. Manikandan); B. Habit (line drawing).



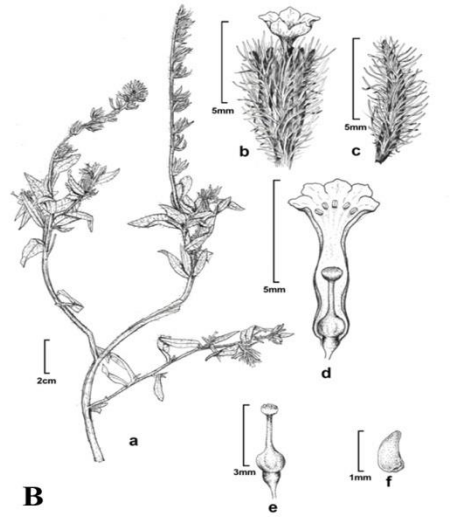


Fig. 2. *Arnebia bhattacharyyae* K. Ambrish & S.K. Srivast. A. Holotype image; B. a. Habit b. Flower c. Sepal d. L.S of Corolla e. Carpel f. Nutlet.

1839. *Macrotomia perennis* (A.DC.) Boiss., Fl. Orient. 4(1): 212.1875. *Macrotomia euchroma* Hook.f. & Thomson in Hook.f., Fl. Brit. India 4: 177. 1883. "*Indian Ratanjot*" (Fig. 3, A. & B.).

Type: India, Naho in Kunawar, *Royle s.n*. (K).

Perennial, erect herb, 30- 40 cm high with thick root stock of purple dye. Stems many, arising from root base and axils of the leaves, densely covered with thick trichomes with white tuberculate bases. Basal leaves petioled, lanceolate, 2.8-14.5 × 0.5-1.2 cm, base ciliate, acute at apex, entire at margins, densely covered with thick trichomes of white tuberculate bases on both surfaces ; cauline leaves sessile, ovate-lanceolate,2.5-8.5 x 1-2.1 cm, upper ones much shorter and broader than lower ones, subcordate at base, acute at apex, glandular-hairy on both surfaces, entire on margins. Inflorescence terminal, subglobular cymes 5-6 cm across; bracts leafy, shorter than calyx. Flowers funnel-shaped, purple or mauve to yellowish. Calyx hispid, lobed, lobes linear-oblong or lanceolate, 0.8-1.0 cm long. Corolla tubular, tube up to 1.5 cm long. Anthers linear, bifid. Style short; stigmas -2. Nutlets ovoid, 3-4 mm long, grayish, tuberculate.

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Key to the varieties

3a. Plants less pungently hirsute, cauline leaves narrower, truncate or round at base and acute at apex..... **var. *euchroma***

3b. Plants more pungently hirsute, cauline leaves broader, subcordate at base, abruptly narrowed in the upper half with long acuminate tip……..…..**....var. *grandis***

var. *euchroma*

Flowering & Fruiting: July- August

Habitat: Grows on dry and stony slopes.

Distribution: INDIA: Jammu & Kashmir, Himachal Pradesh, Uttarakhand; PAKISTAN, NEPAL, IRAN, AFGHANISTAN, RUSSIA, CHINA.

Specimens examined: **INDIA**: Jammu & Kashmir, Ladakh, Khardungla, *D.K. Singh* 101083 (BSD); Dras valley, 2425-2725 m, *Duthie* 11695 (DD); Ladakh, Kangai, 3333 m, July 1905, *A. Meebold* 4223 (CAL). Himachal Pradesh, Lahaul, July, 1864, *Brandis* 4138 (CAL); Pin Valley, Nur Pasture, 4000 m, *K. Chandra Sekar* 100493 (BSD); Lahul, 1.07.1958, *M.A. Rau* 6051 (BSD). Uttarakhand, Uttarkashi, Nelang, 3800 m, 20.07.1988, *B.D. Naithani* 75783; Chamoli, Gohtang, 4000 m, 11.09.1975, *B.D. Naithani* 48086; NDBR, Saraipathak, 05.07.1982, *P.K. Hajra* 73287 (BSD).

