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SYSTEMATIC STUDIES OF THE GENUS *ASPARAGUS* TOURN. *EX* LINN. (LILIACEAE) IN BANGLADESH

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Abstract

The genus *Asparagus* Tourn. *ex* Linn. represented by five species in Bangladesh, *viz.*, *Asparagus adscendens* Roxb., *A. densiflorus* (Kunth) J.P. Jessop, *A. officinalis* L., *A. racemosus* Willd. and *A. setaceus* (Kunth) J.P. Jessop is revised. Each species is described with updated nomenclature, important synonyms, phenology, specimens examined, chromosome number, habitat, distribution, economic value and mode of propagation. A dichotomous bracketed key to the species and illustrations along with photographs of four species are provided.

Introduction

The classification of the lilioid monocots has long been problematic (Chase *et al*., 2009). Some authors treated all lilioid monocots including the genus *Asparagus* Tourn. *ex* Linn. in the single family, Liliaceae *s.l*. (Cronquist, 1981). *Asparagus* species are currently grouped within the subfamily Asparagoideae sensu APG IV (2016), including species of *Hemiphylacus* S. Watson, a former small genus endemic to Mexico (Rudall *et al*., 1998). Three subgenera are currently recognized within the genus (Clifford and Conran, 1987): the subgenus *Asparagus s.s.* includes all the dioecious taxa with Eurasian distribution; the two other subgenera, *Protasparagus* Oberm. and *Myrsiphyllum* Willd., contain hermaphroditic taxa occurring mostly in Africa. However, this infrageneric subdivision was sometimes rejected (Fellingham and Meyer, 1995). Recent phylogenetic studies on the genus *Asparagus* (Kubota *et al*., 2012; Norup *et al*., 2015) have confirmed the monophyly of this genus with sexual dimorphism and polyploidy as the main force of evolution (Castro *et al*., 2013). All these phylogenetic studies have revealed conflicts between the different classifications, highlighting recurrent questions about delimitation of the currently recognized species.

The genus *Asparagus* comprises over 210 species, distributed throughout the world in temperate and tropical regions, with Africa and especially southern Africa as the main center of diversification (Kanno and Yokoyama, 2011). They are herbaceous perennials, woody shrubs and vines, characterized by photosynthetic stems (cladodes), leaves reduced to scales, and berries black or red (Clifford and Conran, 1987). *Asparagus* is remarkable with high variability in reproductive behaviour involving monoecious, dioecious, hermaphroditic, andromonoecious, and in some cases, supermale plants (Kanno and Yokoyama, 2011).

Asparagus species are economically and ecologically important. Many species of *Asparagus* have nutritional components, and the most significant species of the genus is *Asparagus officinalis* L., which is cultivated globally. Several species have long been used in traditional medicines and pharmacopoeia, viz. *A. racemosus* Willd., *A. verticillatus* L. and *A. adscendens* Kunth, while others are used as ornamental, i.e. *A. plumosus* Baker, *A. densiflorus* Kunth and *A. virgatus* Baker

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(Kumar *et al*., 2016). Ecologically, *Asparagus* species are tolerant to drought and high temperatures growing under forest cover as well as in open habitats including predesertic steppes. They constitute a lianascent layer characterizing the Mediterranean forests along with species of other genera, i.e. *Smilax* L. and *Ruscus* L. (Schnitzler and Arnold, 2010). These lianas play a key role in the ecology and dynamic of forests and may be helpful as indicators for the monitoring and management of forest ecosystems (Naidu *et al*., 2014).

In Bangladesh, *Asparagus* appears to be the second largest genus in the family Liliaceae, represented by five species including both wild and cultivated ones. Hooker (1892) recognized 17 *Asparagus* species from the Indian sub-continent, of which only three species were reported from the territory of present Bangladesh. Afterward, Prain (1903) listed two *Asparagus* species from the area of current Bangladesh. Hassan (2007), and Afroz and Hassan (2008) documented four species of *Asparagus* occurring in Bangladesh with inadequate taxonomic description. In the recent past, Akter *et al*. (2017) studied the fluorescent banding in *A. racemosus*, *A. officinalis* and *A. setaceus* in Bangladesh with differential banding patterns. Despite a few studies on *Asparagus* were conducted earlier based on its morphology and cytology, however, there has been no detailed taxonomic study on this medicinally and ecologically important genus in Bangladesh. Therefore, the present study aims to revise the genus *Asparagus* in Bangladesh for the first time.

