Morpho-anatomical observations on *Phyllanthus* of Southwestern Bangladesh with two new records for Bangladesh.

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Abstract: An extensive floristic survey was done to annotate *Phyllanthus* of southwestern Bangladesh from 2015 to 2018. In total, 2189 individuals of *Phyllanthus* were counted and identified as eight different species (five herbs, two trees and a shrub). All species were examined following both morphological and anatomical methods, based on taxonomic notes. The listed species were *Phyllanthus acidus*, *Phyllanthus amarus*, *Phyllanthus debilis*, *Phyllanthus emblica*, *Phyllanthus niruri*, *Phyllanthus urinaria*, *Phyllanthus reticulatus* and *Phyllanthus virgatus*. Among them, *Phyllanthus amarus* and *Phyllanthus debilis* were listed for the first time from Bangladesh during this study period.

Keyword: Angiosperm, *Phyllanthus*, taxonomy, distribution, Bangladesh, *Phyllanthus amarus*, *Phyllanthus debilis*

Introduction

Phyllanthaceae is a very common taxa found in Bangladesh. It is a large family of flowering plants, consisting of 59 accepted genera, 10 tribes, two subfamilies and about 2000 species worldwide (Hoffmann et. al. 2006). This family is the second largest segregation of Euphorbiaceae sensu lato (s.l.) among Pandaceae, Picrodendraceae, and Putranjivaceae (Savolainen et al. 2000; Samuel et al. 2005). Phyllanthus is the largest genera of Phyllanthaceae consisting approximately 1000 species. Most of the Phyllanthus species are distributed in tropical and subtropical region (Sarin et al. 2014; Calixto et al. 1998). Previously, Phyllanthus represented 11 species (5 herbs, 4 shrubs and 2 trees) in Bangladesh (Ahamed et al. 2008). Most of the regional literatures of this region ensured a valuable contribution of it to the regional flora (Uddin & Hassan 2010; Islam et al. 2009; Rahman et. al. 2015; Tutul et. al. 2010). In addition to that, most of them are known to have economic and medicinal uses. Some of them had already been used in ethno-medicine and extraction of antioxidant and other industrial chemicals (Ali et al. 2006; Cesari et al. 2015; Gebhardt et al. 2003; Okafor et al. 2008; Patel et al. 2011; Thyagarajan et al. 1988). So, it is very important to conserve those species in terms of ecology and economy. But, many of the Phyllanthus sp. have a close morphological characteristics, which made them very difficult to differentiate at the species level (Kandavel et al. 2011; Webster 1956). Meanwhile, conservation demands proper identification to study its ecology and distribution. In this current study, available Phyllanthus individuals were collected from the south-western part of Bangladesh and attempted to identify at species level with morphological and anatomical features.

Materials and Methods

Study Site

Khulna division lies between 21.643° N to 24.181° N and 88.56° E to 89.943° E (Fig. 1). It experiences a tropical climatic condition with a mild winter from October to March, hot and humid summer in March to June and humid, warm rainy monsoon in June to October. Temperature varies all the year round, in January and December temperature falls to the lowest 12-15°C and it reached highest in April-June at 41 -45 °C. Daily relative humidity lied between 50-90%, which became lowest in evening and highest in morning. Rainy season occurred here from June to October. Maximum precipitation was experienced in July with 20-25 days of rain with 368 mm precipitation. Wind speed is also variable here. Wind speed shows higher in the months of April, May, June July and August. In those months average wind speed is over 5 Km/h. In the month of May the average wind speed reaches height around 8 km/h. Maximum wind speed also reaches higher in this month is around 80-90 km/h. December is the calmest month of the year, wind speed is lowest here. Average daily wind speed during this month is 2 km/h and maximum reaches only 26 km/h (Bangladesh Bureau of Statistics 2014).

Fig 1: Map of the study area

Sampling design

The study was carried out at nine administrative districts (namely, Khulna, Kushita, Jessore, Bagherhat, Chuadanga, Satkhira, Magura, Meherpur and Jhinaidha) of southwestern of Bangladesh from April 2015 to August 2018. In total, 45 sites were selected from those 9 districts (5 sites from each) by opportunistic sampling technique (Fig. 01, table 1) (Milchunas et al. 1992). Habitat, diversity of *Phullanthus* and population size were considered to select the study sites. Standard herbarium technique (Hyland 1972; Rahman et al. 2013) was used to collect the herbarium specimen for analysis. Live specimens were photographed by Celestron handheld digital microscope and Nikon-3200D camera with Nikkor 18-55mm AF-S DX, Nikkor 55-300mm

AF-S DX and Micro-Nikkor 105 mm FX AF lenses. We recorded GPS quadrate for all surveyed sites with a GPS device (Garmin GPSMAP 76CSx). Image J (1.52a) was used to record morphological measurements and image analysis. Herbarium sheets were prepared and deposited to FWT herbarium to conserve for future use. We did not collect any endangered angiosperm or sample from any protected areas, hence no permission was required for the collections. Collected specimens were analyzed and identified based on key provided by Hooker (1890), Prain (1904), Kanjilal et al. (1938), Deb (1983), Matthew (1999) and Ahmed et. al. (2008).

Table 1: A list of locations in the southwestern region of Bangladesh surveyed during the study period

Result

2189 individuals of *Phyllanthus* were examined and classified into eight different species from southwestern part of Bangladesh. Among these, five were herbs, two trees and a shrubs. Except *Phyllanthus debilis* all the species were well distributed throughout the study area. Meanwhile, *Phyllanthus niruri*, *Phyllanthus urinaria*, *Phyllanthus amarus* and *Phyllanthus reticulatus* were very abundant in the study sites. But *Phyllanthus virgatus* were found in Jessore-Chuadanga belt and absent in Khulna, Satkhira and Bhagerhat (table 2). Apart from these, *Phyllanthus acidus* and *Phyllanthus emblica* could be listed as a plantation species as they were absent at natural habitats. In addition to it, *Phyllanthus amarus* and *Phyllanthus debilis* were listed for the first time from Bangladesh at current study.

