A TAXONOMIC REVISION OF THE GENUS CYNOSURUS L. (POACEAE) IN IRAN

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In this research, the taxonomic status of the genus *Cynosurus* in Iran has been briefly reviewed. The results showed that two species *Cynosurus echinatus* L. and *C. effusus* Desf. are growing in Iran. A total of 13 herbarium and new collected specimens belonging to this genus were analyzed using 61 qualitative and quantitative morphological characters. A taxonomic key, descriptions and habitats of two species with images has been presented. Also, characteristics of the karyotype of *C. echinatus* is provided.

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Key words. Cynosurus, Poaceae, taxonomy, chromosome, karyotype, Iran.

بررسی آرایه‌شناسی جنس Cynosurus (Poaceae) در ایران

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در این تحقیق موقعیت جنس *Cynosurus* در ایران مورد بررسی قرارگرفته است. نتایج نشان می‌دهد که از این جنس دو گونه *C. echinatus* و *C. effuses* در ایران انتشار دارند. در مجموع تعداد ۱۳ نمونه هرباریومی و جمع‌آوری جدید با استفاده ازویژگیهای کمی و کیفی مورد تجزیه و تحلیل قرارگرفتند. کلید شناسایی و شرح گونه‌ها به همراه تصویر ارائه و وضعیت رویشگاه آنها توصیف می‌گردد. همچنین کاریوتیپ گونه *C. echinatus* نمایش داده می‌شود

INTRODUCTION

High morphological similarities among genera in the tribe *Poeae* (*Festuceae*) led to the taxonomic complexities in this tribe. This situation resulted in different taxonomic classifications of the tribe at the generic and species level (Catalan et al. 2004). The genus *Cynosurus* L. is a small member in this tribe with about 8-10 annual or perennial and herbaceous species (Tzevelev 1984), distributed in the North Africa, West Asia and Europe and introduced elsewhere. Three species *C. echinatus* L., *C. elegans* Desf. (Bor 1970, Parsa 1950) and *C. cristatus* L. (Mill 1985) have been reported from Iran. Information on the taxonomic status, geographic distribution and intraspecific variation of these species in Iran is meager. Global distribution of *C. elegans* is limited to the Algeria and Tunisia (Mill 1985) and presence of this species in Iran and neighboring countries is doubtful. *C. cristatus* has been reported from the North of Iran (Talysh) which presence of this species in Iran is not confirmed elsewhere. This study was aimed to clarify taxonomic status and intraspecific variations of the genus *Cynosurus* in Iran.

MATERIALS AND METHODS

A total of 13 populations (herbarium and new collected specimens) were analyzed in this study (Table 1. Fig. 1). Regarding limited geographic distribution of the *Cynosurus* species in Iran, samples were collected from all the reported localities from Iran. Samples were identified morphologically according to Mill 1985 and Bor 1970. Sixty one qualitative and quantitative morphological characters were measured with special focus on those taxonomically important characters in the tribe *Poeae* (Table 2). Data were analyzed using NTSYS pc ver. 2.2 (Rohlf 1997) and similarity values among populations were calculated using different similarity coefficients. The morphological data and calculated similarity matrices were then used for generating dendrogram showing relationships among populations and species (Fig 2).

Table 1. Population codes, locations and other details regarding the populations of *Cynosurus echinatus* and *Cynosurus effusus* used in this study.