Materials and Methods

Plant samples of different *Asparagus* species were collected from different parts of the country and planted in the Dhaka University Botanical Garden for further study. The collected plant specimens were critically studied and examined, and were supplemented by the specimens housed at the Dhaka University Salar Khan Herbarium (DUSH) and Bangladesh National Herbarium (DACB). Identification of the *Asparagus* species were confirmed in consultation with standard literature (Hooker, 1892; Deb, 1983; Karthikeyan *et al*., 1989; Noltie, 1994; Raven and Zhengyi, 2000; Utech, 2002; Hassan, 2007) and matching with authentically identified herbarium specimens deposited at DUSH and DACB. Each species is described with updated nomenclature, important synonyms, English and Bangla names, flowering and fruiting period, specimens examined, chromosome number, habitat, distribution, economic value, and mode of propagation. The updated nomenclature has been determined using The Plant List (2013), and The Plants of the World Online (POWO, 2022). A dichotomous bracketed key to the species and illustrations with photographs of four species are also provided. The voucher specimens are deposited at DUSH.

Results

Genus **Asparagus** Tourn. *ex* Linn.,

Syst. ed. 1 (1735); L., Gen. ed. 1: 93 (1737); Benth. & Hook. f., Gen. Pl. 3: 765 (1883); L., Sp. Pl.: 313 (1753); Gen. Pl. ed. 5: 147 (1754). *Asparagopsis* Kunth, Abh. Akad. Berl. : 35 (1842). *Elide* Medic., Phil. Bot. 2: 71 (1791). *Hecatris* Salisb., Gen. Pl. Fragm. : 66 (1866).

Herbs, shrubs or vines, perennial, form rhizomes, usually with fusiform tubers, often with fern-like appearance. Stem erect, straggling or climbing, terete, grooved or angled. Roots many, clustered. Leaves small, scale-like, membranous or sometimes spiny with hardened base, subtending cladophylls. Inflorescence axillary or terminal, racemose or umbellate, paired or solitary; racemes short. Flowers bisexual or unisexual; pedicels jointed. Perianth greenish, white or yellowish, campanulate to rotate. Tepals 6, distinct or shortly connate basally, equal. Stamens 6, distinct, equal; filaments free; anthers versatile, oblong, 2-locular, dehiscence introrse. Ovary

superior, 3-locular, septal nectaries present; style 3-branched distally. Fruits baccate, red or purplish black, globose, often with tepals persisting at base. Seeds 1-6, black, globose to angular.

Key to the species of *Asparagus*

1.	Inflorescence an axillary raceme; flowers bisexual	2
-	Inflorescence a solitary flower or a cluster of flowers; flowers unisexual or bisexual	4
2.	Stem suberect; cladodes ascending, erect or recurved	*A. adscendens*
-	Stem climbing; cladodes flat	3
3.	Spines 1.5-2.0 cm on the main stem and 0.5-1.0 cm on branches; lower half of the articulated pedicel longer than the bract	*A. racemosus*
-	Spines 0.3-0.5 cm on the main stem and indistinct on branches; lower half of the articulated pedicel shorter than the bract	*A. densiflorus*
4.	Stem climbing; pedicel articulated near the middle or below	*A. setaceus*
-	Stem erect; pedicel articulated above the middle	*A. officinalis*

Asparagus adscendens Roxb., Fl. Ind. 2: 153 (1832); Hook. f., Fl. Brit. Ind. 6: 317 (1892); Hassan, Encycl. Flora & Fauna of Bangladesh 11: 337 (2007). *Asparagopsis adscendens* Kunth, Enum. Pl. 5: 102 (2850).

English name: Asparagus.

Bangla name: *Shatamuli*.