Table 2: List and distribution of the listed *Phyllanthus sp.* at current study

Phyllanthus acidus (L.) Skeels: In: Bull. Bur. Pl. Industr. U.S.D.A. 148: 17 (1909)

Synonyms: *Averrhoa acida* L.: In: Sp. Pl.: 428 (1753), *Cicca acida* (L.) Merr.: In: Interpr. Herb. Amboin.: 314 (1917), *Cicca acidissima* Blanco: In: Fl. Filip.: 700 (1873), *Cicca disticha* L.: In: Mant. Pl. 1: 124 (1767), *Cicca nodiflora* Lam.: In: Encycl. 2: 1 (1786), *Cicca racemosa* Lour.: In: Fl. Cochinch.: 556 (1790), *Diasperus acidissimus* (Blanco) Kuntze: In: Revis. Gen. Pl. 2: 598 (1891), *Phyllanthus acidissimus* (Blanco) Müll. Arg.: In: Linnaea 32: 50 (1863), *Phyllanthus cicca* Müll. Arg.: In: Linnaea 32: 50 (1863), *Phyllanthus cicca* var. *bracteosa* Müll. Arg.: In: Linnaea 32: 50 (1863), *Phyllanthus cochinchinensis* (Lour.) Müll. Arg., nom. illeg.: In: Prodr. 15(2): 417 (1866), *Phyllanthus distichus* (L.) Müll. Arg., nom. illeg.: In: Prodr. 15(2): 413 (1866), *Phyllanthus distichus* f. *nodiflorus* (Lam.) Müll. Arg.: In: Prodr. 15(2): 414 (1866), *Phyllanthus longifolius* Jacq.: In: Pl. Hort. Schoenbr. 2: 36 (1797), *Tricarum cochinchinense* Lour.: In: Fl. Cochinch.: 557 (1790).

A Monoecious, glabrous, deciduous, small sized tree, up to 15m high; branches stout, leafless, with slender deciduous leafy branchlets at the end; bark brownish. Leaves distichous, alternate, stipulate, stipules lanceolate, 0.8-1 mm; petiolate, 1.5-3mm long, distichous; leaf blade ovate to ovate-lanceolate, 3-8mm long and 1-3.5mm wide, leathery, acute to acuminate at apex, rounded or broadly cuneate at base, lateral veins 7-9 pairs, sometimes indistinct. Flower bisexual, dark reddish, at dense clusters forming slender, glabrous, in interrupted racemes, arising along the stem and branches. Male flowers are minute, red; staminate, stamen 4, free, 2 shorter; disc gland 4, smooth, diameter 0.4-0.7mm; pedicellate, pedicels 1-3 mm long and less than 1 mm width, slender; sepal 4, suborbicular, 0.8-1mm long, entire. Female flowers are very few, pedicellate; sepal 4, 1-1.5 mm long, apex rounded; ovary glabrous, 3-4 celled; styles 4, free, fleshy, bifid, recurved. Fruit a drupe, depressed globose to subglobose, smooth, 1.5-2.5 cm in diameter, 6-8 lobed, exocarp

105 fleshy, pale yellowish green, endocarp crustaceous. Seeds reddish brown, trigonous or convex, 2-
106 4mm long. Flowering and fruiting: March-July (Fig. 2).

107 ***Phyllanthus amarus* Schumach. & Thonn.: In: Beskr. Guin. Pl.: 421 (1827)**

108 **Synonyms:** *Phyllanthus swartzii* Kostel.: In: Allg. Med.-Pharm. Fl. 5: 1771 (1836), *Phyllanthus*
109 *niruroides* var. *madagascariensis* Leandri, nom. inval.: In: Notul. Syst. (Paris) 7: 184 (1839),
110 *Phyllanthus scabrellus* Webb: In: Niger Fl.: 175 (1849), *Phyllanthus nanus* Hook.f.: In: Fl. Brit.
111 India 5: 298 (1887), *Diasperus nanus* (Hook.f.) Kuntze: In: Revis. Gen. Pl. 2: 601 (1891),
112 *Phyllanthus amarus* var. *baronianus* Leandri, nom. inval.: In: Notul. Syst. (Paris) 7: 183 (1939),
113 *Phyllanthus niruri* var. *amarus* (Schumach. & Thonn.) Leandri: In: Fl. Madag. 111: 73 (1958),
114 *Phyllanthus niruri* var. *baronianus* (Leandri) Leandri, nom. inval.: In: Fl. Madag. 111: 74 (1958),
115 *Phyllanthus niruri* var. *scabrellus* (Webb) Müll.Arg.: In: Linnaea 32: 43 (1963).

116 A Monoecious erect annual herb, up to 1m high; stems often branching phyllanthoid with age,
117 branches angular, 3-10 cm long (can reach up to 15 cm), usually with 20-42 leaves. Leaves
118 alternate, membranous, oblong or elliptic-oblong; 3-8 mm long and 2-5mm wide, membranous or
119 thinly papery, base rounded, apex obtuse or rounded and often apiculate; stipulate, lanceolate,
120 scarious, acute, 0.8-1m long; petiolate, petioles very short 0.2-0.7mm long; entire leaf margin,
121 lateral nerves 4-7 pairs, slightly conspicuous abaxially; indistinct, dark green above, paler and
122 greyish beneath. Flower bisexual, light yellow, very numerous, axillary, along lower part of leafy
123 shoots usually male, those in middle usually often bisexual with 1 female and 1 male flower, those
124 toward branchlet apex often female. Male flowers are staminate, stamen 3, filamentous, filaments
125 connate; pedicellate, pedicels 0.5-1 mm long and less than 0.4 mm width; sepal 5, 0.2-0.5 mm
126 long, elliptic or obovate, apex acute; midrib yellowish green, margin membranous; disc gland 5,
127 lobulated, orbicular or obovate, filaments completely connate into a column, 0.2-0.3 mm high;

anthers sessile, 1 often reduced to a single anther sac (or sometimes only 2 functional anthers present), anther sacs divergent, slits completely confluent, horizontal. Female flower are pedicellate, pedicle 0.5-1.0 mm long; sepal 5, obovate to obovate-oblong, margin membranous, 0.8-1 mm long and 0.4-0.5 mm width, apex obtuse or acute; lobulate, 5 lobed, nectary disk thin and flat or subulate; ovary globose-triangular, 0.5×0.6 mm, smooth; styles free, erect or ascending, apex shallowly bifid. Fruit a capsule, depressed-globose, approximately 1-1.6 mm in diameter, dilated at apex, the surface smooth, explosively dehiscent. Seeds sharply 3-angled, 0.8-1 mm long and 0.6-0.8 mm width, light brown or yellowish brown, longitudinally 5-6 ribs, minutely transversely striate with hygroscopic cells; Flowering and fruiting: July- October (Fig. 3).