Population code	Species	Location	Date	Collected by	Herbarium code
1	*C. echinatus*	NW: Ardabil, Fandoghloo Forest	2009/8/5	Rahiminejad & Rezaei	HUI17177
2	*C. echinatus*	NW: Asalem toward Khalkhal	2009/8/6	Rahiminejad & Rezaei	HUI17178
3	*C. echinatus*	NW:2th km Ardabil toward Astara, 1945 m	2009/8/6	Rahiminejad & Rezaei	HUI17179
4	*C. echinatus*	N: Golestan, Golestan National Park, between Tang-e-Rah and Tang-e-Gol (N: 37° 27.497 , E: 055° 53.457), 627 m	2010/7/6	Saeidi & Rezaei	HUI17176
5	*C. echinatus*	NW: Azarbaijan-e-Gharbi, 10th km Piranshahr toward Oshnavieh, 1650 m	2003/6/27	Assadi	TARI85153
6	*C. echinatus*	NW: Azarbaijan-e-Sharghi, Arasbaran Protected area, South of Kalale, 1400 m	1995/7/9	Assadi	TARI73907
7	*C. echinatus*	NW: Azarbaijan-e-Sharghi, Arasbaran Protected area, above Kalale Forest, 1000 m	1997/9/27	Hamzei & Assadi	TARI81805
8	*C. echinatus*	NW: Azarbaijan-e-Sharghi, 40th km Ardabil toward Astara, western slopes of Gardaneh Heyran	_	Mozafarian & Nowrozi	TARI34442
9	*C. echinatus*	NW: Azarbaijan-e-Sharghi, Between Astara and Ardabil, 1700 m	1988/6/19	Mozafarian & Nowrozi	TARI34482
10	*C. echinatus*	N: Golestan, Golestan National Park, Tang-e-gol, 700-1000 m	1974/6/21	Wendelbo & Foroughi	TARI12794
11	*C. echinatus*	N: Golestan National Park, Mazalleh Valley, 6thkm South of Tang-e-Rah, 600-700 m	1969/6/24	Bahrami	
12	*C. effusus*	SW: Kohkiloyeh & Boyrahmad, 42 km from Dogonbadan toward Noorabad, 800 m	1982/4/15	Assadi & Abohamzeh	TARI38516
13	*C. effusus*	W: Lorestan, Sefid Kouh, Tange Farahkash, 1800-1900 m	1975/5/6	Wendelbo & Assadi	TARI16672

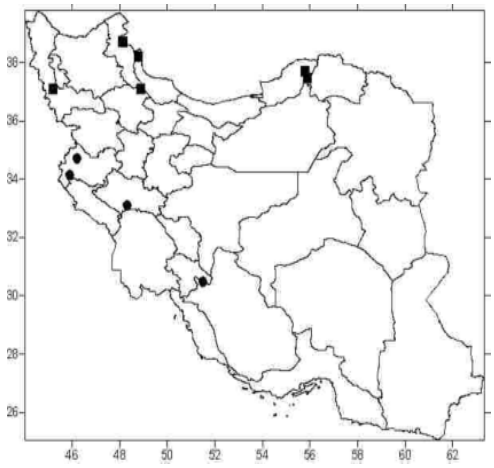

Fig 1. Distribution of *Cynosurus* species in Iran based on collection sites of herbarium specimens (● *C. effusus* and ■ *C. echinatus*).

Table 2. The evaluated qualitative and quantitative morphological characters and their character states observed in species studied.

Qualitative characters					
No	Character	Character states	No	Character	Character states
1	Panicle shape	Ellipsoid Rounded	19	Lemma margins	Ciliate Glabrous
2	Rachilla surface	Scabrous Hairy	20	Lemma surface	Hairy Glabrous
3	Position of fertile & sterile spikelets	- 2 Fertile spikelets placed between two sterile spikelets, - Fertile and sterile spikelets are placed alternatively	21	Palea surface	Hairy Glabrous
4	Peduncle	Erect Geniculate	22	Palea margins	Ciliate Glabrous
5	Panicle color	Green Light green	23	Palea abaxial side shape	Rounded Keeled
6	Whitish bands at Panicle nodes	Present Absent	24	Palea apex shape	Bidentated Entire
7	Swollen nodes in sterile spikelets	Present Absent	25	Leaf lamina shape:	Linear Lanceolate
8	Glume texture	Hyaline Chartaceous	26	Leaf abaxial side	Hairy Glabrous
9	Surface of upper glume	Hairy Glabrous	27	Leaf adaxial side	Hairy Glabrous
10	Surface of lower Glume	Hairy Glabrous	28	Leaf tip shape	Acute Obtuse
11	Apex of upper Glume	Acute Awned	29	Leaf margins	Ciliate Glabrous
12	Apex of lower glume	Acute Awned	30	Auricles arrangement	Opposite Alternate
13	Glume margins	Ciliate Glabrous	31	Leaf ligule shape	Oblong Acute
14	Lemma veins	Ciliate Glabrous	32	Ligule texture	Chartaceous Membranous
15	Lemma texture	Chartaceous Membranous	33	Anther shape	Elongated Flattened
16	Palea margins	Ciliate Glabrous	34	Caryopsis tip shape	Hairy Glabrous
17	Apex of lemma	Emarginated Entire	35	Culm nodes and internode hairiness	Hairy Glabrous
18	Apex of lemma	Emarginated Entire	36	Stem habit	Tufted Solitary