Economic Importance: Roots yield red dye. Also used as a spices.

var. *grandis* (Bornm.) Kazmi in J. Arnold Arbor. 52: 488. 1971; A.N. Shukla, S.K. Srivast. & K. Ambrish in J. Jap. Bot. 86: 245-247. 2011. *Macrotomia grandis* Bornm., Oesterr. Bot. Z. 47: 289. 1897. *Arnebia euchroma* (Royle) I.M. Johnst. subsp. *grandis* Riedl, Oesterr. Bot. Z. 111: 152. 1964; Riedl in Rech.f., Fl. Iranica 48: 166. 1967 (Fig. 4, A. & B.).

Type: Persia, Kerman, Bornmiller 3 948 (Holo: W; Iso: GH!).

Perennial, erect, more pungently hirsute herbs, 25–30 cm high with dye stained tap root. Stems many, unbranched, covered sparsely or densely with white trichomes with minute to large tuberculate bases. Leaves sessile; basal leaves lanceolate, 7–8 x 1–1.5 cm, acuminate at apex, entire on margins, sparsely to densely covered on both the surfaces with white thick or thin, spreading or subappressed trichomes, with tuberculate bases; cauline leaves broader, sessile, lanceolate, 5–8 x 0.5–0.7 cm, sub cordate at base, abruptly narrowed in the upper half into a long acuminate tip. Inflorescence terminal, subglobular cymes. Flowers tubular, brown-purple, *c*. 1.5 cm long. Calyx lobes densely hairy, linear-lanceolate. Corolla purple or brownish-purple, funnelform, 1.6–2.2 cm long. Stigmas 2. Nutlets grey, tuberculate, 3–4 mm long, keeled.

Flowering & Fruiting: August-September

Habitat: Grows on dry and stony slopes.

Distribution: INDIA: Jammu & Kashmir; IRAN.

Specimens examined: **INDIA**: Jammu & Kashmir, Changla, 4800 m., 13.08.2008, *U.C. Bhattacharyya* 71669; On way to Changla, 10.08.1988, *H.J. Chowdhery* & *B.P. Uniyal* 86146 (BSD).

Economic Importance: Roots yield red dye. Also used as a spice.

4. *Arnebia griffithii* Boiss., Diagn. Pl. Orient. 3: 135.1856 & Fl. Orient. 4: 213. 1875; C.B. Clarke in Hook.f., Fl. Brit. India 4: 176.1883; Riedl in Rech.f., Fl. Iranica 48:156.1967; Kazmi in J. Arnold Arbor. 52: 492. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak. & Kashmir 582. 1972; K. Ambrish & S.K. Srivast. in Rheedea: 22(2): 124-126. 2012. *Echioides griffithii* (Boiss.) Rothm. Repert. Sp. Nov. 49: 56.1940. *Lithospermum griffithii* (Boiss.) I.M. Johnst. in J. Arnold Arbor. 33: 326. 1952 (Fig. 5, A., B. & C.).

Type: Afghanistan, without locality, *Griffith* 5953 (Holo: K; Iso: GH!, CAL! & DD!)

Annual, erect herb *c.* 25 cm high with slender purple dye stained tap root. Stems single or ascendingly branched up to 12 cm long, densely covered with stiff, white trichomes, arising from tuberculate bases. Leaves sessile; basal leaves unequal, linear-oblong or oblong-obovate, 2.2-4.5 × 0.2-0.4 cm, attenuate at base, obtuse at apex, entire at margins, both surfaces and margins covered with spreading or thick, white trichomes, with thick tuberculate bases; cauline leaves usually equal, narrower and shorter. Inflorescence short, congested in terminal or sub terminal cymes; bracts leafy. Flowers sessile, tubular, yellow, *c.* 1.5 cm long. Calyx 5-lobed; lobes obtuse, linear-lanceolate, 6-8 mm long, densely hairy. Corolla yellow, tubular; limb with five purple spot; throat glabrous. Stamens exserted; anthers small, ovoid. Style filiform, *c.* 8 mm long; stigmas uniform, reniform, bifid. Nutlets brown, lustrous, tuberculate, *c.* 2 mm long.

Flowering & Fruiting: August-September

Habitat: Grows on open dry sandy slopes along wasteland at an altitude of 2400 m.