***Phyllanthus debilis* J.G.Klein ex Willd.: In: Sp. Pl. 4: 582 (1805)**

Synonyms: *Phyllanthus niruri* var. *javanicus* Müll.Arg.: In: Linnaea 32: 43 (1863), *Phyllanthus niruri* var. *debilis* (J.G.Klein ex Willd.) Müll.Arg.: In: Prodr. 15(2): 407 (1866), *Diasperus debilis* (J.G.Klein ex Willd.) Kuntze: In: Revis. Gen. Pl. 2: 601 (1891), *Phyllanthus boninsimae* Nakai: In: Bot. Mag. (Tokyo) 26: 96 (1912), *Phyllanthus lei* S.Moore: In: J. Linn. Soc., Bot. 45: 217 (1920).

A Monoecious erect annual herb, up to 60 cm high; stems often branching phyllanthoid with age, branches angular, 3-8 cm long (can reach up to 12 cm), usually with 12-35 leaves. Leaves alternate, stipulate, lanceolate, scarious, acute, 1.0-1.5mm long; petiolate, petioles very short 0.3-1mm long; narrowly elliptic to lanceolate, 8-20 mm long and 2-5mm wide, acute to acuminate at the apex and cuneate to acute at the base, entire leaf margin, membranous, lateral nerves 5-7 pairs, indistinct, dark green above, paler and greyish beneath. Flower bisexual, light yellow, very numerous, axillary. Male flowers 3-4 racemose cymes arising first 2-4 node of the branches; staminate,

stamen 3, filamentous, filaments connate; pedicellate, pedicels 0.4-0.5 mm long and less than 0.5 mm width; sepal 6, 0.5-0.7 mm long, obovate, rounded, midrib yellowish green; disc gland 6, lobulate; anther horizontal. Female flower solitary in the node above male flowers; pedicellate, pedicle 1-1.6 mm long; sepal 6, obovate to oblong, rounded, 1.2-1.6 mm long and 0.4-0.6 mm width, lobulate, 6 lobed, margin whitish and scarious, nectary disk thin and flat, deeply lobed into 6-10, bifid; ovary subglobose, 0.8-1.1 mm diameter, smooth, styles minute and free. Fruit a capsule, depressed-globose, approximately 2-2.2 mm in diameter, the surface smooth, explosively dehiscent. Seeds angled ca. 1 mm long and 0.6 mm width, longitudinally 6-7 ribs and fine transverse striations on back, pale yellowish brown. Flowering and fruiting: March- June (Fig. 4).

***Phyllanthus emblica* L.: In: Sp. Pl.: 982 (1753)**

Synonyms: *Cicca emblica* (L.) Kurz: In: Forest Fl. Burma 2: 352 (1877), *Diasperus emblica* (L.) Kuntze: In: Revis. Gen. Pl. 2: 599 (1891), *Dichelactina nodicaulis* Hance: In: Ann. Bot. Syst. 3: 376 (1853), *Emblica arborea* Raf.: In: Sylva Tellur.: 91 (1838), *Emblica officinalis* Gaertn.: In: Fruct. Sem. Pl. 2: 122 (1790), *Phyllanthus glomeratus* Roxb. ex Benth., nom. nud.: In: Numer. List: n. ° 7903 (1847), *Phyllanthus mairei* H.Lév.: In: Bull. Acad. Int. Géogr. Bot. 25: 23 (1915), *Phyllanthus mimosifolius* Salisb.: In: Prodr. Stirp. Chap. Allerton: 391 (1796), *Phyllanthus taxifolius* D.Don: In: Prodr. Fl. Nepal.: 63 (1825).

A Monoecious, phloescent or glabrous, deciduous, medium sized tree, up to 25m high; bark brownish; main stems terete, sparsely lenticellate; leafy shoots angular, tawny pubescent. Leaves distichous, alternate, stipulate, stipules triangular-ovate, 0.8-1.5 mm; petiolate, petioles very short 0.3-0.8mm long, attenuate to acuminate, ciliolate, brown; leaf blade oblong or linear-oblong, 8-25mm long and 1.5-5mm wide, papery to leathery, paler abaxially, green adaxially, drying reddish or brownish, base shallowly cordate and slightly oblique, margin narrowly revolute, apex truncate,

rounded or obtuse, mucronate or retuse at tip; lateral veins 4-9 pairs, sometimes indistinct. Flower bisexual, in axillary cymes, with many male flowers and sometimes 1 or 2 larger female flowers per cyme. Male flowers are staminate, stamen 3, filamentous, filaments coherent into a central column, 0.3-0.7mm long; anthers erect, oblong, 0.5-1mm long, horizontal; pedicellate, pedicels 1-3 mm long and less than 1 mm width, slender; sepal 6, 1.5-2.5 mm long and 0.5-1mm wide, obovate or spatulate, subequal, obtuse or rounded, entire, midrib yellowish green with a pale hyaline margin; disc gland 6, smooth, 0.2-0.5mm diameter. Female flowers are pedicellate, pedicle ca. 0.7mm long; sepal 6, oblong or spatulate, 1.5-2.5 mm long and 0.6-1.3 mm width, apex obtuse or rounded, thicker, margin membranous; ovary ovoid, ca. 1.5 mm, 3-celled; styles 3, stout, fleshy, 1.5-4 mm long, connate at base, apex deeply bifid, lobes divided at tip. Fruit a drupe, subglobose, smooth, 1-1.3 cm in diameter, exocarp fleshy, pale green or yellowish white, endocarp crustaceous. Seeds reddish, trigonous or plano-convex, 3-6mm long and 2-3 mm wide. Flowering and fruiting: March-October (Fig. 5)