Quantitative characters			
No	Character	No	Character
37	Panicle length	50	Number of lemma veins
38	Panicle width	51	Lemma length /width ratio
39	Rachis length	52	Palea length /width ratio
40	Number of fertile spikelets per spike	53	Lemma awn length
41	Number of glumes per sterile spikelet	54	Awn length/ lemma length ratio
42	Fertile spikelet length including awn	55	Leaf width
43	Sterile spikelet length	56	Leaf length
44	Upper glume/lower glume length ratio in fertile spikelets	57	Ligule length
45	Number of fertile florets per spikelet	58	Stem length
46	Number of lower glume veins	59	Number of nodes
47	Number of upper glume veins	60	Caryopsis length
48	Lower glume/lemma length ratio	61	Anther length
49	lower glume/ lemma width ratio		

Table 3. Details regarding Karyotype of *Cynosurus echinatus*. Values are provided as average. The chromosomes were metacentric and sub-metacentric.

Chromosome number	TL (µ)	L (µ)	S (µ)	L/S (µ)
1	10.29	5.50	4.59	1.20
2	9.71	5.27	4.28	1.23
3	9.29	5.04	4.24	1.22
4	8.37	4.39	3.98	1.09
5	7.28	4.55	2.79	1.67
6	7.13	4.54	2.58	1.81
7	6.62	4.34	2.28	2.33

In addition, a preliminary study on the cytological characters of *C. echinatus* was also performed. Cytological study was not carried out for *C. effusus* due to the limited population sizes of this species (a few individuals at each locality). In order to evaluate cytological features of *C. echinatus*, 4 populations were analyzed. Seeds were germinated in Petri dishes and chromosome slides were prepared from root meristems according to Aghayev 1996 method. Briefly, the 1.5-2 cm roots were placed in 1% α-bromonaftalin for 4-6 h. Then the roots were transferred in fixative of Levitsky (Sharma and Sharma 1999) in fridge. Roots were washed under running water for 3 h and transferred in 70% ethanol. Roots were placed for 10 min. in NAOH at 60°c, stained by Hematoxylin for 24h in 30°c and squashed on microscopic slides after 10 min. in Cellulase-Pectinase enzyme solution and visualized under light microscope.

Chromosome were categorized according to Levan et al. (1965). Several parameters regarding the Karyotypes symmetry/asymmetry such as total form percent [$TF\% = \frac{\Sigma \text{ (Total lengths of short arms of chromosomes)}}{\Sigma \text{(Total chromosome Length)}}$], Stebbines Cofficient [Stebbins 1971; S%= (shortest chromosome length)/(longest chromosome length)].

(Table 1).

RESULTS AND DISCUSSION

Based on our results, two species of the genus *Cynosurus* (*C. echinatus* and *C. effuses*) are growing in Iran. The two species were clearly separated in dendrogram based on morphological characters (Fig 2). The intraspecific variations cannot be divided in subspecies or varieties. *C. effusus* was misidentified as *C. elegans* by Bor (1970) and Parsa (1950). These two species are morphologically similar but *C. effusus* has exclusive conspicuous whitish bands on the panicle axis. The populations of *C. echinatus* are mainly distributed in the North of Iran (Table 1 and Fig. 1) with considerable population sizes. The limited populations of *C. effusus* grow along Zagros Mountains (Table 1 and Fig 1). Cytological analysis of the *C. echinatus* showed that all populations are diploid with 2n = 2x = 14 (Table 3 and Fig. 3). No considerable cytological variations were found. The karyotype symmetric factors (TF= 42%, S= 64%) showed a relatively symmetric karyotype for this species.

