Schoenoplectus heptangularis Cabezas & Jiménez Mejías (Cyperaceae), a new species from Equatorial Guinea

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Abstract

JIMÉNEZ-MEJÍAS, P. & F. CABEZAS (2009). Schoenoplectus heptangularis Cabezas & Jiménez Mejías (Cyperaceae), a new species from Equatorial Guinea. *Candollea* 64: 101-115. In English, English and French abstracts.

Schoenoplectus heptangularis Cabezas & Jiménez Mejías *(Cyperaceae),* a new species from Bioko Island (Equatorial Guinea), is described and illustrated. It is included in the group of *Schoenoplectus corymbosus* (Roem. & Schult.) J. Raynal which is widely distributed in tropical and subtropical areas of the Old World. Multivariate analyses performed on morphological characters data to support the distinction of this new species with other closed taxon are presented as well as the determination key for the species of the *Schoenoplectus corymbosus* group.

Key-words

CYPERACEAE – *Schoenoplectus* – Equatorial Guinea – West Tropical Africa – Multivariate analysis – Taxonomy

Résumé

JIMÉNEZ-MEJÍAS, P. & F. CABEZAS (2009). Schoenoplectus heptangularis Cabezas & Jiménez Mejías (Cyperaceae), une nouvelle espèce de Guinée Equatoriale. *Candollea* 64: 101-115. En anglais, résumés anglais et français.

Schoenoplectus heptangularis Cabezas & Jiménez Mejías *(Cyperaceae),* une nouvelle espèce de l'île de Bioko (Guinée Equatoriale) est décrite et illustrée. Elle est incluse dans le groupe de *Schoenoplectus corymbosus* (Roem. & Schult.) J. Raynal qui est largement distribué en région tropicale et subtropicale de l'Ancien Monde. Des analyses multivariées conduites sur des données de caractères morphologiques pour attester de la distinction de cette nouvelle espèce avec d'autres taxons proches sont présentées ainsi qu'une clé de détermination des espèces du groupe *Schoenoplectus corymbosus.*

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Introduction

Schoenoplectus (Rchb.) Pallas is a medium size-genus of ca. 77 species (Smith, 2002). It is a segregate from *Scirpus* L. and today widely accepted by cyperologists and frequently used in general floras. It comprises plants morphologically characterized by pseudolateral inflorescences -the lower bract is erect and culm-like-, terete spikelets with spirally-arranged glumes and leaves commonly reduced to sheaths. *Schoenoplectus* is mainly distributed in tropical areas, with a diversity centre in Africa.

Taxonomy of *Schoenoplectus* is problematic and some of its species constitute intricate complexes, for instance the temperate *S. lacustris* (L.) Palla group, which has been treated under heterogeneous taxonomic criteria according to different authors (Defilipps, 1980; Kukkonen, 1998; Smith, 2002; Pignotti, 2003; Luceño & Jiménez Mejías, 2008). Furthermore, recent molecular (Young & al., 2002) and anatomical works (Pignotti & Mariotti, 2004) may suggest a revision of the genus taxonomy, since their results show that sect. *Actaeogeton* (Rchb.) J. Raynal could be considered apart from sect. *Schoenoplectus* even as a different genus. As a result, the genus *Schoenoplectiella* Lye was recently created to comprise the annual species of the sect. *Actaeogeton* (Lye, 2003). However, the relationships within this section are still obscure and a comprehensive taxonomical revision is necessary.

The *Schoenoplectus corymbosus* (Roem. & Schult.) J. Raynal group has been included in sect. *Actaeogeton* by some authors (Beetle, 1942; Luceño & Jiménez Mejías, 2008), but it was treated in sect. *Schoenoplectus* by Raynal (1976a). This complex comprises large plants, with robust rhizomes, linear anthers, smooth achenes and perianth bristles generally absent. It is distributed in Africa (Täckholm & Drar, 1950; Maire, 1957; Hooper, 1972; Raynal, 1976a, 1976b; Haines & Lye, 1983; Browning, 1991; Gordon-Gray, 1995; Lye, 1997), southwest Spain (Jiménez Mejías & al., 2007), Pakistan and India (Kukkonen, 1998). Most authors recognize two taxa within the complex: *S. corymbosus* s.s. and *S. brachyceras* (A. Rich.) Lye. Haines & Lye (1983) treated both taxa as varieties, the var. *corymbosus* and the var. *brachyceras* (A. Rich.) Lye. However, the taxonomy of the complex in Southern Africa was clarified by Browning (1991) and the specific rank for both taxa determined (Browning, 1992). A third taxon, *S. decipiens* (Nees) J. Raynal, reported from South Africa, though being much smaller than the former, has been considered close to *S. brachyceras* and hybrids among them have been reported (Browning, 1990, 1992).

Equatorial Guinea material from Bioko Island (formerly known as Fernando Poo Island) were recorded as *Scirpus brachyceras* A. Rich in the "Flora of West Tropical Africa" (Hooper, 1972). Later, Cabezas & al. (2004), in the "Checklist of Cyperaceae of Equatorial Guinea", considered the Bioko plants *Schoenoplectus corymbosus*. Only one population of this plant has been reported from the island, at lake Biaó, in volcano Biaó crater in Bioko Sur province (Fig. 1) and the scarce available materials are known by several exsiccata. These specimens show the main characteristics of the *S. corymbosus* group: large rhizomatous plants with smooth achenes and linear anthers. However a detailed observation reveals that it is a problematic taxon, which cannot be easily identified as one of the species of the complex.

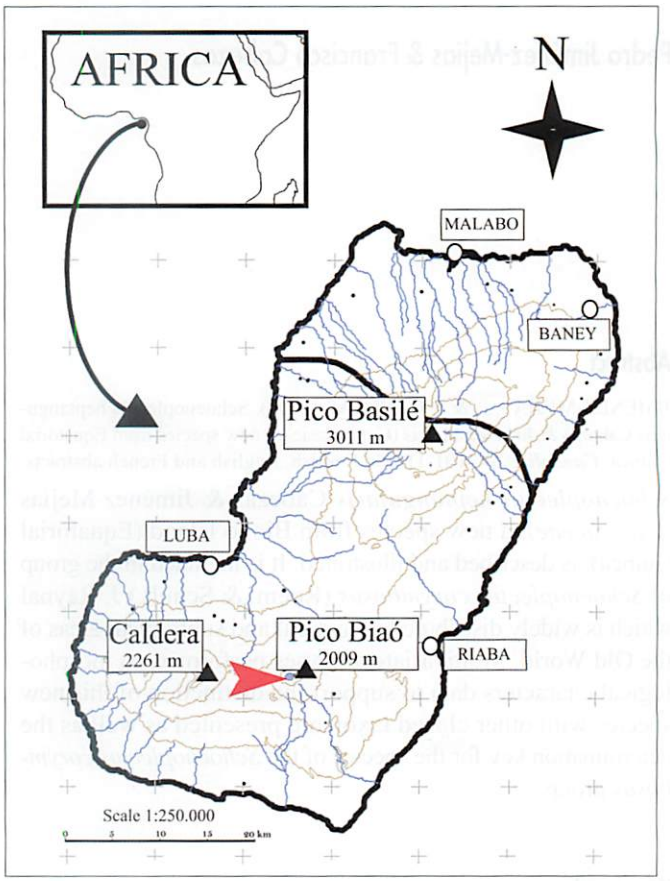

Fig. 1. – Geographical location of *Schoenoplectus corymbosus* (Roem. & Schult.) J. Raynal in Bioko Island. The labels indicate the main towns (o) and peaks (▲) of the island. The red arrow indicates the exact location of the population at the lake Biaó, in the crater of volcano Biaó.