***Phyllanthus niruri* L.: In: Sp. Pl.: 981 (1753)**

Synonyms: *Urinaria erecta* Medik.: In: Malvenfam.: 80 (1787), *Nymphanthus niruri* (L.) Lour.: In: Fl. Cochinch.: 545 (1790), *Phyllanthus carolinianus* Blanco: In: Fl. Filip.: 691 (1837), *Niruris annua* Raf. : In: Sylva Tellur.: 91 (1838), *Niruris indica* Raf.: In: Sylva Tellur.: 91 (1838), *Phyllanthus moeroris* Oken: In: Allg. Naturgesch. 3(3): 1601 (1841), *Phyllanthus filiformis* Pav. ex Baill.: In: Recueil Observ. Bot. 1: 29 (1860), *Phyllanthus ellipticus* Buckley, nom. illeg.: In: Proc. Acad. Nat. Sci. Philadelphia 1862: 7 (1863), *Phyllanthus lathyroides* var. *commutatus* Müll.Arg.: In: Linnaea 32: 41(1863), *Phyllanthus niruri* var. *genuinus* Müll.Arg., nom. inval.: In: Prodr. 15(2): 406 (1866), *Diasperus niruri* (L.) Kuntze: In: Revis. Gen. Pl. 2: 600 (1891),

196 *Phyllanthus lathyroides* f. *decoratus* Standl. & Steyerl.: In: Fieldiana, Bot. 24(6): 152 (1949),

197 *Phyllanthus erectus* (Medik.) M.R.Almeida: In: Fl. Maharashtra 4B: 343 (2003).

198 A Monoecious erect annual herb, up to 70 cm high; stems often branching phyllanthoid with age,
 199 branches angular, 2-5 cm long (can reach up to 8cm), usually with 13-26 leaves. Leaves alternate,
 200 stipulate, lanceolate, scarious, acute, 1.0-1.2mm long; petiolate, petioles very short 0.3-1mm long;
 201 elliptic-oblong to elliptic-oblongate, 5-12 mm long and 2-5mm wide, obtuse or rounded at the
 202 apex and tapering to the base, entire leaf margin, membranous, lateral nerves 4-7 pairs, indistinct,
 203 dark green above, paler and greyish beneath. Flower bisexual, light yellow, very numerous,
 204 axillary, the male 1-3, female solitary. Male flowers are staminate, stamen 3, filamentous,
 205 filaments united into a short column; pedicellate, pedicels are 0.9-1 mm long and less than 0.5 mm
 206 width; sepal 6, 0.6-0.7 mm long, obovate, rounded, midrib yellowish green; disc gland 6, lobulated,
 207 verruculose; anther horizontal. Female are pedicellate, pedicle 1.4-1.9 mm long; sepal 6, unequal,
 208 oblong to oblongate, rounded, white, 1.0-1.5 mm long and 0.4-0.5 mm width, lobulate, 6 lobed;
 209 nectary disk thin and flat, deeply lobed into 6-10, some crenate and broad, some are bifid, some
 210 others linear and entire; ovary subglobose, 0.8-1 mm diameter, smooth, styles minute and free,
 211 adpressed or ascending, lobes recurved. Fruit a capsule, trilobate-subglobose, approximately 1.5-
 212 2.5 mm in diameter, the surface smooth, olivaceous or stramineous. Seeds angled ca. 1 mm long
 213 and 0.6 mm width, longitudinally 7-8 ribs on back, ochreous-fulvous, dark yellowish brown.
 214 Flowering and fruiting: August- October (Fig. 6).

215 ***Phyllanthus reticulatus* Poir.: In: Encycl. 5: 298 (1804)**

216 **Synonyms:** *Anisonema reticulatum* (Poir.) A.Juss.: In: Euphorb. Gen.: 4 (1824), *Cicca reticulata*
 217 (Poir.) Kurz: In: Forest Fl. Burma 2: 354 (1877), *Diasperus reticulatus* (Poir.) Kuntze: In: Revis.
 218 Gen. Pl. 2: 600 (1891), *Kirganelia reticulata* (Poir.) Baill.: In: Étude Euphorb.: 613 (1858),

219 *Anisonema dubium* Blume: In: Bijdr. Fl. Ned. Ind.: 589 (1826), *Anisonema intermedium* Decne.:
 220 In: Nouv. Ann. Mus. Hist. Nat. 4: 482 (1831), *Anisonema jamaicense* (Griseb.) Griseb.: In: Fl.
 221 Brit. W. I.: 716 (1864), *Phyllanthus alaternoides* Rchb. ex Baill.: In: Recueil Observ. Bot. 1: 83
 222 (1860), *Phyllanthus jamaicensis* Griseb.: In: Fl. Brit. W. I.: 34 (1859), *Phyllanthus sinensis*
 223 Müll.Arg.: In: Linnaea 32: 12 (1863), *Phyllanthus sinensis* var. *dalbergioides* Müll.Arg., nom.
 224 inval.: In: Linnaea 32: 12 (1863), *Phyllanthus takaoensis* Hayata: In: Icon. Pl. Formosan. 9: 94
 225 (1920).

226 A Monoecious erect perineal shrub, up to 6 m high; bark peeling or flaking, grayish-brown; leaves
 227 and pedicels puberulous or plabrous, yellowish green; usually with 11-28 leaves. Leaves alternate,
 228 stipulate, stipule subulate-lanceolate, 0.8-2mm long, acuminate, truncate at base; petiolate, petioles
 229 very short 1.5-3mm long, chartaceous; leaf blade varies, mostly elliptic to ovate; 15-26 mm long
 230 and 5-15mm wide, obtuse to rounded at the apex and cuneate at the base, entire leaf margin,
 231 membranous, lateral nerves 5-9 pairs, indistinct, tertiary veins reticulate; dark green above, paler
 232 and greyish beneath. Flowers an axillary fascicle, rarely a cyme, with 2-10 male and 1 or 2 female
 233 flowers. Male flowers are staminate, stamen 5, outer 2 free, inner 3 short and united at base, longer,
 234 filamentous stout; pedicellate, pedicels are 6-10 mm long; sepal 5-6, in 2 series, ovate or obovate,
 235 unequal, entire, 0.6-1.5 mm long; disc gland 5, scale like, diameter ca. 0.5mm; anther
 236 longitudinally dehiscent, less than ca. 0.5 mm in diameter. Female are pedicellate, pedicle 3-8mm
 237 long, slender; sepal 5-6, unequal, in 2 or 3 series, oblong-elliptic or suborbicular, 1-1.5 mm long
 238 and 0.7-1.2 mm width; disk glands 5-6, free, oblong or obovate, flattened; ovary 4-12 celled,
 239 smooth, ca. 1mm; styles free, bifid at apex. Fruit a berry, globose to oblate, c 4-6 mm wide,
 240 greenish at initial stage, black and dark purplish at maturity, 4-12-celled, 8-16-seeded. Seeds
 241 trigonous, 1.6-2 mm, brownish yellow. Flowering and fruiting: March-November (Fig. 7).