Morphological characters

Morphological analyses showed that panicle shape, branching and color, rachis characteristics, arrangement of fertile and sterile spikelets, peduncle status, panicle branching and glume tip shape are taxonomically valuable for recognizing species. These characters had low variation within species.

Taxonomy

Based on the results of this study, the following taxonomic key, description and conclusions concerning the taxonomic status of the species belonging to the genus *Cynosurus* in Iran can be made.

1- Panicle condensed, without whitish bands, peduncle erect, ligule 4-14 mm long, fertile spikelet 8.2 – 16 mm, abaxial surface of lower lemma pilose toward the apex, 2 fertile spikelets placed between 2 sterile spikelets in one spikelet ***C. echinatus***

- Panicle not condensed, with a conspicuous whitish band at each joint, peduncle ± geniculate, ligule 2-3 mm long, fertile spikelet 9-14 mm long, abaxial surface of lower lemma all over pilose, fertile and sterile spikelets are placed alternatively ***C. effusus***

Cynosurus echinatus L. (Fig. 4)

Annual plant, solitary or fasciculately branched at base. Stems 18-70 cm, smooth, glabrous. Leaf blade smooth, uppermost scabrous, lower surface glabrous, 6-30 cm × 0.1-5 mm. Panicle dense, globose or ellipsoid, unilateral, 1.2-4 cm × 1-3 cm., rachis erect. Rachilla glabrous. Glumes linear lanceolate. Lemma scabrid towards the apex, awned, awn as long as lemma or 2 times longer. Palea green. Two fertile spikelets placed between 2 sterile ones with one fertile spikelets placed separately, sterile spikelets 9-20, glumes awned, upper ones broader than lower. Sterile spikelets have joints somewhat swollen. Fertile spikelet with 2-3 florets. Lodicules 2, apex bidente or 2 lobed. Stamens 3. Ovary glabrous, stigmas 2, caryopsis 1.5- 4 mm. hillum ellipsoid or broad linear, caryopsis apex acuminate.

Distribution & ecology: Europe, Transcaucasia, Asia Minor, Iran (North, Table 1 and Fig 1). The populations