A dioecious evergreen shrub with white tuberous roots. Stem tall, stout, suberect, terete, smooth, branchlets grooved, ascending, angled, spines 1.3-2.0 cm long, stout, straight. Cladodes 6-20 nate, 1.3-5.0 cm long, slender, filiform, terete, erect or recurved. Inflorescence of racemes, many-flowered, bracts minute. Flowers pedicellate, c. 2.5 cm in diam., jointed above or below the middle, bracts minute. Perianth segments 6. Stamens 6. Carpels 3, syncarpous, ovary 3-celled; placentation axile. Fruit a berry, 1-seeded.

Specimen examined: **Gazipur**: *Sal* forest, 10.12.1944, Balwant Singh, *s.n.* (DUSH).

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: *Sal* forests and well-drained moist soils in semi-shady condition.

Distribution: Afghanistan, Argentina, Bhutan, India, Iran and Pakistan (GBIF, 2020).

Economic value: Tuberous root is a source of nutritious starch. The roots are demulcent, diaphoretic, galactogogue and stimulant, and are useful in the treatment of diarrhoea, dysentery and general debility (Hassan, 2007).

Propagation: By seeds.

Asparagus densiflorus (Kunth) J.P. Jessop, Bothalia 9: 51 (1966). *Asparagopsis densiflora* Kunth, Enum. Pl. 5: 96 (1850); *Asparagus sprengeri* Regel., Act. Hort. Petrop. 11: 302 (1890); *Asparagus aethiopicus* L., Mant. 1 (1767); *Protasparagus densiflorus* (Kunth) A.A. Oberm., Fl. S. Afr. 5(3): 49 (1992). (**Fig. 1. Plate 1A**).

English names: Sprenger Asparagus, Basket Asparagus, Asparagus-fern, Lace-fern.

Bangla name: *Shatamuli*.

Evergreen, perennial herb. Tuber more or less globose, c. 4 × 2 cm. Stem stiff or spreading-arching, up to 20 cm long. Larger branches usually bearing minute axillary spines, spines c. 4 mm long. Cladodes scale-like, linear, light green, c 1.7 × 0.1 cm, 2-9 nate, clustered at branch nodes. Inflorescences arise from the main branch, c. 5-9 flowered. Flowers small, bell-shaped, greenish-white, fragrant; perianth segments 6, c. 2 × 1 mm; pedicel c. 2 mm long, atriculate at middle. Stamens 6; filament c. 2 mm long, white; anthers oblong, c. 1 mm long, orange. Carpels 3, syncarpous, ovary globose, c. 3 mm long, ovules many; stigma minute; placentation axile. Fruit a bright-red berry, oval, c. 8 mm in diam., 1-3 seeded.

Flowering and fruiting: February-April.

Specimens examined: **Dhaka**: Baldha Garden, 23.03.2007, Sumona 11 (DUSH); Baldha Garden 26.04.2007, Sumona 23 (DUSH).