Distribution: INDIA: Spiti in Himachal Pradesh; AFGHANISTAN AND PAKISTAN.

Specimens examined: **INDIA**: Himachal Pradesh, Spiti, Kaurik, 2400 m, 21.08.1994, *S.K. Murti* & *Surendra Singh* 81582 (BSD). **AFGHANISITAN,** 1862-64, *Griffith* 5953 (CAL & DD-Isotypes!). **PAKISTAN**: Waziristan, Nai Ubbo, 20.05.1897, *Harsukh* 20593 (CAL); Peshawar, 1212 m, 1891, *H.G. Praves* (*s.n.*); Rawalpindi, 24.03.1871, *J.E. T. Aitcheson* 1081 (DD).

Economic Importance: Roots yield purple dye.

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Fig. 3. ***Arnebia euchroma*** **(Royle ex Benth.) I.M. Johnst. A. Photograph of Habit; B. Specimen image.**

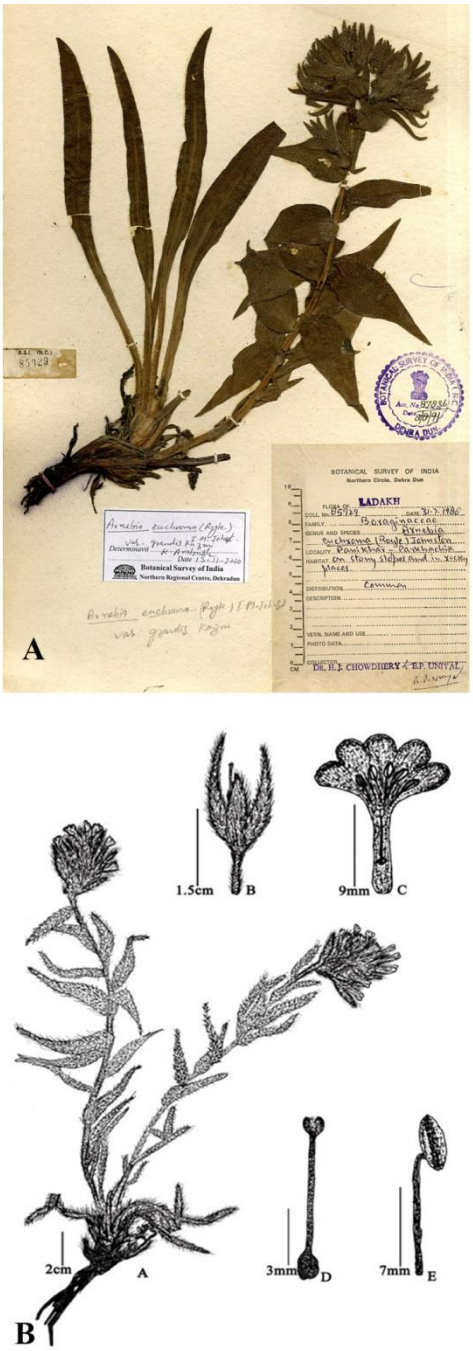


Fig. 4. ***Arnebia euchroma*** **var.** ***grandis*** **(Bornm.) Kazmi A. Specimen image; B. a. Habit b. Flower c. Corolla d. Pistil e. Stamen.**