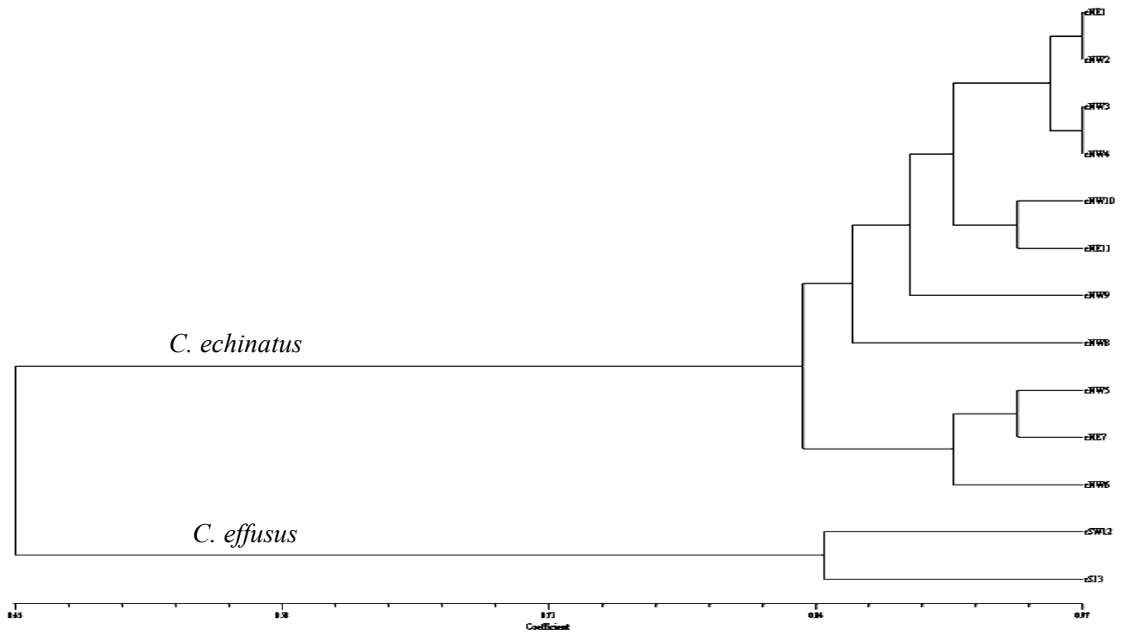

Fig. 2. A morphological similarity based UPGMA dendrogram showing relationships among 13 populations of *C. echinatus* and *C. effusus* in Iran. The OTUs names are provided with geographic origin (NE = Northeast, NW = Northwest, SW = Southwest and S = South) and populations number

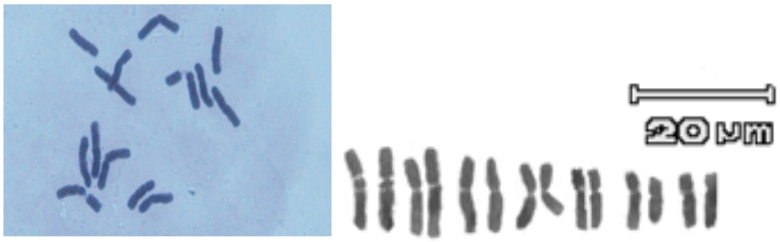

Fig. 3. Karyotype of *Cynosurus echinatus*.

of this species can be found on dry to wet soils, in grasslands, woodlands and road sides.

Cynosurus effusus Link (Fig. 5).
Syn.: *C. elegans* sensu auct. Fl. Iran non Desf.
Annual. Stems erect or geniculate, smooth and glabrous, solitary or fasciculated. Leaf blades flat, linear, acute, 8 cm × 2-3 mm, blade dorsal scabrous, margin scabrous. Panicle unilateral, ovoid to subglobose, laxer than in *C. echinatus*, with a conspicuous whitish band at each joint, 1-1.3 × 1.2 – 1.5 cm, shortly branched, rachilla scabrous. Two fertile and 2 sterile spikelets are placed alternatively. Sterile spikelet with 9 short owned glumes, upper ones broader than lower, fertile spikelets with 2 -3 florets, with long awn. Lemma scabrid-ciliate, 2 -3 mm, awn 10 – 11.5 mm, green to pale-green. Lodicules 2, bidentate or 2 lobed. Stamens 3. Ovary glabrous. Stigmas 2. Caryopsis 1.5 – 4 mm, apex ciliate, hillum elliptic or linear.

This species was misidentified as *C. elegans* in Flora Iranica (Bor 1970) and Flore de L' Iran (Parsa 1950).
Distribution & ecology: Atlantic islands, Portugal, Mediterranean region, Turkey, Iraq, Iran (along Zagros Mountains in the West and Southwest, Table 1 and Fig 1).