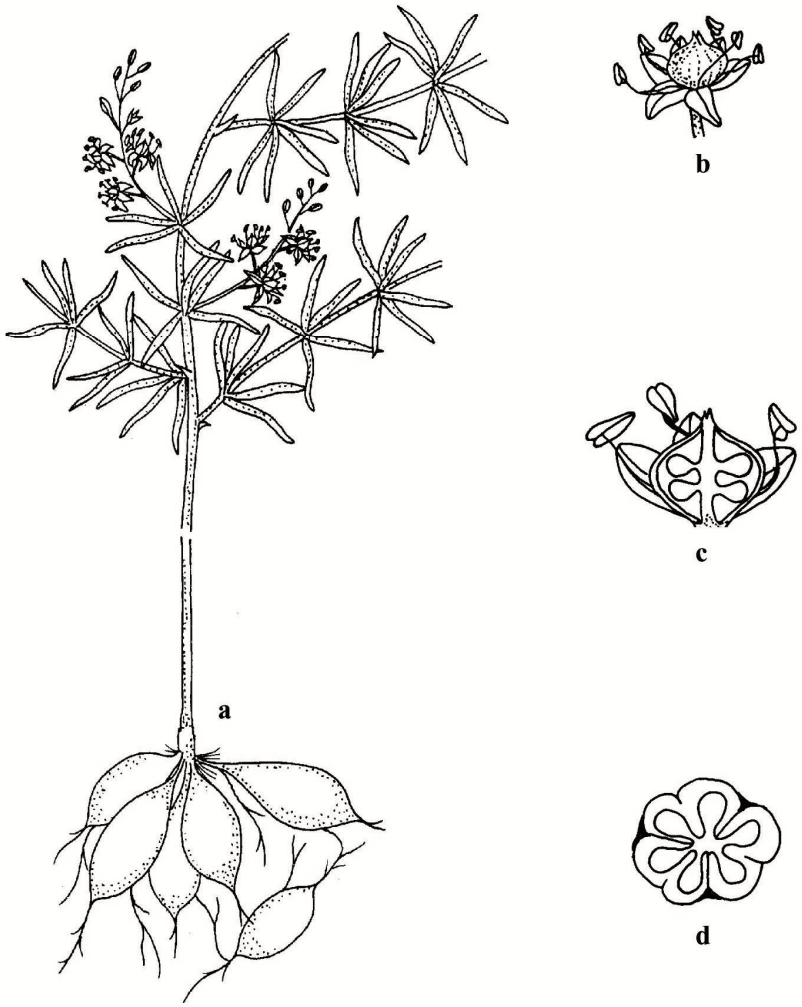

Fig. 1. *Asparagus densiflorus* (Kunth) J.P. Jessop, a) Habit (×1); b) Flower (×3); c) L.S. of a flower (×6); d) T.S. of ovary (×8).

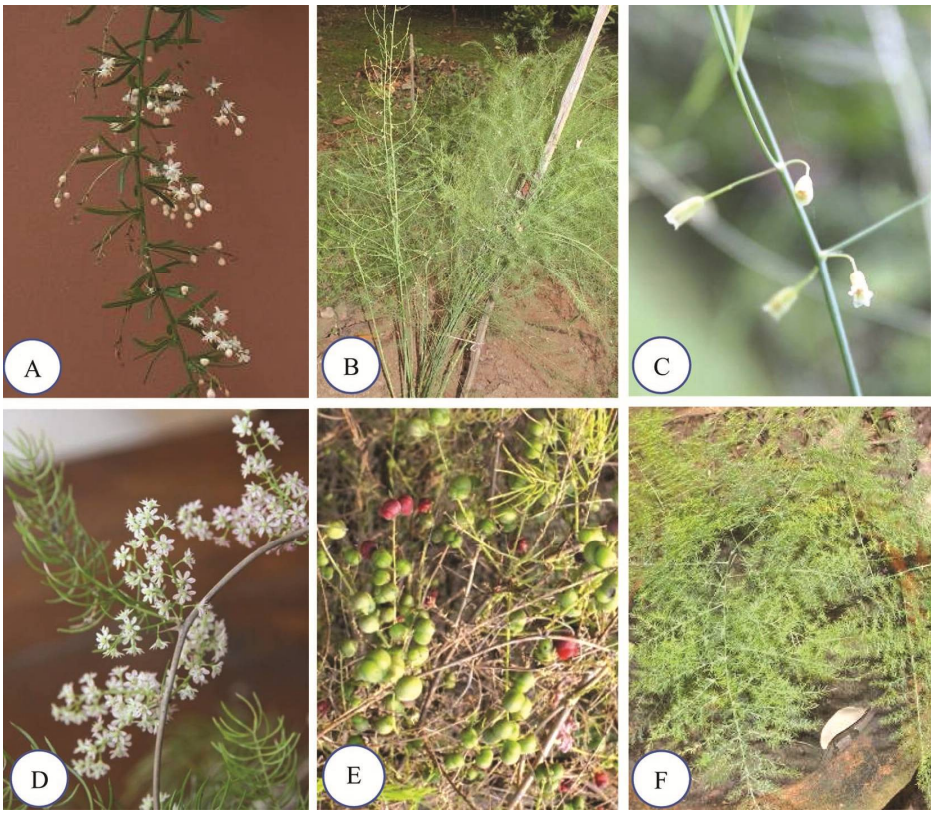

Plate 1. Different species of *Asparagus*: A. *Asparagus densiflorus*; B-C. *Asparagus officinalis*; D-E. *Asparagus racemosus*; F. *Asparagus setaceus.*

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: Waste places and also cultivated in gardens.