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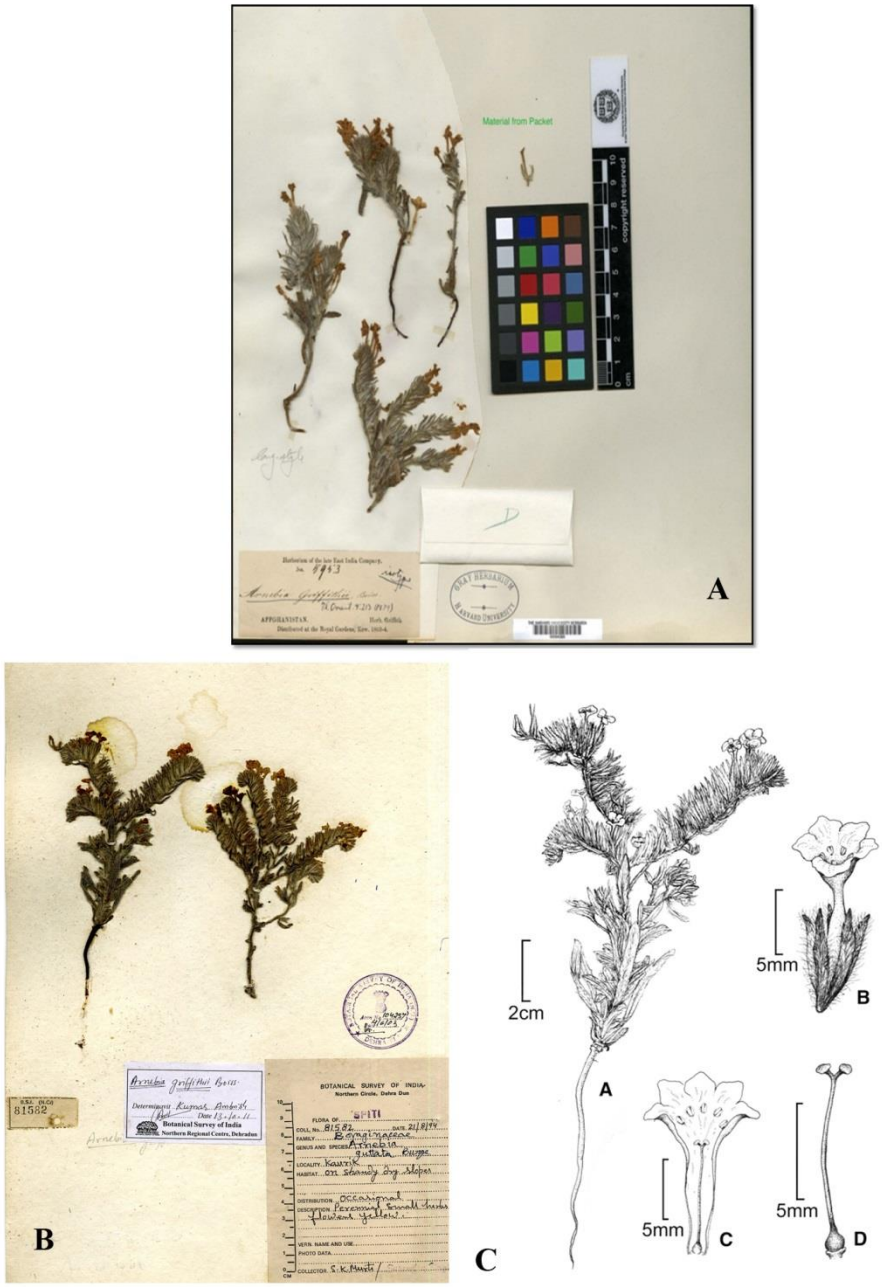


Fig. 5. *Arnebia griffithii* Boiss. : A. Holotype image; B. Specimen image; C. a. Habit b. Flower c. Corolla split-open d. Pistil

5. ***Arnebia guttata*** Bunge, Index Sem. Hort. Dorpat. 1840, 7. 1840; Ledeb. Fl. Ross. 3: 139. 1847; I.M. Johnst. in J. Arnold Arbor. 33: 331. 1952; Riedl in Rech.f., Fl. Iranica 48:157.1967; Kazmi in J. Arnold Arbor. 52. 493. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak. & Kashmir 58. 1972; Aswal & B.N. Mehrotra, Fl. Lahaul-Spiti: 442. 1994. *A. tibetana* Kurz, J. Asiat. Soc. Bengal. Pt.2, Nat. Hist. 43(2): 189. 1874; Kachroo *et al.*, Fl. Ladakh 116. 1977. *Lithospermum guttatum* (Bunge) I.M. Johnst. in J. Arnold Arbor. 33. 330. 1952 excl. *Arnebia thomsoni* C.B. Clarke (1883) *in syn.* (Fig. 6, A. & B.).

Type: Hab. ad, fluv. Ima in Tschiyan influentem, witout collectors name, *s.n.* (Holo: LE. Iso: P)

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Fig. 6. *Arnebia guttata* Bunge : A. Photo; B. Specimen image.