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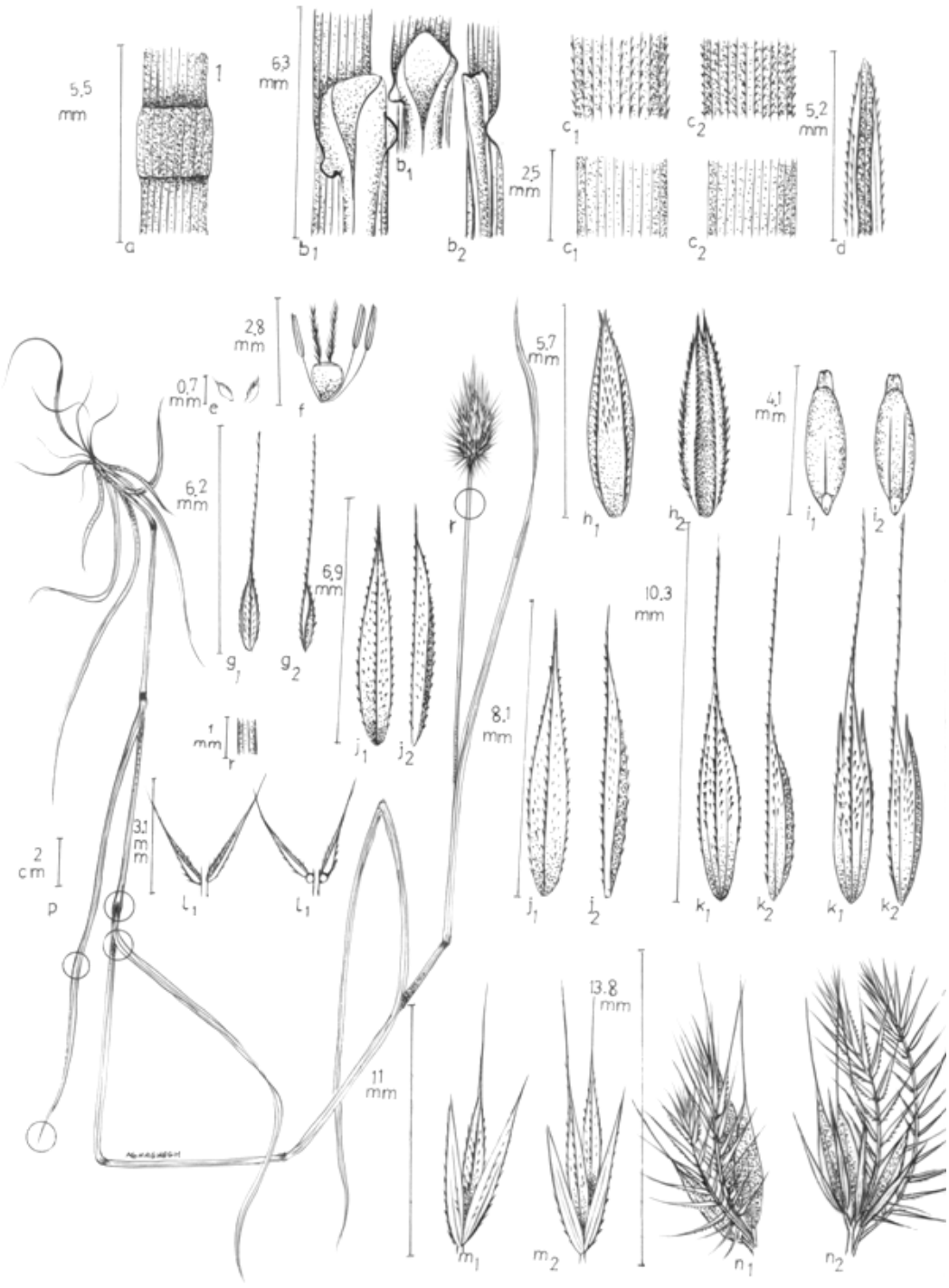

Fig. 4. *Cynosurus echinatus*. **p:** plant habit, **a:** node, **b_1, b_2:** adaxial and lateral surface of ligule and auricle, **c_1, c_2:** adaxial and abaxial leaf surface, **d:** leaf apex, **e:** lodicules, **f:** anthers and pistil, **g_1 ,g_2:** adaxial and lateral surface of glume of sterile spikelet, **h_1, h_2:** adaxial and abaxial surface of palea, **i_1, i_2:** adaxial and abaxial surface of caryopsis, **j_1, j_2:** adaxial and lateral surface of glume, **k_1, k_2:** adaxial and lateral surface of lemma, **l_1, l_2:** Joints somewhat swollen in sterile spikelets, **m_1,m_2:** number of florets in fertile spikelet, **n_1, n_2:** fertile and sterile spikelets, **r:** peduncle.