Distribution: Australia, Brazil, Chile, China, Greece, India, Mexico, Portugal, Puerto Rico, South Africa and Spain (GBIF, 2020).

Economic value: An infusion of the leaves is used to treat thrush and ulcers in the mouth, for abdominal pains, as a tonic to boost immunity, as a cleansing agent to rid the body of "poison" and "dirty blood" (Mfengwana and Mashele, 2019).

Propagation: By seeds.

Asparagus officinalis L., Sp. Pl. 1: 313 (1753); Roxb., Fl. Ind. 2: 163 (1832); Noltie, Fl. Bhutan 3(1): 62 (1994); Raven and Zhengyi, Fl. China 24: 214 (2000); Utech, Fl. North. America 26: 214 (2002). *Asparagus polyphyllus* Steven, Bull. Soc. Imp. Natur. Mosc. 30(3): 91 (1857)**.**

(**Fig. 2, Plate 1B-C**).

English names: Garden Asparagus, White Asparagus, Sparrow Grass, Common Asparagus.

Bangla name: *Asparagus.*

Erect herb, 1.0-2.5 m tall; rhizomes fibrous. Stem annual, densely branched distally; branches finely dissected, ascending to perpendicular, unarmed; cladophylls in clusters of (2) 4-15(-25) per

node, filiform, straight or curved, 1-3 cm long. Leaves scale-like, cladodes 0.5-3.0 cm long; blade lanceolate, base hardened. Inflorescence axillary raceme, 1-3-flowered. Flowers of both sexes solitary or in clusters of 2-4; pedicel 0.8-1.2 cm long, jointed at or above middle. Male flowers: perianth yellowish-green, campanulate, c. 5-6 mm long; filaments adnate to perianth segments for about half of their length; anthers c. 1 mm long. Female flowers: perianth c. 3 mm long. Berries red, 0.6-1.0 cm in diam., 2-3-seeded.

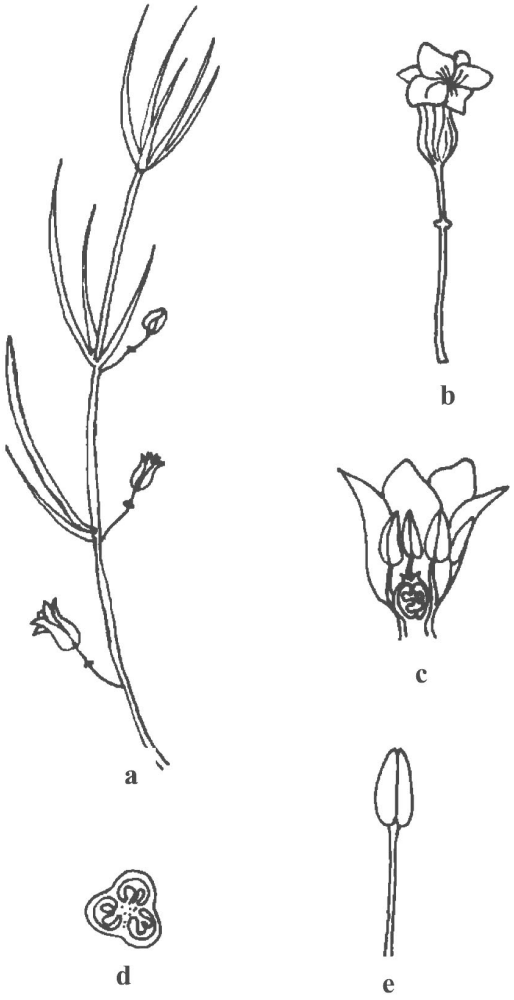

Fig. 2. *Asparagus officinalis* L., a) Habit (×1); b) Flower (×5); c) L.S. of a flower (×10); d) T.S. of ovary (×10); e) Stamen (×10).