Multivariate analyses, as Principal Component Analysis (PCA), are statistical tools widely used to clarify taxonomic relationships within plant species complexes (Crins & Ball, 1989; Blackstock & Ashton, 2001; Nieto Feliner & al., 2001; Albadalejo & al., 2004). This method, together with One-Way Analysis of Variance (ANOVA), are used in our study to clarify the phenetic relationship between *S. corymbosus* group and the anomalous Bioko plants, evaluate its taxonomic status, and provide a new and definitive specific rank.

Materials and methods

Plant material

Seventy six specimens from different herbaria (B, BM, BOLUS, G, KMG, MA, NBG, NY, PRE and UNIN) were studied (Appendix 1). Additional materials were obtained during field work in Doñana National Park (SW Spain), Northern Morocco (2006), and Equatorial Guinea (2007). The Spain and Morocco material were deposited at UPOS herbarium (Seville, Spain) while the Equatorial Guinea material was sent to several herbarium. African materials from the Guinea Gulf area (Cameroun and Nigeria) were also studied in K (Appendix 2), although unfortunately it could not be included in the analyses. Those areas would have represented a significant gap in our sampling and we considered it important to check this material, taking into account the variability of the plants from the continental African areas closest to Bioko Island.

All of the data included in the analyses were taken from dried specimens. Traditional characters used in taxonomic delimitation of *S. corymbosus* s.s., *S. brachyceras* and *S. decipiens* (HAYNES & LYE, 1983; BROWNING, 1991; GORDON-GRAY, 1995; LYE, 1997), as well as other used in treatments of different species of *Schoenoplectus* were chosen. Ten characters and one ratio were included in the numerical analyses (Table 1). Other quantitative and qualitative features were also examined for a better characterization of the plants. Measurements were made using an ocular micrometer, with the exception of the larger ones (more than 10 mm), which were measured using a standard 30 cm line ruler.

Achene and anther morphology was examined under scanning electron microscopy (SEM) after gold coating. A Hitachi S3000-N electron microscope was used. Anatomical details of the stem were studied from thin slices cut transversely by hand and embedded in fasga (TOLIVIA & TOLIVIA, 1987). Observations of the general anatomical pattern were made with a binocular lens.

Statistical analysis

The variation patterns within the dataset were analyzed using PCA. A two step analysis was performed to get a better discrimination within the dataset: 1) including all the taxa (PCA-1) and 2) excluding *S. decipiens* and STW character (PCA-2). Stem width was the character with the highest component loading in PCA-1. Since it is strongly related to plant size, it helped to discriminate the smaller *S. decipiens* from the remaining larger plants. Removing both the STW character and *S. decipiens* dataset allowed for better separation among *S. corymbosus* s.l. taxa, which are more homogeneous in size. Data were standardised for PCA. Differences in the mean values for single characters between all the taxa were tested using ANOVA. Data were first tested for normal distribution and variance equivalence. When those assumptions could not be confirmed, the different values were transformed (Table 1). All the analyses were carried out using the software SPSS (SPSS Inc., version 15.0).

Results

Principal Components analysis

The scatter plot of the principal components PCI *vs* PCII of PCA-1 (Fig. 2) showed three different clusters: (a) *S. decipiens*, (b) *S. corymbosus* s.l. and (c) Bioko plants. Separation from *S. corymbosus* s.l. cluster was not complete for *S. decipiens*,

Table 1. – Variables included in the numerical analyses: PCA-1, PCA-2, ANOVA and box-plots (BP). Transformations to meet the normality and homocedasticity requirements for ANOVA are also showed.

Character	Label	Analyses	Transformation for ANOVA
Stem upper width [mm]	STW	PCA-1; ANOVA; BP	Square-root transformed
Bract length [mm]	BRL	PCA-1; PCA-2; BP	-
Bract width [mm]	BRW	PCA-1; PCA-2; ANOVA; BP	Square-root transformed
Spikelet length [mm]	SPL	PCA-1; PCA-2; ANOVA; BP	Square-root transformed
Spikelet width [mm]	SPW	PCA-1; PCA-2; ANOVA; BP	Untransformed
Glume length [mm]	GLL	PCA-1; PCA-2; ANOVA; BP	Square transformed
Glume width [mm]	GLW	PCA-1; PCA-2; ANOVA; BP	Logarithm transformed
Glume mucro [mm]	GLM	PCA-1; PCA-2; BP	-
Anther length [mm]	ANL	PCA-1; PCA-2; BP	-
Anther mucro [mm]	ANM	PCA-1; PCA-2; BP	-
Anther length/width ratio	ANS	PCA-1; PCA-2; ANOVA; BP	Square-root transformed
Achene length [mm]	ACL	BP	-