242 ***Phyllanthus urinaria* L.: In: Sp. Pl.: 982 (1753)**

243 **Synonyms:** *Diasperus urinaria* (L.) Kuntze: In: Revis. Gen. Pl. 2: 601 (1851), *Phyllanthus alatus*
 244 Blume: In: Bijdr. Fl. Ned. Ind.: 594 (1826), *Phyllanthus cantoniensis* Hornem.: In: Enum. Pl. Hort.
 245 Hafn.: 29 (1827), *Phyllanthus croizatii* Steyerm.: In: Fieldiana, Bot. 28: 317 (1952), *Phyllanthus*
 246 *echinatus* Buch.-Ham. ex Benth., nom. nud.: In: Numer. List: n.º 7893B (1847), *Phyllanthus*
 247 *lauterbachianus* Pax: In: Repert. Spec. Nov. Regni Veg. 8: 325 (1910), *Phyllanthus leprocarpus*
 248 Wight: In: Icon. Pl. Ind. Orient. 5: t. 1895 (1852), *Phyllanthus mauritianus* Henry H. Johnst.: In:
 249 Trans. & Proc. Bot. Soc. Edinburgh 20: 329 (1895), *Phyllanthus muricatus* Benth., nom. nud.: In:
 250 Numer. List: n.º 7898D (1847), *Phyllanthus nozeranii* Rossignol & Haicour: In: Amer. J. Bot. 74:
 251 1858 (1988), *Phyllanthus rubens* Bojer ex Baker: In: Fl. Mauritius: 309 (1877), *Phyllanthus*
 252 *urinaria* var. *laevis* Haines: In: Bot. Bihar Orissa 2: 125 (1921), *Phyllanthus urinaria* var.
 253 *oblongifolius* Müll. Arg.: In: Linnaea 32: 19 (1863), *Phyllanthus verrucosus* Elmer, nom. illeg.: In:
 254 Leaf. Philipp. Bot. 7: 2649 (1915).

255 A Monoecious erect annual herb, sometimes perineal, glabrous or puberulous, up to 1m high, stems
 256 much-branched at base, branchlets 3-12 mm long, angular, usually with 12-22 leaves. Leaves
 257 alternate, stipulate, ovate-lanceolate, 1.0-1.5mm long; petiolate, petioles very short 0.3-0.5 mm
 258 long; leaf blade linear or oblong to oblong-obovate, 5-20 mm long and 2-7 mm wide, acute apex,
 259 mucronulate, conspicuously ariculate or obtuse base; lateral nerves 4-6 pairs, conspicuous,
 260 glaucous beneath; dark greenish brown above, paler and greyish beneath. Flower bisexual, light
 261 yellow to reddish yellow, axillary, glomerules on deciduous branch. Male flowers are pedicellate,
 262 pedicels are 0.5 mm long, ariculate above the middle; staminate, stamen 3, filamentous, filaments
 263 united into a slender column; sepal 6, 0.3-0.6 mm long, elliptic to oblong-obovate, obtuse at apex;
 264 disc gland 6, green, papillose, alternate with sepal; anther erect, longitudinally dehiscent, sessile

but not fused together. Female are solitary, pedicellate, pedicle 0.2-0.5 mm long; sepal 6, subequal, oblong-lanceolate, obtuse or subacute, subglabrous, yellowish with a reddish-olive midrib, 0.7-1.1 mm long and 0.2-0.5 mm width; nectary disk flat, entire; styles 3, minute and free, adpressed to the top of the ovary; ovary bifid, lobes recurved. Fruit a capsule, globose, 2-2.5 mm in diameter, with reddish blotches, scurfy-tuberculate. Seed 3-sided, 1-1.2mm long and 0.9-1 mm wide, light grayish brown, with 12-15 sharp transverse ridges on back and sides, often with 1-3 deep circular pits on side. Flowering and fruiting: April-October (Fig. 8).

***Phyllanthus virgatus* G.Forst.: In: Fl. Ins. Austr.: 65 (1786)**

Synonyms: *Phyllanthus simplex* var. *virgatus* (G.Forst.) Müll.Arg., nom. illeg.: In: Linnaea 32: 32 (1863), *Diasperus virgatus* (G.Forst.) Kuntze: In: Revis. Gen. Pl. 2: 597 (1891), *Diasperus beckleri* (Müll.Arg.) Kuntze: In: Revis. Gen. Pl. 2: 598 (1891), *Diasperus conterminus* (Müll.Arg.) Kuntze: In: Revis. Gen. Pl. 2: 599 (1891), *Diasperus depressus* Kuntze: In: Revis. Gen. Pl. 2: 599 (1891), *Diasperus minutiflorus* (F.Muell. ex Müll.Arg.) Kuntze: In: Revis. Gen. Pl. 2: 600 (1891), *Diasperus miquelianus* (Müll.Arg.) Kuntze: In: Revis. Gen. Pl. 2: 600 (1891), *Diasperus pedunculatus* (Kostel.) Kuntze: In: Revis. Gen. Pl. 2: 597 (1891), *Macraea oblongifolia* Wight: In: Icon. Pl. Ind. Orient. 5(2): 27 (1852), *Melanthesa anceps* (Vahl) Miq.: In: Fl. Ned. Ind. 1(2): 371 (1859), *Phyllanthus anceps* Vahl: In: Symb. Bot. 2: 95 (1791), *Phyllanthus beckleri* Müll.Arg.: In: Linnaea 34: 74 (1865), *Phyllanthus eboracensis* S.Moore: In: J. Linn. Soc., Bot. 45: 216 (1920), *Phyllanthus patens* Miq. ex Müll.Arg.: In: Linnaea 32: 34 (1863), *Phyllanthus simplex* Retz.: In: Observ. Bot. 5: 29 (1789), *Phyllanthus simplex* var. *myrtifolius* Domin: In: Biblioth. Bot. 22: 876 (1927), *Phyllanthus weinlandii* K.Schum.: In: Fl. Schutzgeb. Südsee, Nachtr.: 287 (1905).