Flowering and fruiting: May-August.

Specimen examined: **Dhaka**: Dhaka University Botanical Garden, 25.09.2016, Sumona 109 (DUSH).

Chromosome number: 2n = 20, 40 (Kumar and Subramaniam, 1986).

Habitat: Fields, fence rows and roadsides. The species is cultivated since ancient Greek times.

Distribution: Argentina, Australia, Austria, Canada, Denmark, Ecuador, France, Germany, New Zealand, Norway, Slovakia, Spain, Sweden, Switzerland and Ukraine (GBIF, 2020).

Economic value: *Asparagus officinalis* possesses anticancer, antimicrobial, antioxidant, hypolipidemic and antidiabetic properties (Snafi, 2015). This is eaten as a green vegetable, and it is widely cultivated for its young shoots. Mature asparagus can cause poisoning in cattle. Young plants can cause dermatitis, and the red berries are poisonous (Utech, 2002).

Propagation: By dividing the crowns.

Asparagus racemosus Willd., Sp. Pl. 2: 152 (1799). Hook. f., Fl. Brit. Ind. 6: 316 (1892); Prain, Beng. Pl. 2: 805 (1903); Haines, Bot. Bih. Or.: 1089 (1924); Fischer in Gamble, Fl. Pres. Madras: 1517 (1928) & Rec. Bot. Surv. Ind. 12(2): 146 (1938); Hassan, Encycl. Flora & Fauna of Bangladesh 11: 337 (2007). *Asparagus dubius* Decne, Nouv. Ann. Mus. Paris 3: 363 (1834). *Asparagopsis decaisnei* Kunth, Enum. Pl. 5: 103 (1850). *Asparagopsis javanica* Kunth, Enum. Pl. 5: 100 (1850). *Asparagopsis schoberioides* Kunth, Enum. Pl. 5: 70 (1850). (**Fig. 3, Plate 1D-E**).

English name: Asparagus.

Bangla names: *Shatamuli, Satmuli, Shaktichara* (Chakma), *Mimong Tamache* (Garo).

A perennial, slender, scandent shrub-like plant with reflexed spines; root tuberous, many together. Leaves scale-like, minute. Cladodes present in scale-like leaf axils, 2-6 nate, acicular, triquetrous, falcate, finely acuminate, 1.0-2.5 cm long. Inflorescence a raceme, solitary or fascicled, simple or branched. Flowers bisexual, greenish-white at initiation, then light pink and finally dark maroon, sweet-scented, bracteate, bracts minute, c. 3 × 1 mm, off white, pedicellate, pedicel c. 4 mm long, green. Perianth segments 6, spreading, obovate, c. 4 × 1 mm, off white with vertical green line. Stamens 6, adnate to the base of the perianth lobes; filaments free, c. 2 mm long; anthers minute, oblong, purplish. Carpels 3, syncarpous, ovary superior, c. 2 mm long, trigonous, 3-celled, 2-several ovules in each cell; stigma 3-fid; placentation axile. Fruit a berry, globose, c. 5-8 mm in diam., green, turn red when ripe.

Flowering and fruiting: November-March.