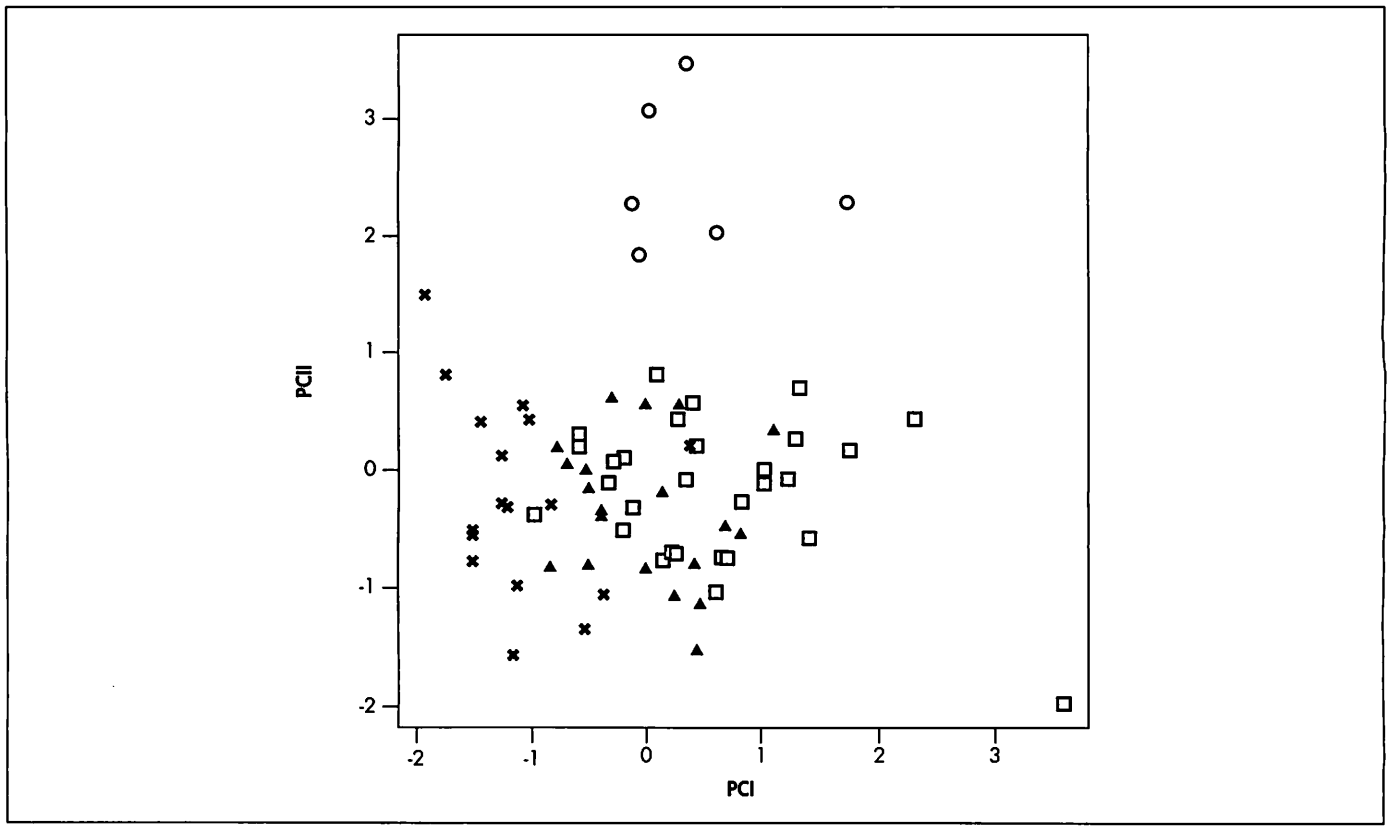

Fig. 2. – Scatter plot of PCI vs PCII from PCA-1 (O Bioko plants; □ *Schoenoplectus brachyceras*; ▲ *S. corymbosus*; ✖ *S. decipiens*).

whereas Bioko plants were placed disjunct in an independent cluster. *Schoenoplectus brachyceras* and *S. corymbosus* s.s. were completely intermingled in a *S. corymbosus* s.l. cluster. The first two principal components accounted for 50.3% of the variance within the data set (29.4% for PCI; 20.9% for PCII). The variables with the highest component loadings (Table 2) on PCI were, in descending order, STW, BRW and ANM, of which the two first are closely related with plant size. The highest component loadings on PCII were GLL, GLW and ANS, characters which are associated with flower morphology.

The scatter plot of the first two principal components of PCA2 (Fig. 3) grouped each set of samples in a different cluster: Bioko plants, *S. corymbosus* s.s. and *S. brachyceras*, the two latter slightly superposed. In this case, the first two principal components accounted for 50% of the variance (28.3% for PCI; 21.7% for PCII). The highest component loadings (Table 2) on PCI were, in descending order, SPL, ANS, GLL, GLW, ANL and SPW. On the other hand, on PCII these variables were ANM, BRL, GLM, ANM, ANL and SPW.

Table 2. – Loadings for the first two principal components (PCI and PCII) for PCA-1 and PCA-2.

Character	PCA-1		PCA-2	
	PCI	PCII	PCI	PCII
STW	0.939	-0.039	0.031	-0.096
BRL	-0.091	-0.417	-0.257	0.731
BRW	0.933	-0.036	-0.014	-0.144
SPL	-0.189	0.548	0.803	0.114
SPW	-0.08	0.175	0.519	0.518
GLL	0.004	0.752	0.759	-0.158
GLW	0.211	0.741	0.684	-0.124
GLM	0.103	0.119	-0.018	-0.664
ANL	-0.076	0.385	0.513	0.625
ANM	0.599	0.247	0.101	-0.743
ANS	-0.249	0.58	0.799	0.082

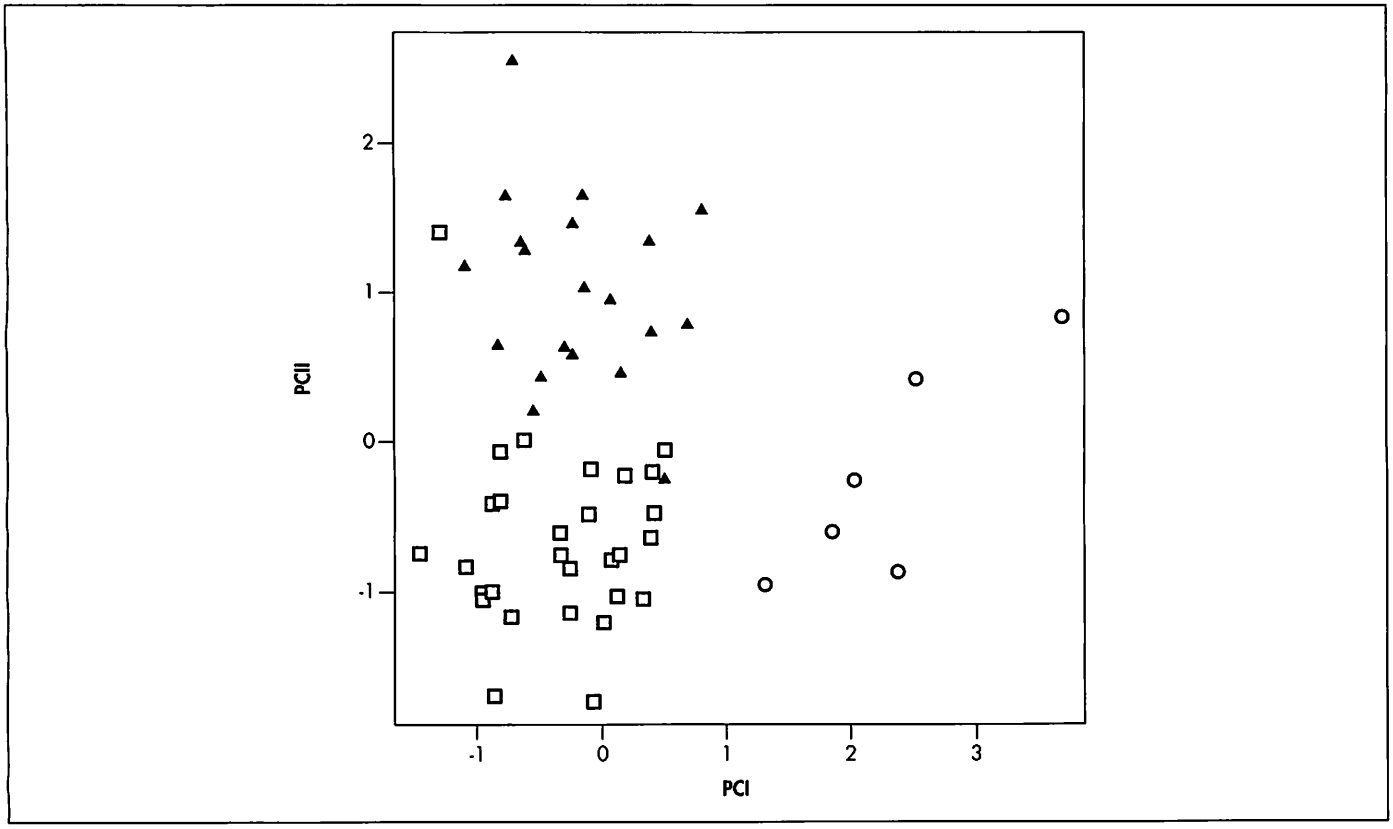

Fig. 3. – Scatter plot of PCI vs PCII from PCA-2 (O Bioko plants; □ *Schoenoplectus brachyceras*; ▲ *S. corymbosus*).