A monoecious erect annual herb, sometimes perineal, up to 70 cm high, glabrous throughout, branchlets angled, more or less compressed, smooth; stem usually slightly woody at base. Leaves

stipulate, stipule 0.8-1.0mm long, membranous, ovate, acuminate at apex, prominently and asymmetrically auriculate at base; petiolate, petioles very short 0.6-0.9 mm long; leaf blade linear-lanceolate, oblong or narrowly elliptic, 5-18 mm long and 2-8mm wide, obtuse or acute at the apex, rounded and slightly oblique at the base, entire leaf margin, membranous, lateral nerves obscure at both surface. Flower bisexual, axillary fascicled, usually 2-4 male and one female per fascicle. Male flowers are pedicellate, pedicels are 0.9-1 mm long; sepal 6, 0.4-0.6 mm long, broadly elliptic, ovate or orbicular, oblong; staminate, stamen 3, filamentous, filaments are 0.3-0.5 mm long; disc gland 6, lobulated; anther subglobose, 0.2-0.3 mm in diameter, horizontally dehiscent. Female are pedicellate, pedicle 3-5 mm long; sepal 6, subequal, ovate-oblong, acute to obtuse, margin slightly white-membranous, reflected in fruits, purple, 0.7-1.0 mm long, lobulate, 6 lobed; nectary disk thin and flat, orbicular, entire or subentire, ca. 0.6 mm diameter; ovary globose, 0.2-3 mm diameter, bifid; smooth, styles minute and free, 3-celled, ca. 0.3 mm long, revolute. Fruiting occurred at pedicels, fruiting pedicels are 5-12 mm long; fruit is a capsule, capsules oblate, 2-3 mm in diameter, purple, with raised scales or smooth. Seeds trigonous, 1.2-1.5 mm, finely warty. Flowering and fruiting: May- October (Fig. 9).

Table 3: Morphological comparisons among studied *Phyllanthus*.

Key to identify the *Phyllanthus* of South-western Bangladesh

- 1.1 Branching phyllanthoid2
- 2.1 Small to medium sized tree, up 15 m. Fruit's endocarp fleshy.....3
- 3.1 Fruit is a drupe, stamen 4, male flower sepal 4 (radish), steam without non-glandular hair1. *P. acidus*
- 3.2 Fruit is a capsule, stamen 3, male flower sepal 6 (white), steam with non-glandular hair..... 4. *P. emblica*

311	2.2 Shrub up to 5m, fruit is a berry, sepal 5, filaments stout.....	6. <i>P. reticulatus</i>
312	2.3 Herbs, less than 1m height, fruit is a capsule.....	4
313	4.1 Seed surface with longitudinal ridged.....	5
314	5.1 Sepal 5, calyx lobe 5.....	2. <i>P. amarus</i>
315	5.2 Sepal 6, calyx lobe 6.....	6
316	6.1 Calyx tip acute, leaves Elliptic-oblong to elliptic-oblongate, lateral vine 4-	
317	7 pair, filaments completely connate.....	5. <i>P. niruri</i>
318	6.2 Calyx tip rounded, leaves narrowly elliptic to lanceolate, lateral vine 5-7 pair,	
319	filaments connate at base but free at apex	<i>P. debilis</i>
320	4.2 Seed surface without longitudinal ridged, seed surface is not smooth, sepal 6,	
321	filaments are united in to a column.....	7. <i>P. urinaria</i>
322	1.1 Branching not phyllanthoid, herbs, with a large fruit petiole (5-8mm), calyx six lobed, male	
323	flower with six sepal	8. <i>P. vibratus</i>

324 **Anatomical observation**

325 The epidermis of the studied eight species was one to three layer. The mesophylls are differentiated
326 into palisade and spongy parenchyma layer but those varied from species to species. Among the
327 studied species, epidermal circumference found rounded for *P. amarus*, *P. reticulatus*, *P. acidus*,
328 and angular for *P. emblica*, *P. debilis*, *P. niruri*, and *P. urinaria*. *P. vibratus* was the only species
329 which had the elliptical circumference only. Besides, *P. urinaria* had a special anatomic feature
330 called rings and farrows were observed in cortex. In consideration of hypodermis, most of the
331 species found rectangular except *P. vibratus* had a thick oval shape hypodermis composed of 3-6
332 layers. Structure of the studied species cortex had a wide range of variations. *P. amarus*, *P. niruri*,
333 *P. urinaria*, *P. reticulatus* and *P. acidus* had oval shaped cortex. On the other hand, *P. emblica* had

a sub-oval shaped cortex, elliptical for *P. virgatus* and rectangular for *P. debilis*. All the species found a moderately thick layered parenchyma composed of 1-15 layer parenchyma or spongy parenchyma cells. *P. acidus* had the thickest layer of parenchyma cells which was 8-15 layered thick (9 A). For all of the studied species, phloem section was thicker than xylem. *P. acidus* had the thickest layer of phloem cells which was composed of 5-15 layers (table 4, Fig 10).

Table 4: Anatomical comparison of stem cross section among studied *Phyllanthus*.

Discussion

In Bangladesh, very limited works were found that addressing to identify *Phyllanthus* sp. Ahamed et al. (2008) reported 11 species representing *Phyllanthus* genus in Bangladesh including 5 herbs, 4 shrubs and 2 trees. This study found 5 herbs, 1 shrubs and 2 trees in the study area including two new species (*Phyllanthus debilis* and *Phyllanthus amarus*) for Bangladeshi flora. Besides application of anatomical features along with taxonomic notes improve the identification of species (Kandavel et al. 2011).

Among listed five *Phyllanthus* herbs, *P. urinaria* and *P. virgatus* were easy to differentiate than others, based on morphological and anatomical features. With rough fruit surface for *P. urinaria* and long fruit petiole for *P. virgatus*, they were conveniently identifiable in field surveys. *P. amarus*, *P. debilis* and *P. niruri* were morphologically very close and difficult to differentiate. With five calyx segments *P. amarus* was different than *P. niruri* and *P. debilis* with six calyx segments. In the current study, filament stricture found most convenient option to differentiate among them *P. niruri* observed completely connate and joined filaments but for *P. debilis* they were connate at base but free at apex (table 3). In terms of anatomy, *P. amarus* have rounded epidermal circumference but *P. niruri* and *P. debilis* had angular epidermal circumference.