Specimens examidned: **Dhaka**: Baldha Garden, 17.02.1988, Rezia Khatun 249 (DACB). Dhaka University Botanical Garden, 05.02.1983, M.A. Hassan 501 (DUSH); Dhaka University Science Library compound, 04.02.2006, Sumona 1 (DUSH); Science Library compound, 01.01.2012, Sumona 72 (DUSH); Dhaka University Omor Ekushey Hall compound, 02.12.2006, Sumona 4 (DUSH); Dhaka University Botanical Garden, 21.05.2007, Sumona 34 (DUSH); Savar, Jahangirnagar University campus, 05.01.2009, Sumona 61 (DUSH). **Sunamganj**: Near Pashua Haor, 23.05.1992, Khan *et al*. K. 8669 (DACB). **Tangail**: Madhupur forest, 05.08.1976, Huq, Rahman & Khan K. 4173 (DACB). **Chittagong**: Bariyadhala, 17.11.1986, A.M. Huq & M.K. Mia H. 7992 (DACB); Sandwip, Horishpur, Hazipara, 10.02.1988, Mia & Mahfuz M. 1522 (DACB); Chunati Wildlife Sanctuary, 25.02.1999, Rahman *et al*. 4029 (HCU). **Sylhet**: Chattak, 05.01.1978, Huq & Rahman H. 3662 (DACB). **Patuakhali**: Mirzaganj, Subidkhali, 20.11.2004, M. Sultana 567 (DUSH); Dumki, Srirampur, 17.05.2005, M. Sultana 899 (DUSH); Patuakhali Sadar, Laukathi, 15.05.2006, M. Sultana 1262 (DUSH). **Cox's Bazar**: Whykeong Range, Raikeong, 11.09.1999, Rahman *et al*. 5916 (HCU). **Rangamati**: Belaichari, 23.07.1999, Rahman *et al.* 5101 (HCU).

Chromosome number: 2n = 20, 22, 30, 40, 48 (Kumar and Subramaniam, 1986).

Habitat: Scrub jungles.

Distribution: Afghanistan, Australia, Bhutan, India, Kenya, Liberia, Madagascar, Nepal, Somalia, South Africa, Spain, Tanzania, Thailand and Uganda (GBIF, 2020).

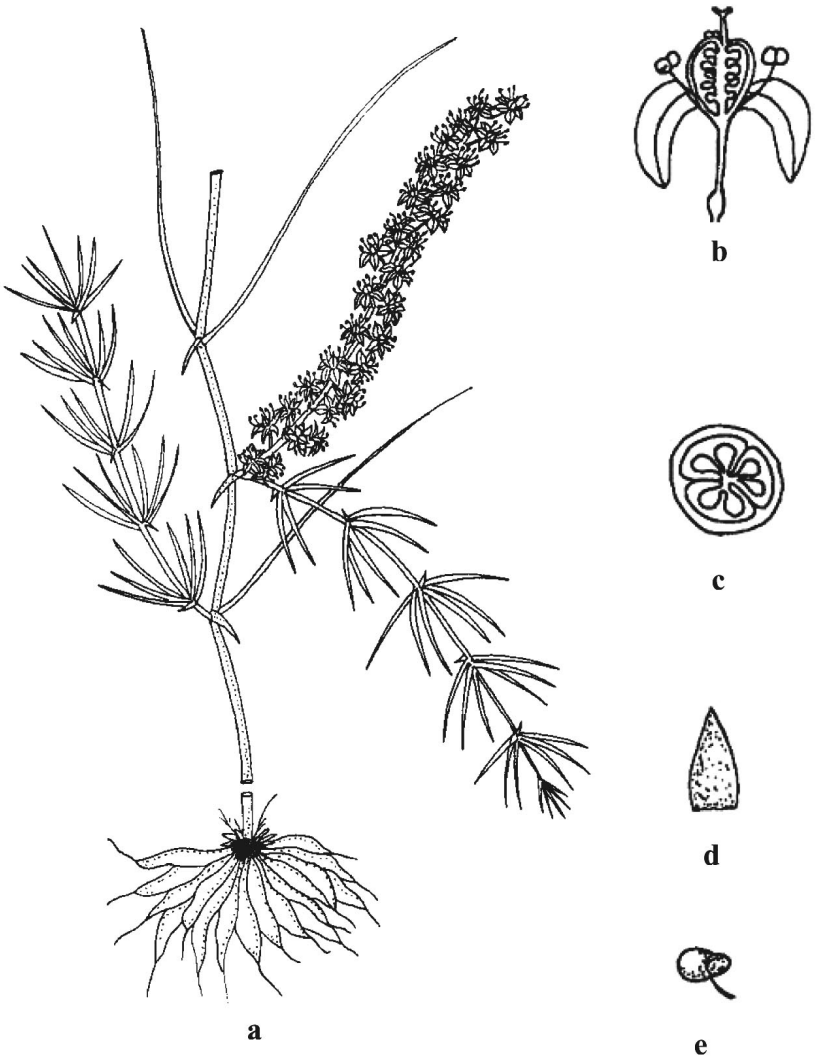

Fig. 3. *Asparagus racemosus* Willd., a) Habit (×0.5); b) L.S. of a flower (×5); c) T.S. of ovary (×10); d) Bract (×5); e) Fruit (×1).