ANOVA

The ANOVAs revealed significant differences in the mean values of each included character between the considered taxa (including Bioko plants). Only SPW displayed incongruities concerning *post hoc* tests. Box-plots (Fig. 4) let us check the differences between analyzed characters. BRL, GLM, ANL and ANM were not included in the ANOVA because they do not meet normality and homogeneity of variances even after transformation. No single character can be used alone to discriminate all the taxa, since no characters are clearly disjunct in their ranges. However, several of them allow the distinction of some sample groups. For example, Bioko plants can be discriminated from *S. corymbosus* s.l. by GLL, and *S. brachyceras* together with Bioko plants are separated from *S. decipiens* by BRL.

Qualitative characters

The observation of qualitative characters revealed a great congruence among the classic features reported for the different *Schoenoplectus* species and the sample clustering showed in PCA scatter plots. Glume coloration and mucro and anther mucro habit characters (Table 3) matched previous works. Concerning Bioko plants, the constant presence of perianth bristles was noted (Fig. 5A, 5B), a character not common among *S. corymbosus* s.s. neither in *S. brachyceras* samples.

Micromorphology and anatomy

SEM photographs of the achene surface showed narrow cells arranged in transverse rows (Fig. 5C, 5D).

The transverse sections of the Bioko plants stem (Fig. 6) revealed an irregular polygonal section, generally with seven sides, which matches with the seven vascular bundles displayed in the photograph. This character can be seen in herbarium material due to the presence of wider ribs (stem angles). It has not been observed in any samples of the other *Schoenoplectus* species studied. Moreover, *S. corymbosus* s.s. and *S. brachyceras* herbarium materials usually retain the terete stem shape.

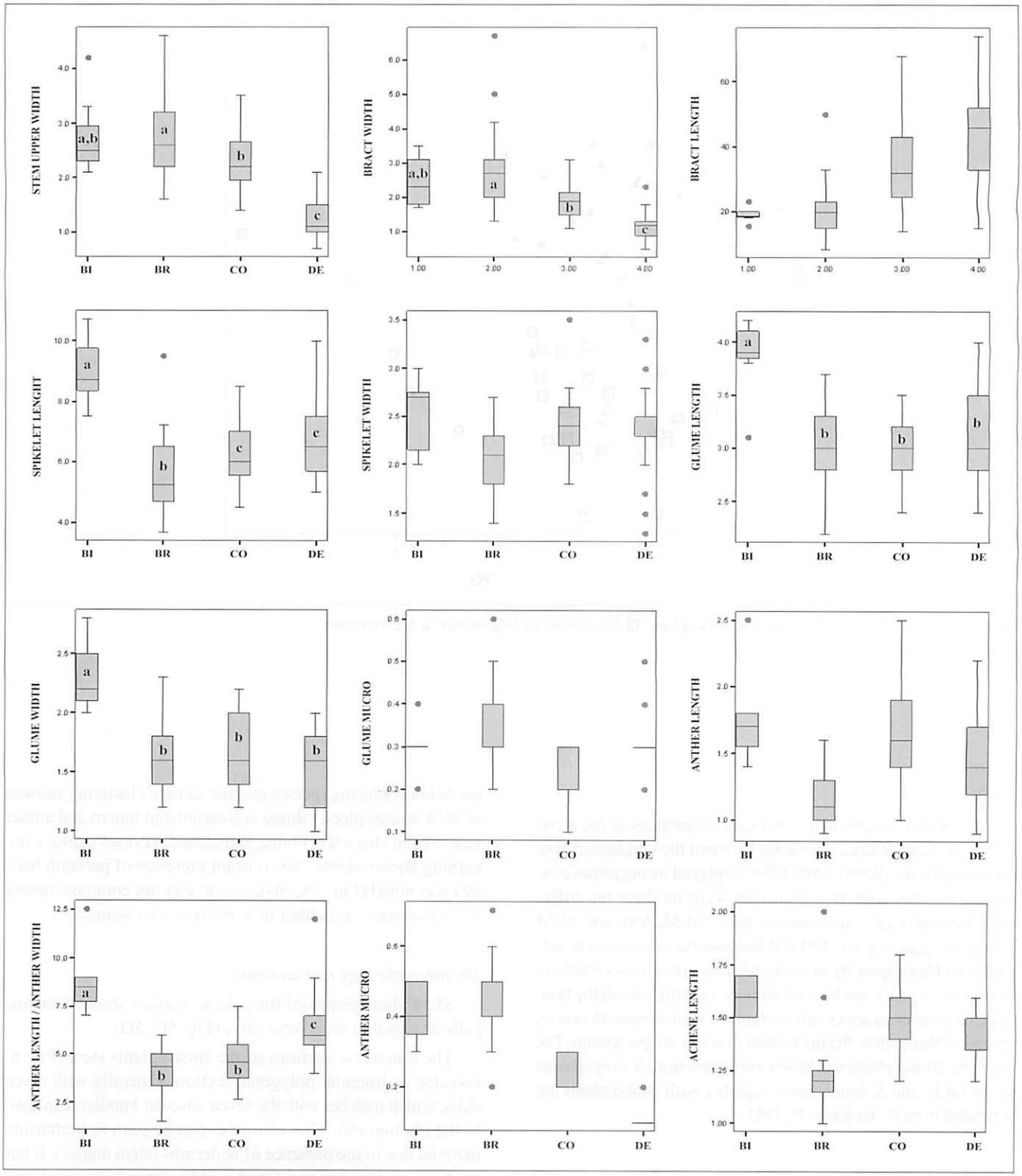

Fig. 4. – Box-plots of examined characters. The examined groups of plants are labelled as follow: Bioko plants (BI), *Schoenoplectus brachyceras* (A. Rich.) Lye (BR), *S. corymbosus* (Roem. & Schult.) J. Raynal (CO) and *S. decipiens* (Nees) J. Raynal (DE). The box together with the vertical line cover 100% of the data values, the box 50% values, and the horizontal line within the box is at the median. Points represent extreme values. Letters within box indicate groups with similar mean values following ANOVA post hoc tests.

Table 3. – Comparison of morphological data among the studied species *(Bioko plants, Schoenoplectus brachyceras* (A. Rich.) Lye, *S. corymbosus* (Roem. & Schult.) J. Raynal s.s. and *S. decipiens* (Nees) J. Raynal).