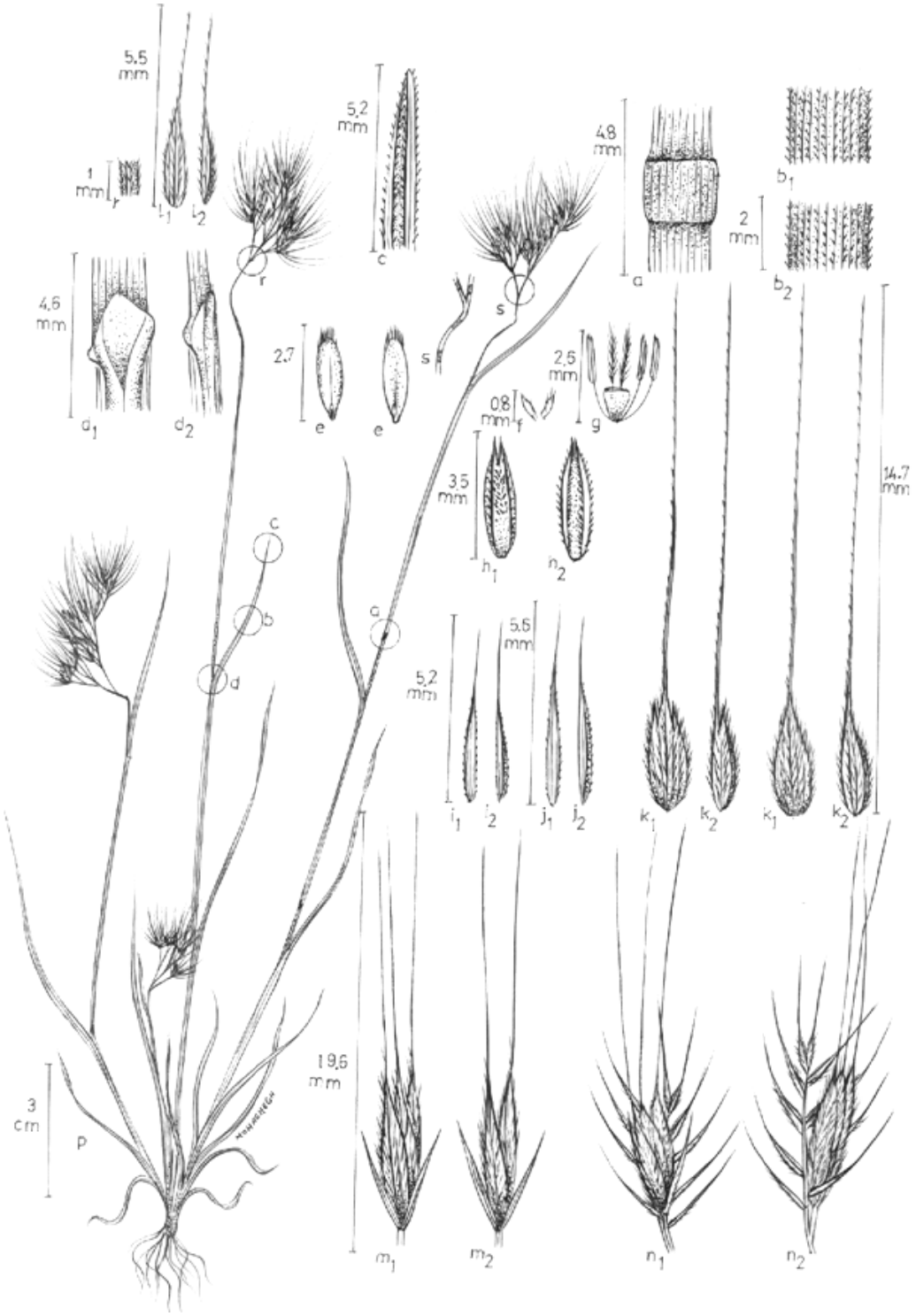

Fig. 5. *Cynosurus effusus* Link. **p:** plant habit, **a:** node, **b_1, b_2:** adaxial and abaxial leaf surface, **c:** leaf apex, **d_1, d_2:** adaxial and abaxial surface of ligule and auricle, **e_1, e_2:** adaxial and abaxial surface of caryopsis, **f:** lodicules, **g:** anthers and pistile, **h_1, h_2:** adaxial and abaxial surface of palea, **i_1, i_2:** adaxial and lateral surface of upper glume, **j_1, j_2:** adaxial and lateral surface of lower glume, **k_1, k_2:** adaxial and lateral surface of lemma, **m_1,m_2:** florets in fertile spikelet, **n_1, n_2:** fertile and sterile spikelet, **r:** hairs of rachilla, **s:** whitish bands of rachilla.

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