Hypodermis layer found key features for differentiate among *P. niruri* and *P. debilis*. More than 3 layered rectangular cell *P. debilis* Hypodermis was different than *P. niruri*, which has less than or exact 3 layered rectangular hypodermis (table 4; Fig 10).

Both *Phyllanthus debilis* and *Phyllanthus amarus* were first recorded from India by J. D. Hooker (1890) from North-west India, Sikkim, Bhutan, Hazaribag, Behar and Assam (Hooker, 1890). Prain (1904) also recorded them from Orissa, Chota Nagpur, Behar, Trihut and North Bengal (Prain 1904). In recent days these species were listed in Chennai, Tamil Nadu; Great Nicobar (Srirama et al. 2012). However, they were absent in all regional floristic works of Bangladesh (Rahman & Jamila 2016; Kona & Rahman 2015; Rahman et al. 2015; Rahman et al. 2014; Rahman 2013; Rahman & Akter 2013; Rahman et al. 2013; Uddin & Hassan 2012; Uddin et al. 2013; Arefin et al. 2011; Uddin & Hassan 2010; Tutul et al. 2010; Islam et al. 2009; Ahamed et al. 2008; Hossain et al. 2005; Khan & Huq 2001; Mia & Khan 1995; Datta & Mitra 1953). These facts, ensure that this two species were new to the floral database of Bangladesh. This finding will help the path of ecological study of this species for their conservation in Bangladesh.

A specimen *Phyllanthus debilis* J. G. Klein ex Willd. was collected from Khulna University Campus ((22°48'01.89"N; 89°32'04.60"E) in late October 2015. This species was found in a built-up habitat of Khulna University Nursery and was associated with *Phyllanthus niruri* L., *Hedyotis corymbosa* (L.) Lam., *Cynodon dactylon* (L.) Pers., *Cyperus rotundus* L., *Synedrella nodiflora* (L.) Gaertn., *Scoparia dulcis* L., *Lindernia crustacea* (L.) F. Muell., *Imperata cylindrical* (L.) Raeusch, *Euphorbia hirta* L. and others. Specimen of *Phyllanthus amarus* Schumach. & Thonn. was collected from Jessore city area (23° 09'55.97"N; 89°12'15.27"E) in late April of 2017. It was in association with *Synedrella nodiflora* (L.) Gaertn., *Scoparia dulcis* L., *Phyllanthus niruri* L., *Hedyotis corymbosa* (L.) Lam., *Cyperus rotundus* L., *Lindernia crustacea* (L.) F. Muell.,

Euphorbia thymifolia L., *Euphorbia microphylla* Lam. Both specimens were identified with key provided by Hooker (1890), Prain (1904) and Wurdack et al. (2004).

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500 **Fig.2- Fig. 10**

501 **Figures and table option**

502 **Fig 1: Map of the study area**

503

504 **Fig. 2:** Different parts of *Phyllanthus acidus* (L.) Skeels

505

506 **Fig. 3:** Different parts of *Phyllanthus amarus* Schumach. & Thonn

507

508 **Fig. 4:** Different parts of *Phyllanthus debilis* J.G.Klein ex Willd.

509

510 **Fig. 5:** Different parts of *Phyllanthus emblica* L.

511

512 **Fig. 6:** Different parts of *Phyllanthus niruri* L.

513

514 **Fig. 7:** Different parts of *Phyllanthus reticulatus* Poir.

515

516 **Fig. 8:** Different parts of *Phyllanthus urinaria* L.

517

518 **Fig 9:** Different parts of *Phyllanthus virgatus* G.Forst.

519

520 **Fig 10:** Cross section of stem of phyllanthus of southwestern Bangladesh. (a: *P. acidus*, b: *P.*

521 *amarus*, c: *P. debilis* d: *P. emblica*, e: *P. niruri*, f: *P. reticulatus*, g: *P. urinaria*, h: *P. vibratus*)

523 **Table 1:** A list of locations in the southwestern region of Bangladesh surveyed during the study
524 period

Sl no.	District	Place	Latitude	Longitude	No. of individuals	No. of species
1.	Khulna	KU Campus	22.80125° N	89.53466° E	117	6
2.		Boyra	22.83289° N	89.54131° E	46	5
3.		Dumuria	22.80936° N	89.41360° E	67	5
4.		Dhigholia	22.89416° N	89.52221° E	32	4
5.		Baintala	22.75812° N	89.58919° E	13	3
6.	Jessore	Pouro park	23.16508° N	89.20466° E	41	4
7.		M. M. collage	23.16234° N	89.20328° E	33	4
8.		Cantonment	23.19148° N	89.14975° E	41	6
9.		Labutala	23.27200° N	89.23148° E	49	6
10.		Bagherpara	23.22126° N	89.34825° E	11	4
11.	Satkhira	Govet. collage	22.71028° N	89.08503° E	23	5
12.		Medical collage	22.69100° N	89.04764° E	41	5
13.		BGB camp	22.73244° N	89.08453° E	78	5
14.		Binerpota	22.75447° N	89.10717° E	47	4
15.		Patkelgatha	22.76752° N	89.16900° E	39	4
16.	Bhagerhat	Satgomuj Mosque	22.67461° N	89.73788° E	71	4

17.		Khanjahan Ali Majar	22.66067° N	89.76032° E	23	3
18.		PC College	22.66543° N	89.78261° E	87	6
19.		Pouro Lake	22.65560° N	89.79535° E	21	4
20.		Pocha Dighi	22.64870° N	89.77262° E	23	5
21.	Magura	Govt. HSS College	23.48938° N	89.41914° E	19	3
22.		Stadium Para	23.48232° N	89.41420° E	40	4
23.		District Fishery Office	23.48080° N	89.41904° E	47	5
24.		Arpara	23.37775° N	89.37197° E	38	5
25.		Salikha	23.30223° N	89.37575° E	112	6
26.	Jhinaidha	KC College	23.54539° N	89.17012° E	13	2
27.		Kaligang	23.40495° N	89.13213° E	35	4
28.		Dulal-Mundia	23.38004° N	89.13924° E	72	5
29.		Gazi-Kalu Mazar	23.30836° N	89.16321° E	67	6
30.		Barobazar Railway Station	23.30488° N	89.15081° E	93	6
31.	Kushtia	Kushtia Govt. College	23.90175° N	89.12837° E	73	6
32.		Kushtia Soshan	23.89993° N	89.15211° E	65	5
33.		Chourhas	23.88921° N	89.10866° E	34	5