	Bioko plants	*S. brachyceras*	*S. corymbosus s.s.*	*S. decipiens*
Stems	2.1-3.3(-4.2) mm wide below the inflorescence, irregularly heptagonal in transverse section	1.6-4(-4.6) mm wide below the inflorescence, terete	1.4-2.8(-3.5) mm wide below the inflorescence, terete	0.7-2.1 mm wide below the inflorescence, terete
Bract	15.5-23 × 1.7-3.5 mm, shorter than the inflorescence	10.2-36.8(-50) × 1.3-5(-6.7) mm, usually shorter than the inflorescence	14-57.5(-68) × 1.1-3.1 mm, usually longer than the inflorescence	15-74 × 0.5-2(-2.3) mm, always longer than the inflorescence
Inflorescence	Simple anthela, with 1-4 rays	Simple or 1-2 times branched anthela, with (3-)4-11(-14) rays	Simple or 1(-2) times branched anthela, with (1-)3-15(-19) rays, rarely a sessile cluster of spikelets	Sessile cluster of spikelets, sometimes a simple anthela with 1-3(-4) rays
Spikelets	8.2-10.7 × 2-2.7 mm, 14-24 flowered	3.7-8.1(-9.5) × 1.4-2.3 mm, 8-16 flowered	4.5-8.5 × 1.8-2.8 mm, 8-16 (-18) flowered	5-10 × 1.5-2.7(-3.8) mm, 10-20(-24) flowered
Glumes	3.1-4.2 × 2-2.8 mm, brown, frequently darker towards the top, with a narrow straw coloured midrib	2.2-3.5 × 1.2-2.2(-2.3) mm, pale to dark brown, uniformly coloured or darker towards the top, sometimes with narrow scarious margins and a straw coloured midrib	2.4-3.5 × 1.4-2.2 mm, pale brown, frequently with narrow scarious margins and a straw coloured midrib	2.4-4 × 1-2 mm, hyaline to straw coloured, with broad scarious margins, dark brown coloured at the apex forming an inverted V
Glume mucro	0.2-0.4 mm, straight	0.2-0.6 mm, generally slightly curved outside	0.1-0.3 mm, straight	0.2-0.4(-0.5) mm, straight or slightly curved
Anthers	1.4-1.8(-2.5) × 0.2, mm with a 0.3-0.5 mm mucro, scabrid at the apex	0.9-1.6 × 0.2-0.4(-0.6) mm, with a 0.3-0.5(-0.6) mm mucro, generally spinulose along the entire length	1-2.2(-2.5) × 0.2-0.3 mm, with a scarcely developed mucro up to 0.1(-0.2) mm, smooth or scabrid at the apex	0.9-2.2 × (0.1-)0.2-0.4 mm, with a 0.1(-0.2) mm smooth mucro
Achenes	1.5-1.9 × 0.9-1 mm, obovate	1-1.6(-2) × (0.8-)0.9-1.4 mm, broadly obovate	1.2-1.8 × 0.9(-1.4) mm, obovate to elliptical	1.2-1.6 × 0.9-1.2(-1.6) mm, obovate
Perianth bristles	4(-5), smooth, sometimes retrorsely scabrid at the apex	Generally absent; if present, 1-4, usually scarcely developed, bristle-like and smooth, retrosely scabrid at the apex if well developed	Generally absent; if present, 1-4, usually scarcely developed and smooth, strap-like with fimbriate margins if well developed	0-5, smooth or retrorsely scabrid at the apex

Discussion

Our data support the phenetic congruity of the three analyzed taxa, as well as the morphological distinctiveness of Bioko plants.

PCA-1 (Fig. 2) do not provide a satisfactory separation among *S. brachyceras* and *S. corymbosus* s.s. due to the strong weight of plant size in PCI. However, we overcame this problem in PCII (Fig. 3) by removing *S. decipiens* samples and the STW character. Characters previously used to distinguish species within the *S. corymbosus* complex (HAINES & LYE, 1983; BROWNING, 1991; GORDON-GRAY, 1995; LYE, 1997) are supported by our studies, showing some of the highest loadings in both PCA analyses.

Specimens from the Guinea Gulf (Cameroun and Nigeria) were all determined as *S. brachyceras*. The quantitative measurements and qualitative characters of these specimens were within the observed variability range of this species.

In spite of small sample size, both PCA (Fig. 2, 3) analyses clearly support the separation of Bioko materials, giving strong disjunctions, first along PCII in PCA-1 (mainly due to glume size), and second along PCI in PCA-2 (mainly due to spike and glume size and anther shape). These differences are statistically supported by the results of the ANOVA (Fig. 4). In addition, the heptagonal transverse section of the stems (Fig. 5) could be the more notable feature which distinguishes Bioko samples from the remaining species of the *S. corymbosus* group. Table 3 summarizes the taxonomical characters of the different taxa studied.

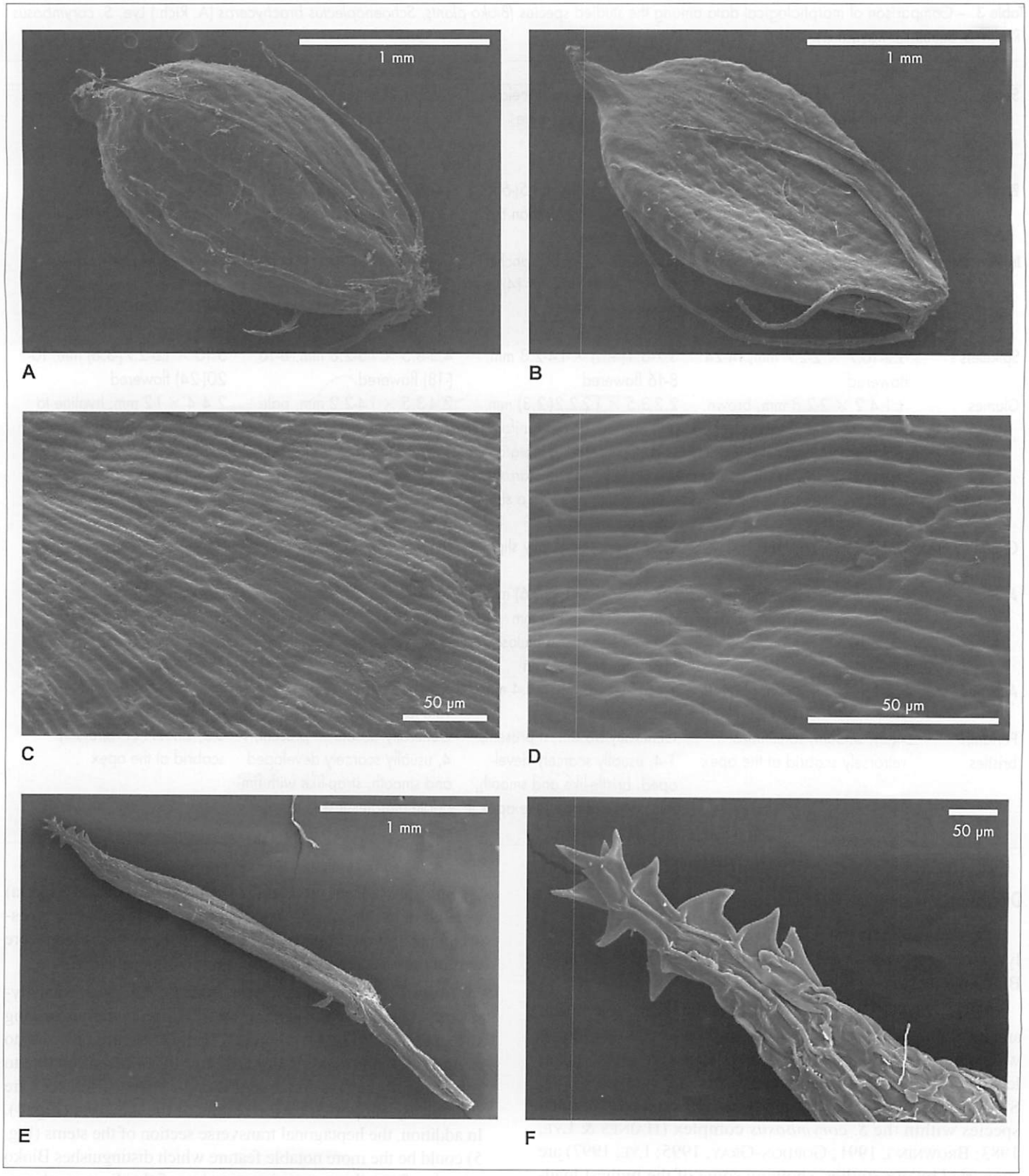

Fig. 5. – *Schoenoplectus heptangularis* Cabezas & Jiménez Mejías from Bioko Island. **A.** Achene abaxial side; **B.** Achene adaxial side; **C-D.** Pericarp surface; **E.** Anther; **F.** Anther mucro. [*Cabezas, Estrella & Fero 1114FJC, MA*]