Economic value: Tuberous roots are used as aphrodisiac, alterative, tonic, demulcent and diuretic. Ethanol extracts of aerial parts possess anticancer properties (Ghani, 2003). The plant is ground with other ingredients, made into pills, and fed to cattle for diarrhoea (Alam, 2000). Tubers are used as a vegetable (Deb, 1983). Root is used as antidepressant, anti-diarrhoeal, antibacterial, analgesic, anti-inflammatory and antioxidant (Hasan *et al.*, 2016). The species can improve the milk production and reproduction capacity of dairy animals (Kushwah *et al.*, 2018).

Ethnobotanical information: Tuberous root paste mixed with sesame oil or coconut oil is used as a hair tonic. Root taken with milk is useful in gonorrhoea (Hassan, 2007).

Propagation: By seeds and tuberous root with crown.

Asparagus setaceus (Kunth) J.P. Jessop, Bothalia 9: 51 (1966); Hassan, Encycl. Flora & Fauna of Bangladesh 11: 338 (2007). *Asparagopsis setacea* Kunth, Enum. Pl. 5: 82 (1850); *Asparagus plumosus* Baker, Journ. Linn. Soc. 14: 613 (1875). (**Fig. 4, Plate 1F**).

English names: Climbing Asparagus-fern, Lace-fern.

Bangla name: *Fern Asparagus*.

A woody vine, scrambling or climbing, up to 5 m long, smooth, much branched, branches spreading horizontally, branchlets and cladodes arranged in one plane, like a fern frond. Cladodes in fascicles of 10-15 per node, very slender, 4-10 × c. 0.5 mm. Leaves membranous, 1-2 mm long, blade forming a short spine with reflexed apex, mostly on the main stem. Inflorescence terminally umbellate, 1-4 flowered. Flowers bisexual, short pedicellate, pedicel c. 4 mm long. Perianth of 6 tepals, c. 3.0 × 1.2 mm, campanulate, spreading, white, fragrant. Stamens 6; filament c. 1.5 mm long; anthers oblong, c. 1.0 × 0.5 mm. Carpels 3, united, ovary superior, 3-celled, c. 3 × 3 mm; style minute, style with stigma c. 1 mm long; stigma 3-fid; placentation axile. Fruit a berry, purplish-black, 5-6 mm in diam., 1-3 seeded.

Fig. 4. *Asparagus setaceus* (Kunth) J.P. Jessop, a) Habit (×0.5); b) Flower (×3); c) L.S. of a flower (×3); d) T.S. of ovary (×5).

Flowering and fruiting: February-June.

Specimens examined: **Dhaka**: Dhaka University Botanical Garden, 05.07.2016, Sumona 106 (DUSH); Nazimuddin Road, 20.1.1956, Shaliqehan (DUSH); Baldha Garden, 17.2.1988, Rezia *et al.* 249 (DACB). **Patuakhali**: Dumki, Srirampur, 17.05.2005, M. Sultana 900 (DUSH).

Chromosome number: 2n = 20 (Kumar and Subramaniam, 1986).

Habitat: Waste places.

Distribution: Argentina, Australia, Bermuda, Brazil, China, Colombia, Ecuador, Mexico, New Zealand, Portugal, South Africa and Uruguay (GBIF, 2020).

Economic value: *Aaparagus setaceus* is used as a popular ornamental plant because of its attractive characters of extremely feathery, soft leaves, and an elegant posture (Li *et al*., 2020). This species is reported to have multiple uses in traditional oriental medicine (McGaw and Eloff, 2008).

Ethnobotanical information: Foliage is used for decorative purposes by florists (Hassan, 2007).

Propagation: By seeds.

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