Fig. 7 . *Arnebia guttata* var. *thomsonii* (C.B. Clarke) Kazmi A. Holotype image; B. Specimen image.

Perennial, erect to suberect or procumbent, hispid herb up to 30 cm high, with thin purple dye stained tap root. Stems grooved, simple or shortly ascending branched, with stiff, white trichomes of tuberculate bases. Leaves sessile; basal lanceolate to oblanceolate, margins, coriaceous, covered with white trichomes on oblong-ovate, shorter and narrowed. Inflorescence 1-3.5 × 0.5 × 1.2 cm, acute-acuminate at apex, entire on both surfaces, attenuate at base; cauline leaves terminal,globular cymes, 1-2 cm across; bracts as long as calyx. Flowers orange or yellow, wooly shortly stalked, c. 1 cm across, heterostyled. Calyx erect, lobes linear, covered with white trichomes. Corolla tubular, up to 1.5 cm long. exserted, yellow, villous. Stamens exserted; anthers oblong-ovoid, up to 2 mm long. Stigmas 4. Nutlets broadest at base, 3-4 mm long, gray, smooth or tubercled, keeled.

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Key to the varieties

5.1a. Calyx hairy. Nutlets uniformly tuberculate ……. **var. *guttata***
5.1b. Calyx densely hairy. Nutlets usually smooth……..……**var. *thomsonii***

var. *guttata*

Flowering & Fruiting: June- August

Habitat: Grows on dry and rocky slopes.

Distribution: INDIA: Jammu & Kashmir, Himachal Pradesh, Uttarakhand; PAKISTAN, AFGHANISTAN, RUSSIA, CHINA.

Specimens examined: **INDIA**: Jammu & Kashmir, Leh, Sabunullah, 3500 m, *B.M. Wadhwa* 593777 (BSD); Kashmir, Dudhari Pass, 3940 m, *Ludlow & Sherriff* 9216 (CAL). Himachal Pradesh, Lahaul, *Bor* 97716 (DD); Pin Valley, Thango-Kilung, 4000 m, *K. Chandra Sekar* 103702 (BSD).

Economic Importance: Roots yield purple dye.

var. *thomsonii* (C.B. Clarke) Kazmi in J. Arnold Arbor. 52: 495. 1971. *Arnebia thomsonii* C.B. Clarke in Hook.f., Fl. Brit. India 4: 176. 1883 (Fig. 7, A. & B.).

Type: Tibet occ., region alp., 14000 ped., Herb. Ind. Or. Hook. f. & T. Thoms., T. Thomson, s.n. as *Arnebia* no. 6. (Holo: K; Iso: GH!)

Perennial, erect to suberect or procumbent, hispid herb up to 30 cm high, with thin purple dye stained tap root. Stems grooved, simple or less branched, with stiff, white trichomes of tuberculate bases. Leaves sessile; basal lanceolate to oblanceolate, acute-acuminate at apex, entire on margins, coriaceous, covered with white trichomes on both surfaces, attenuate at base; cauline leaves oblong-ovate, shorter and narrowed. Inflorescence terminal, globular cymes, 1-2 cm across; bracts as long as calyx. Flowers orange or yellow, wooly shortly stalked, *c.* 1 cm across. Calyx densely hairy; lobes linear, covered with dense, white, thick trichomes. Corolla tubular, up to 1.5 cm long, exserted, yellow, villous. Anthers oblong-ovoid, up to 2 mm long. Nutlets grey, almost smooth or less tubercled.

Flowering & Fruiting: June- August

Habitat: Grows on dry and rocky slopes.

Distribution: INDIA: Jammu & Kashmir, Himachal Pradesh; PAKISTAN, TIBET.

Specimens examined: **INDIA**: Jammu & Kashmir, Ladakh, Stok, 26.06.2006, *M. Sanjappa & S. Singh* 110634 (BSD). Himachal Pradesh, Spiti, 3030 m, 16.08.1933, *H.A.C. Gill* 2026 (DD).

Economic Importance: Roots yield purple dye.