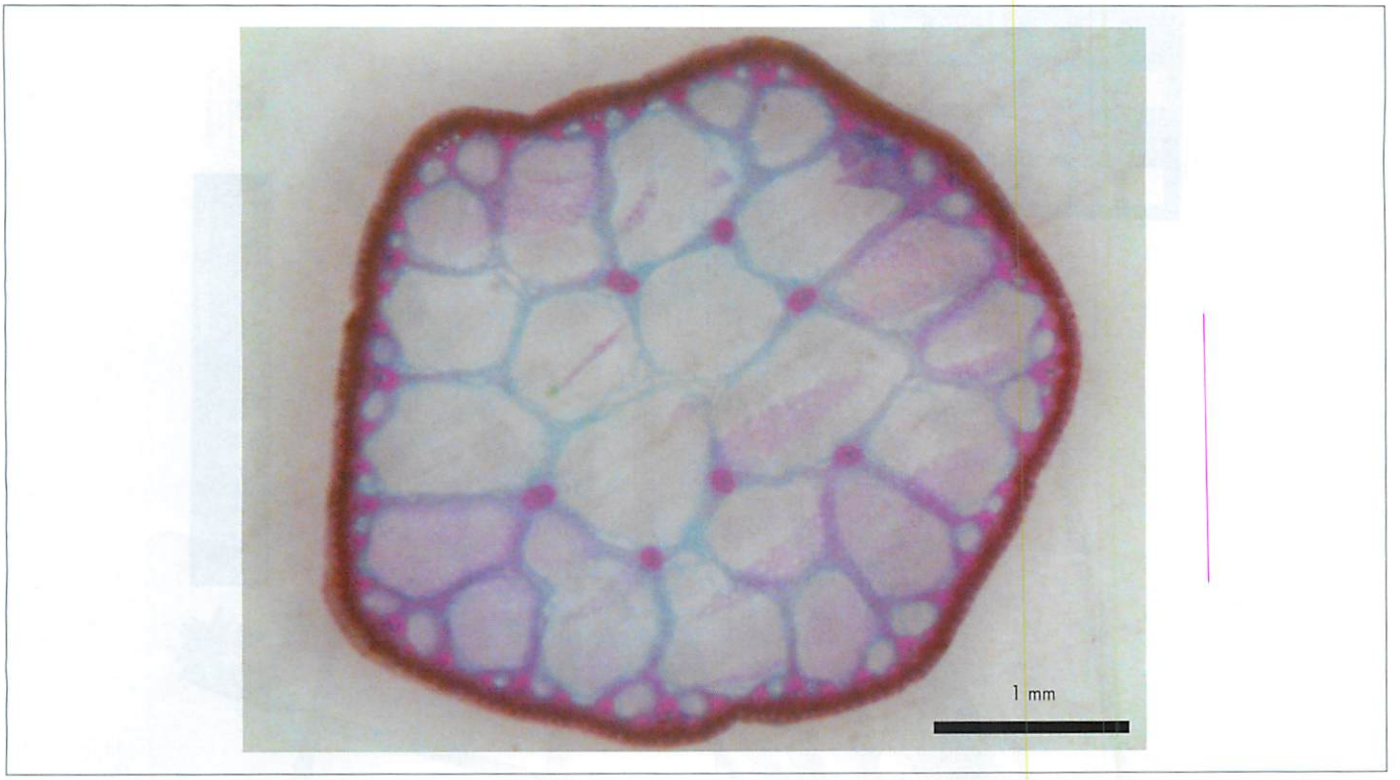

Fig. 6. – Transverse section of the culm medially of *Schoenoplectus heptangularis* Cabezas & Jiménez Mejías from Bioko Island. [*Cabezas, Estrella & Fero 1114FJC*, MA]

Micromorphological features of the achene (Fig. 5C, 5D) correspond with those reported from sect. *Actaeogeton* (PIGNOTTI & MARIOTTI, 2004) and support the inclusion of Equatorial Guinean materials within this section.

On the basis of these results, we conclude that Bioko plants are not referable to any known taxon and therefore, we describe them as the following new species.

Schoenoplectus heptangularis Cabezas & Jiménez Mejías, **spec. nova** (Fig. 5-8)

Typus: **EQUATORIAL GUINEA. Bioko Island:** Moca, lago de Biaó, dentro del lago, 3º21'06"N 8º37'42"E, 1825 m, 18.XII.2007, *Cabezas, Estrella & Fero 1114FJC* (holo-: MA [766844]); iso-: B, BM, BR, C, G, K, LISC, MA, MO, NY, P, PRE, UPOS, W, WAG).

Species nova est Schoenoplecto corymboso similis Schoenoplecto brachycera, quarum dissimilitudines sunt caulis septem faciebus, praeter squamas et spiculas maiores.

Robust rhizomatous *perennial*. Culms up to 150 cm tall, 2.1-4.2 mm wide just below the inflorescence, up to 1 cm wide medially, irregularly heptagonal in transverse section. *Leaves* reduced to bladeless sheaths or sometimes with a small mucro-like blade. *Inflorescence* a simple anthela, with 19-47 spikelets, most of them sessile, 4-17 of those clustered in fascicles at branch tips; inflorescence branches slightly canaliculate, smooth; lowest bract 15.5-23 × 1.7-3.5 mm, erect, culm-like, shorter than the inflorescence; spikelets 8.2-10.7 × 2-2.7 mm, 14-24 flowered, ovate to ovate-lanceolate. *Glumes* 3.1-4.2 × 2-2.8 mm, ovate, with a (0.2-)0.3-0.4 mm straight mucro; brown, darker towards the apex, slightly plurinerved, with the central nerve distinct as a thin straw-coloured midrib. *Anthers* 1.4-1.8(-2.5) × 0.2 mm, linear, yellow, with a 0.3-0.5 mm mucro, this scabrid at the apex. *Style* 3-fid. *Achenes* 1.5-1.9 × 0.9-1 mm, obovate, broadly trigonous; pericarp smooth, with slight irregular wrinkles visible under high magnification, composed of narrow elongate cells transversally arranged; perianth bristles 4(-5), 1.1-2.3 mm long, smooth, sometimes retrorsely scabrid at the apex.