34.		Bot-toil	23.85114° N	89.09854° E	59	5
35.		IU Campus	23.72105° N	89.15204° E	20	6
36.	Chuadanga	Chuadanga Govt. College	23.63979° N	88.84907° E	67	5
37.		Rail Para	23.64256° N	88.85871° E	17	4
38.		Bus Terminal	23.63715° N	88.86063° E	90	5
39.		Jafarpur	23.62353° N	88.85984° E	42	5
40.		BGB Camp	23.62049° N	88.86415° E	65	5
41.	Meherpur	Mujibnagar	23.64411° N	88.59134° E	43	5
42.		Kedergong	23.66181° N	88.60596° E	34	3
43.		Bollovpur	23.64793° N	88.63281° E	51	3
44.		Collage road	23.76746° N	88.63974° E	9	2
45.		Gangni	23.81729° N	88.74912° E	81	5

526 **Table 2:** List and distribution of the listed *Phyllanthus sp.* at current study (* new record for
527 Bangladesh).

	<i>P.</i> <i>acidus</i>	<i>P.</i> <i>amarus*</i>	<i>P.</i> <i>debilis*</i>	<i>P.</i> <i>emblica</i>	<i>P.</i> <i>niruri</i>	<i>P.</i> <i>reticulatus</i>	<i>P.</i> <i>urinaria</i>	<i>P.</i> <i>virgatus</i>
Khulna	✓	✓	✓	✓	✓	✓	✓	
Jessore	✓	✓		✓	✓	✓	✓	✓
Satkhira	✓	✓		✓	✓	✓	✓	
Bhagerhat	✓	✓		✓	✓	✓	✓	
Magura	✓	✓		✓		✓	✓	
Jhinaidha	✓	✓		✓		✓	✓	✓
Chuadang	✓	✓		✓	✓	✓	✓	✓
a								
Meherpur	✓	✓		✓	✓	✓	✓	✓
Kushtia	✓	✓		✓	✓	✓	✓	✓

	<i>P. amarus</i>	<i>P. debilis</i>	<i>P. niruri</i>	<i>P. urinaria</i>	<i>P. virgatus</i>	<i>P. reticulatus</i>	<i>P. acidus</i>	<i>P. emblica</i>
Form	Herb	Herb	Herb	Herb	Herb	Shrub	Tree	Tree
Branchlets	Present	Present	Present	Present	Absent	Present	Present	Present
Leaf shape	Oblong or elliptic-oblong	Narrowly elliptic to lanceolate	Elliptic-oblong to elliptic-ob lanceolate	Linear-oblong to oblong-obovate	Obolong-elliptic	Varying but mostly obtuse to rounded	Ovate to ovate-lanceolate	Oblong or linear-oblong
Leaf apex	Cbtuse or rounded	Acute to acuminate	Obtuse or rounded	Acute	Obtuse or acuminate	Obtuse to rounded	Acute to acuminate	Obtuse
Leaf base	Rounded	Cuneate to acute	Tapering	Mucronulate, conspicuously ariculate or obtuse	prominently and asymmetrically auriculate	Cuneate	Rounded or broadly cuneate.	Shallowly cordate and slightly oblique
Lateral vine	4-7 pair	5-7 pair	4-7 pair	4-6 pair	6-9 pair	5-9 pair	5-7 pair	4-9 pair

Sepals	Five	Six	Six	Six	Six	Five	Four	Six
Disk segments	Five	Six	Six	Six	Six	Five	Four	Six
Filaments	Completely connate	Connate at base and free at apex	Completely connate	Connate, united into a slender column	Connate, Free	Stout	Kidney shaped.	Stout
Style	Three, Minutely bifid at tip.	Three, Minutely bifid at middle.	Three, triangular and bifid.	Three, free and adpressed to the top of ovary.	Three, boiled at apex	Five, two free and three united.	Four, free and two shorter.	Two parted
Fruit	Capsule	Capsule	Capsule	Capsule	Capsule	Barry	Drupe	Capsule
Calyx	Five lobed	Six lobed (apex rounded)	Six lobed (apex acute)	Six lobed	Six lobed	Five lobed	Six lobed	Six lobed

531 **Table 4:** Anatomical comparison of stem cross section among studied *Phyllanthus*.

	<i>P. amarus</i>	<i>P. debilis</i>	<i>P. niruri</i>	<i>P. urinaria</i>	<i>P. virgatus</i>	<i>P. reticulatus</i>	<i>P. acidus</i>	<i>P. emblica</i>
Epidermal circumference	Rounded	Angular	Angular	Angular	Elliptical	Rounded	Rounded	Rounded
Ring and Farrows	Absent	Absent	Absent	Present	Absent	Absent	Absent	Absent
Hypodermis	Rectangular 2-3 layer thick	Rectangular 4-5 layer thick	Rectangular 2-3 layer thick	Rectangular 2-5 layer thick	Rectangular 3-4 layer thick	Rectangular 3-5 layer thick	Rectangu lar 2-5 layer thick	Oval 3-6 layer thick
Cortex	Oval	Rectangular	Oval	Oval	Elliptical	Oval	Oval	Sub-oval
Parenchyma	4-6 layer thick	3-5 layer thick	3-6 layer thick	2-5 layer thick	1-3 layer thick	3-5 layer thick	8-15 layer thick	6-8 layer thick
Pericycle	2-3 layer thick	3-5 layer thick	3-5 layer thick	2-4 layer thick	2-3 layer thick	2-7 layer thick	2-8 layer thick	2-5 layer thick

Xylem	3-6 layer thick	1-3 layer thick	2-4 layer thick	2-5 layer thick	1-3 layer thick	2-4 layer thick	1-3 layer thick	1-3 layer thick
Phloem	4-9 layer thick	5-8 layer thick	4-7 layer thick	3-5 layer thick	2-3 layer thick	4-7 layer thick	5-15 layer thick	5-8 layer thick