6. *Arnebia hispidissima* (Lehm.) A. DC., Prodr. 10: 94. 1846; Boiss., Fl. Orient 4: 213. 1875; C.B. Clarke in Hook.f., Fl. Brit. India 4: 176. 1883; Riedl in Rech. f., Fl. Iranica 48:162.1967; Kazmi in J. Arnold Arbor. 52: 489. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak & Kashmir 482. 1972; B.M. Sharma & Kachroo, Fl. Jammu 220. 1981. *Lithospermum hispidissimum* Lehm. Icon. Descr. Nov. Stirp.1: 23. t. 39. 1823. *Anchusa hispidissima* Siber ex DC. Prodr. 10: 94. 1846 (Fig. 8, A. & B.).

Type: Aegyptus: Wadi Gamuhs, *Sieber s.n.* (Holo: BM; Iso: GH, W)

Annual, erect or decumbent herb *c.* 20 cm high, with purple dye stained tap root. Stems simple or much branched at base, hispid with white pungent stout trichomes, with large tuberculate base. Leaves sessile; basal leaves usually dry at anthesis, linear-lanceolate, 0.8-3.5 × 0.3-0.6 cm, attenuate at base, acute at apex, entire on margins, hairy on surfaces; cauline leaves shorter and narrower upwards. Inflorescence of scorpioid cymes, upto 20 cm long bearing close flowers; bracts narrowed. Flowers tubular, yellow *c.* 1 cm long. Calyx lobes linear-lanceolate, *c.* 6 mm long. Corolla tubular, 1.0-1.5 cm long, yellow, villous, throat glabrous. Stamens *c.* 3 mm long, attached at the upper half of the tube; anthers ovoid, bilobed. Style reaching at the middle of corolla tube; stigmas reniform, 2. Nutlets pyramidal-ovoid, *c.*2 mm long, smooth or tuberculate, pinkish-brown.

Flowering & Fruiting: June - October.

Habitat: Grows on open dry sandy places along wasteland at lower elevations.

Distribution: INDIA: Jammu & Kashmir, Punjab, Himachal Pradesh, Uttarakhand, U.P. & Rajasthan; PAKISTAN, AFRICA, ARABIA, IRAN.

Specimens examined: **INDIA**: Himachal Pradesh, Jogi PangaKhad, 17.07.1977, *B.P. Uniyal* 61059 (BSD); Punjab, Hissar, 16.12.1957, *M.A. Rau* 3519 (BSD); Rajasthan, Jaipur, 25.03.1964, *M.A. Rau* 14400 (BSD); Uttar Pradesh, Saharanpur, Badsahibagh, 01.03.1985, *Y.S. Murty & A.K. Goel* 1631(BSD); Uttarakhand, Haldwani, 8.03.1986, *Athar* 76 (BSD).

7. *Arnebia linearifolia* A.DC. in DC., Prodr. 10: 95.1846; Boiss., Fl. Orient. 4: 214. 1875; Kazmi in J. Arnold Arbor. 52: 497. 1971; R.R. Stewart in Nasir & Ali, Annot. Cat. Vasc. Pl. W. Pak. & Kashmir 583. 1972; K. Ambrish & S.K. Srivast. in Indian J. Forest. 33 : 651-652. 2012. *Echioides linearifola* (DC.) Rothm., Repert. Sp. Nov. 49: 56.1940. *Arnebia flavescens* Boiss., Diagn. Pl. Orient.11: 117.1849. *Lithospermum aucheri* I. M. Johnst. in J. Arnold Arbor. 33: 328. 1952 (Fig. 9A&B).

Type: In deserto Syriaco, *Aucher- Eloy* 2368 (Holo: G)