Fig. 7. – Holotype of *Schoenoplectus heptangularis* Cabezas & Jiménez Mejías. [*Cabezas, Estrella & Fero 1114FJC*, MA]

Fig. 8. – Detail of *Schoenoplectus heptangularis* Cabezas & Jiménez Mejías inflorescence from the holotype.
[*Cabezas, Estrella & Fero 1114FJC*, MA]

Etymology. – The epithet *heptangularis* is in reference to the irregularly heptagonal transverse section of the stems.

Ecology. – Helophyte, growing with the base of the stems under water up to 1 m, replacing *Pteridium aquilinum* (L.) Kuhn communities in the lakeside.

Distribution. – Only known from Bioko Island (Equatorial Guinea, Bioko Sur province), in Biaó volcano crater, on lake Biaó shores (Fig. 1).

Paratypi – **Equatorial Guinea. Bioko Province:** Fernando Po, Moka crater lake, 1130 m, 30.I.1933, *Exell, A. W. s.n.* (BM [926960]); Bioko, orillas del lago de Moka, 1939?, *Lope del Val s.n.* (MA [386424]); Bioko, Moka, 1939, *Lope del Val s.n.* (MA [500343]); Bioko, Fernando Po, Lago de Moka, 30.I.1947, *Guinea 2207* (MA [386381], [MA 386382]); Fernando Po, Lagoa Biao, 14.IX.1959, *Wrigley, T. C. & F. A. Melville s.n.* (BM [926978], K); Bioco, desembocadura del lago Biaó, 32NMJ5770, 1860 m, 22.II.1989, *Fernández Casas s.n.* (B [100017525], BM [926953], K, MA [558527], NY).

Key to species of the *Schoenoplectus corymbosus* group

1. Stems polygonal in cross section; perianth bristles present, well developed, at least half as long as the achenes; glumes 3.1-4.2 mm long; spikelets 8.2-10.7 × 2-2.7 mm, 14-24 flowered; anther mucro 0.3-0.5 mm long, scabrid at apex ..... ***S. heptangularis***

1a. Stems terete in cross section; perianth bristles generally absent or much shorter than the achenes, rarely well developed; glumes smaller, if longer than 3.1 mm, then spikelets 3.7-8.1(-9.5) × 1.4-2.3 mm, 8-16 flowered or anther mucro 0.1(-0.2) mm long, scabrid at apex or smooth 2

2. Plants slender, with stems 0.7-2.1 mm wide below the inflorescence; glumes hyaline to straw coloured, with broad scarious margins, dark brown coloured at the apex forming an inverted V; inflorescence a sessile cluster of spikelets, rarely a simple anthela with 1-3(-4) rays ..... ***S. decipiens***

2a Plants robust, with stems 1.6-4(-4.6) mm wide below the inflorescence; glumes pale to dark brown, sometimes with narrow scarious margins; inflorescence a simple to 1-2 times branched anthela, rarely a sessile cluster of spikelets 3

3. Anther mucro 0.2-0.3 mm long, smooth or scabrid at the apex; bract generally longer than the inflorescence, terete; glume mucro 0.1-0.3 mm long, straight ..... ***S. corymbosus***

3a. Anther mucro 0.2-0.6 mm long, spinulose along the whole length; bract generally shorter than the inflorescence, boat shaped; glume mucro 0.2-0.6 mm long, generally slightly recurved ..... ***S. brachyceras***

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Appendix 1. – List of materials included in the statistical analyses.

1. *Schoenoplectus brachyceras* (A. Rich.) Lye

Angola: Hab. ad et in rivulis montanis prope Palmira, XII.1854, *de Casengo, D. 7015* (BM).

Democratic Republic of the Congo: Kihevi meadow, near Burunga, Kivu district, 7200 m , 2.VI.1927, *Chapin, J. P. s.n.* (NY).

Ethiopia: 19.VIII.1862, *Schimper 84* (BM); Bonghé district, Gughé highlands, XII.1948, *Scott, H. 128* (BM).

Kenya: Omboni river, 1926, *Prescott* (BM); Eldoret dist., on swampy place, in the shade of the margin of *Syzygium* trees near the stream, 900 m, 10.IV.1951, *Williams, G. R. 102* (NY); Southern N'guaso Nyiro River, Sotik Country, 1800-2100 m, 24-30.VII.1909, *Mearns, E. A. 720* (NY); Nyanza Province, Londiani Distr., Tinderet Forest Reserve, 0°6'S 35°29'E, 2400 m, 21.VI.1949, *Maas Geesteranus, R. A. 5101* (PRE).

Republic of South Africa: KwaZulu-Natal: Richmond Town Lands dam Richmond, 18.XI.1976, *Musil, C. F. 483* (PRE). **Northern Territory:** Pietersburg Municipal Game Reserve, in stream sterk loops, 1.XII.1979, *Bredenkamp & van Vuuren 272* (UNIN); Percy Fyfe Nat. Reserve, Pietersburg District, 4500 m, 22.XI.1987, *Huntley, B. J. 1268* (PRE). **Transvaal:** Barbenton district, Sogimvelo Game Reserve, Dunbar, Msauli Valley, in mud, by river, 8.XII.1992, *Browning, J. 491* (B); Wakkerstroom, in running water at the higher altitudes, 6500 m, 26.XII.1963, *Devenish, N. G. 1098* (NY); Dist. Pretoria, Prenoon river, 11.I.1962, *Lubke, R. A. 177* (PRE); Johannesburg district, Florida, intersection of Hendrick Potgieter Drive and Magongo rd., marshy grassland, 13.XI. 1984, *Robinson, E. R. & al. 13/11/84/005* (PRE); North of Potchefstroom al Mooi River Oog, *Germishuizen, G. 4328* (PRE); Lyndenburg distr., Crocodile River between Bambi & Lydenburg Marshy river, 9.I.1985, *Reid, C. 815* (PRE).

Swaziland: Malolotja Nature Reserve, in river below Mortimer's dam, 1486 m., 17.XII.1985, *Heath, L. M.* (PRE).

Tanzania: Landschaft West Usam-bara, Manolo, Magamba, 31.V.1914, *Peter, A. 4201* (B); Landschaft Merú, bei Ngongongare, 11.III.1914, *Peter, A. 2635* (B); Landschaft Winter Hochland, am Mogad See des Ngorongoro Kraters, 23.VII.1926, *Peter, A. 43177* (B); Landschaft Irakú, Düngobesch, Mdungara, Salzguelle, 10.VIII.1926, *Peter, A. 43848* (B); Leikipia plateau, Massai-Land, *Gregory, J. W.* (BM); NW Side of Munge Swamp, Ngorongoro Crater, ca. 5500 m, 8.VII..1966, *Greenway, P. J. & Kanuri 12546* (NY); Ngonparl, 16.V.1909, *Mücke, M. 90* (PRE).

Zimbabwe: Ad pagum Inyanga, in solo humido ad rivulum, 19.XI.1930, *Fries, C. E. & al. 3018* (B); Gazaland, Southern Melsetter, Chimanimani, X.1912, *Swynnerton, C. F. M. s.n.* (BM); Grassland, Marandellas, 27.I.1948, *Colvile, P. A. 59* (PRE).

2. *Schoenoplectus corymbosus* (Roem. & Schult.) J. Raynal

Egypt: Vers le Canal de Salabieh, bord oriental du Delta d'Egypte, V.1880, *Dr. Schweinfurth s.n.* (G); Teh-el-Hasad (Delta), 25.IV.1885, *Dr. Schweinfurth s.n.* (G); II.1904, *Muschler s.n.* (G).