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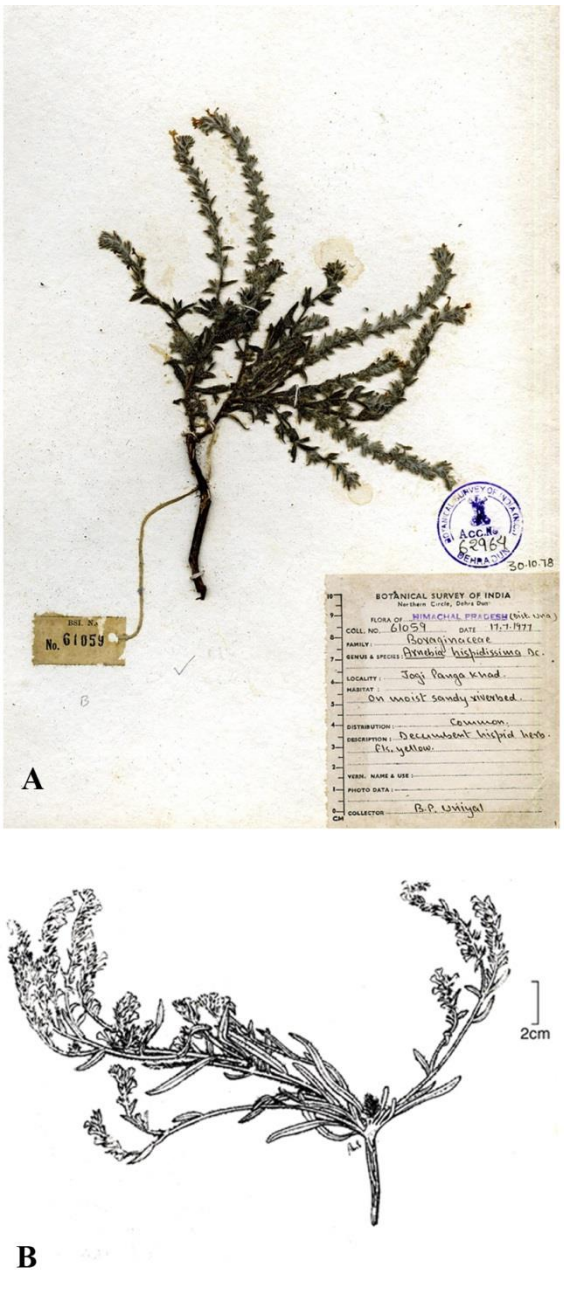


Fig. 8. *Arnebia hispidissima* (Lehm.) A. DC. A. Specimen image; B. Habit (line drawing).

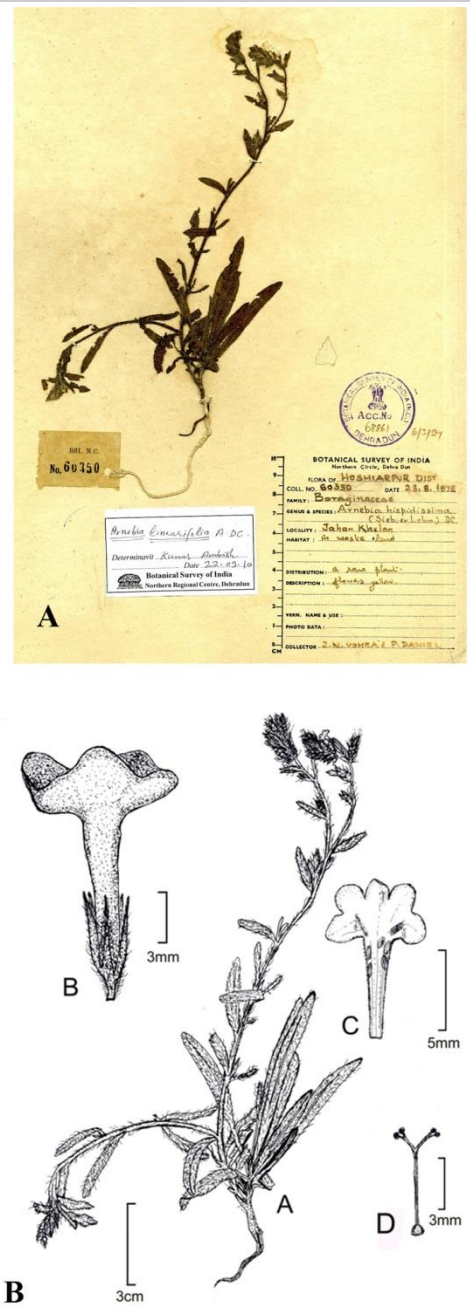


Fig. 9. *Arnebia linearifolia* A.DC. : A. Specimen image; B. a. Habit b. Flower c. Corolla L.S. d. Style.

Annual, erect to sub erect herb, 20-25 cm high, with dye stained tap root. Stems branched near the base, with thin white hairs, often with tuberculate base. Leaves subsessile; basal leaves oblong or oblanceolate, 3.2-7.2 × 0.5-1.2 cm, attenuate at base, obtuse or subrounded at apex, entire, tuberculate on both the surfaces covered with thin sinuous trichomes; cauline leaves few, lanceolate, 1.2-2.2 × 0.4-0.7 cm, narrowed at base, trichomes on both the surfaces longer than those on basal leaves. Inflorescence in terminal or subterminal compact cymes, rarely axillary, 1.8-2.5 cm long; bracts leafy, linear- lanceolate. Flowers tubular, yellow, *c.* 1.5 cm long. Calyx 5-lobed; lobes linear, 5-10 mm long, densely hairy. Corolla yellow, subtubular; tube 8-10 mm long; limb obtusely 5-lobed. Style filiform, doubly bifid, *c.* 6 mm long; stigmas-4, uniform, reniform. Nutlets brown, punctate-tuberculate, *c.* 2.5 mm long.

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Flowering & Fruiting: August-September

Habitat: A rare plant growing in open dry areas along wasteland at an altitude of 700 m.

Distribution: INDIA: Hoshiarpur in Punjab; NORTH AFRICA, TRANS CAUCASUS, SYRIA, IRAQ, IRAN, AFGHANISTAN AND PAKISTAN.

Specimens examined: **INDIA**: Punjab, Hoshiarpur, Jahan Khelan, 700 m, 23.08.1978, *J.N. Vohra* & *P. Daniel* 60350 (BSD); **PAKISTAN**: Baluchistan, Gazhara, 1818 m, 01.05.1893, *A.V. Munro* 112 (DD); Baluchistan, Abdulla, 10.04.1888, *J.H. Lace* 8687 (DD). Peshawar, 03.05.1888, *J.H. Lace* 5200 (DD); **AFGHANISTAN**, 17.04.1885, *J.E.T. Aitcheson* 184 (DD); **AFGHANISTAN**, 20.03.1888, *J.H. Lace* 3663 (DD).

8. *Arnebia nandadeviensis* Chandra Sek. & R. S. Rawal in J. Amer. Sci. 5: 105-106.2009. (Fig. 10).

Type: India, Uttarakhand, Bageshwar, Nanda Devi Biosphere Reserve, Pindari, 3820 m, 29.08.2008, *R.S. Rawal, K. Chandra Sekar, Sanjay Gairola* and *Balbant Rawat* 2895 (Holo: GBP)

Perennial, tufted herb, 30-40 cm high with stout, red root. Stems few, erect, spreading bristly. Leaves sessile, basal leaves 7-10, petioled, oblanceolate or obovate, 10.5-14.5 × 1.0-2.5 cm, attenuate at base, obtuse at apex, glandular downy, tapering to broad petiole, 1.5-2.3 cm long, pale green-yellow; cauline leaves 8-12, sessile, alternate. Inflorescence globose, capitate in a dense slender thyrse, 7-8 cm long, nodding; bracts leafy, many, linear- lanceolate, up to 3 cm long, densely hairy. Flowers deep red, nodding, 2-3.2 cm long. Calyx lobed, linear up to 2.5 cm long, bristly. Corolla tubular, red, tube up to 2 cm long, usually shorter then calyx; limb campanulate. Stamens short; anthers attached near the middle of corolla tube, 6-7 mm long. Style exserted; stigmas 2. Ovary globose, 2-3 mm across, ovules small. Nutlets subglobose.



Fig. 10. *Arnebia nandadeviensis* Chandra Sek. & R. S. Rawal (Photograph of Habit).

Flowering & Fruiting: August to September

Habitat: Grows on open alpine slopes along wasteland at an altitude between 3500-3820 m.

Distribution: INDIA: Bageshwar in Uttarakhand.

Specimens examined: **INDIA**: Uttarakhand, Bageshwar, Nanda Devi Biosphere Reserve, Pindari, 3820, 29.08.2008, *R.S. Rawal, K. Chandra Sekar, Sanjay Gairola* and *Balbant Rawat* 2895 (GBP).

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