India: Aurangabad, Delhi gatein, shallow water, *Naik, V. N. 265* (NY); Telinkhen, Nagpur, M. S. India, 310 m, 15.I. 1965, *Dande, V. P. D4/5* (NY).

Morocco: carretera de Tiflet a Maaziz, a 2-3 km del cruce Kenitra-Khemisset, 385 m, 32°52'N 6°16'E, 18.IV.2006, *Martín Bravo, S. & al. 37SMB06* (UPOS).

Niger: Niger Français, Tosolé dans le desert, 11-14.II.1932, *Chevalier, A. 44189* (B); Soudan Français, Tilabéry à Onsongo, 1.III.1932, *Chevalier, A. 43762* (B).

Republic of South Africa: Cape Province: Hay, Witsand, W of Doornaar homestead, moist depression between white sand dunes, 25.III.1959, *Leistner, O. A. 1391* (KMG); W Itsands, Lamgerberg farm, Morgamswag, W side of High Duneveld, growing in water at edge of pond/seep, 18.III.1986, *Gubb, A. A. 1480* (KMG); W Cape; Worcester Dist., along banks of Breede River ca 10 km E of Worcester, 10.V.1979, *van Breda, P. A. B. 4477* (PRE). **KwaZulu-Natal:** Rustenberg Rd, from Bergville, Bergville District, 17.XII.1958, *Edwards, D. 2411* (PRE). **North West Territories:** Nimrodsvlei farm, alluvial soil W-facing on Molopo river bed, 16.II.1982, *Gubb, A. A. 5584* (KMG). **Transvaal:** Moorddrift, in dried up ulei in Nyl River, 3000 m, 19.XII.1963, *Mauve, A. A. 4284* (NY); Pretoria, van Riebeeck Natuur-reservaat, 1500 m, 22.XII.1967, *Kok, P. 254* (PRE); 10 km before Volksrust from Standerton, 18.I.1979, *Arnold, T. 1083* (PRE).

Spain: Huelva: Moguer, Parque Natural de Doñana, Laguna de Moguer, 8.VI.2006, *Jiménez, P. & M. Escudero 55PJM06* (UPOS).

Tanzania: D-Ost Afrika, Landschaft Frangi: Biché, 1350 m, 18.VIII.1926, *Peter, A. 44394* (B); Lake Kwela, drying lake-edge, 6000 m, 18.IV.1956, *Robinson, E. A. 1672* (NY); Capri point, Mwanza Town, Mwanza District, in water at lake edge, 3800 m, 10.X.1953, *Tanner, R. E. S. 165* (NY).

Uganda: Lake Victoria, Port Kivanga, Agnatu, VIII.1914, *Dümmer, R. 1020* (BM); Buka Bay, Lake Victoria, 20.VIII. 1952, *Ross, R. 1161* (BM).

Zambia: Shangombo, moist sandy soil at edge of swamp, 3400 m, 5.VIII.1952, *Codd, L. E. 7560* (BM); Matlapeneng, Thamalakane, bridge, 8 km. NE of Maun, *Wild, H. & R. B. Drummond 7177* (NY).

Zimbabwe: Cleveland Dam Park, app. 10 km W of Harare, 1500 m, 11.XII.1990, *Laegaard s.n.* (B).

3. ***Schoenoplectus decipiens*** (Nees) J. Raynal

Lesotho: Leribe, Basutoland; 5-6000 m, *Wieterlen, M. A. 6991* (NBG); Sehlabathebe Nat. Park, Maal Cof., standing water, 2350 m, 22.II.1978, *Hoener, F. K. 2035* (PRE).

Madagascar: Ankaratra, XII.1920, *Perrier de la Bathie 13393* (B).

Republic of South Africa: *Ecklon & Zeyher 12580* (NBG); **Cape Province:** Betsgoeanaland, Kanye dist., source of Ramongala, 16.XI.1948, *Robertson, H. 582* (PRE); Kaffraria, 3500 m, III.1885, *Baur, B. 448* (BOLUS); *Baur, R. 12740* (NBG); Riversdale dist., 100 m, X.1923, *Muir, Dr. J. s.n.* (PRE); 4 km from Aliwal North on Zastron road, *Arnold, T. H. s.n.* (PRE); 16 km SE of Cookhouse on Paryshoogte Rd. E Cape, 6.XII.2006, *Smook, L. 3981* (PRE). **KwaZulu-Natal:** Ladysmith, temporary pool a karoo, VII.1929, *N. R. L. 4198* (BOLUS); in humidis ad Zwartkops, *Zeyher 4386* (BOLUS). **Orange Free State:** Bloemfontein, Dewetodomp Road, XII.1915, *Potts G. 1096* (BOLUS); Free State, Soutpan, N side of main pan, disturbed grassland, 28°42'S 26°4'E, 1250 m., 26.X.1988, *Ward, C. J. 10485* (PRE); 19 km from Zastron on Wepener road, open grassveld, *Arnold, T. H. 1205* (PRE); Free State, Steynsrus, Kafferfontein Plaas, Dubbeldam, 10.XI.1993, *van Eeden, P. s.n.* (PRE). **Transvaal:** Bethal distr., 11 km East of Bethal on road to Ermelo, small dam, 19.III.1984, *Reid, C. 1984* (PRE); Heidelberg, 4980 m, 15.XI.1959, *Acocks, J. P. H. 20837* (PRE).

4. ***Schoenoplectus heptangularis*** Cabezas & Jiménez Mejías

Equatorial Guinea: Bioko Province: Fernando Po, Lagoa Biao, 14.IX.1959, *Wrigley, T. C. & F. A. Melville 483* (BM); Bioco, desembocadura del lago Biaó, 32NMJ5770, 1860 m, 22.II.1989, *Fernández Casas 11963* (B, BM, NY); Fernando Po, Moka: crater lake, 1130 m, 30.I.1933, *Exell, A. W. s.n.* (BM); Moca, lago de Biaó, dentro del lago, 3°21'06"N 8°37'42"E, 1825 m, 18.XII.2007, *Cabezas, Estrella & Fero 1114FJC* (MA [766844]).

Appendix 2. – List of studied materials from Guinea Gulf area not included in the analysis.

Schoenoplectus brachyceras (A. Rich.) Lye

Cameroun: 6 km NE of Bangem, Manengouba Mts., 2000 m, 29.III.1972, *Leeuwenberg, A. J. M. 9529* (K).

Nigeria: North East, Sardauna Province, Mambilla Plateau, 19.VII.1973, *Chapman, H. M. 24* (K); British Cameroons, N. Trusteeship Territory, Adamawa Division, Mambila District, Mambila Plateau, Ngel, Nyaki, 1650 m, 20.I.1958, *Hepper, F. N. 1717* (K); Bauchi, IV.1929, *H. V. L. 225* (K); Southern Cameroons, Bamenda Division, Jakiri, 1780 m, 13.II.1958, *Hepper, F. N. 1960* (K); Prov. Plateau, Roop rd. 17 miles from Jos, 23.VI.1968, *Hall, J. B. 630*; Vom, 27.XII.1963, *Haines, W. s.n.* (K); North Eastern, Mambilla Dist., Gembu, 10.V.1972, *Wital, P. FHI66725* (K).