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TAXONOMIC REVISION OF THE GENUS *ERAGROSTIS* WOLF SPIKELETS AND SEEDS WILDLY GROWN IN IRAQ

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SUMMARY

The revision of taxonomic information of genus *Eragrostis* Wolf in Iraq was this work's aim, based on the literature and herbarium collections, such as BAG, BUE, BUH, BUNH, MOS, and SUH, as well as, field survey. Sixteen species enumerated had their spikelets and seed phenological characteristics, such as length, width, color, and shape, examined to isolate species. A taxonomic revision of the genus *Eragrostis* with an artificial key to species with phenology, national, and distribution data for all taxa, specimens examined, and photographs were available for easy identification. The results showed the species *E. mossullensis* has the longest spikelet uniqueness, *E. cilianensis* with a large width, and isolated species *E. tremula* identified with yellowish-brown to pink spikelets. The species *E. mossullensis* was superior with 38 seeds. The species *E. ciliate* was distinct with hairs. Notably, the present results, species *E. aspera* (Jacq.) Nees*, E. atrovirens* (Desf.) Trin. Ex Steud*, E. basedowii* Jedwabne*, E. ciliate* (Roxb.) Nees*, E. poaeoides* P.Beauv., Ess.Agrost.*, E. tenuifolia* (A. Rich.) Hochst.ex Steud.*, E. tremula* Hochst.ex Steud.*, and E. unioloides* (Retz.) Nees ex Steud., were not endemic. However, it is the first time for these reports to exist in Iraq.

Keywords: *Eragrostis*, Iraq monocot, seed Poaceae, spikelet, taxonomy

Key findings: Taxonomic revision of the genus *Eragrostis*' spikelets and seeds occurred, wildly grown in Iraq. Based on the morphological and taxonomic traits, 16 different species attained enumeration with varied morphological characters.

INTRODUCTION

The genus *Eragrostis* Wolf belongs to the family Poaceae (Chloridoideae), comprises approximately 423 species, the largest genus in subfamily Chloridoideae, a group with about 1,500 species (Van den Borre and Watson, 1994). Its distribution also spreads in tropical

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and subtropical areas worldwide (Clayton and Renvoize, 1986; Ingram and Doyle, 2007; Giraldo-Canas *et al*., 2012; Powo, 2022). Taxa of *Eragrostis*, as a rule, are characteristically with paniculate inflorescence, multi-floreted spikelets, glabrous three-nerved lemmas, ciliate ligules, and C4 photosynthesis. The genus varied morphologically and anatomically, however, enunciated a wide range of diversity in multicharacter.

For instance, the panicles range from very loose and open to highly contracted and close structures. The majority of the species are of less economic importance; however, one species (*E. cilianensis*) is a cultivated major cereal crop in Ethiopia. This species also has an important forage grass, as many other species. With its large size and wide geographic distribution, no comprehensive taxonomic treatment of *Eragrostis* existed, with some debating in the recent literature whether the genus is monophyletic (Hilu and Alice 2001**)**.

The first description of *Eragrostis* came from Wolf (1776) in the material of *E. minor*. Since the original description, a few agreements emerged as to which species actually belong in the genus and how they relate to each other. The various modes of spikelet disarticulation visible in the genus have been the most common source of characters for delimiting infrageneric groups (Ingram and Doyle, 2007). Practically, this means herbarium material may be impossible to score if its collection precise at the correct stage.

These intermediacies also cloud the distinction of the character states. Numerous botanists relied heavily on spikelets' characters, and even more recent classifications have included some other morphological features, including the spikelet shape (Lazarides, 1997), pubescence on the palea keels, panicle branching, lemma keel, margin shape and curvature, and floret fertility. Spikelet disarticulation traits led the author to conclude that division based on these numerous exceptions, most characters appeared as diagnostic of the subgenera. However, Taxa of the hybrid origin can reveal the unique combinations of morphological and anatomical character states and spikelet disarticulation types linking with three-nerved lemmas and fringed ligules qualities (Watson and Dallwitz, 1992).

Grass taxonomists have struggled with the classification of *Eragrostis* for many years, and out of 423 species, 55 species were endemic to Australia (Lazarides, 1997), followed by India. The genus *Eragrostis* has 48 taxa representations belonging to 43 species and five cultivars, widely distributed from sea level to 2800 m elevations, with about five species and four cultivars were endemic (Vivek *et al*., 2021; Jalander and Swamy, 2023). Mexico has 36 species (Espejo-Sernaetal, 2000) but in flora of Iran, the 17 species revealed endemic (Rechinger, 1970), while in flora of Lebanon and Syria, four species were endemic (Post, 1933).

The Orientalis flora mentioned 11 species (Boissier, 1963), while in the flora of Turkey, there are five species (Davis *et al*., 1988). In the Iraqi flora, it reported eight endemic species, i.e., *E. barrelieri* Daveau., *E. boriana* Launert*., E. cilianensis* (All) Vign. Ex Janchen*, E. collina* Trin*, E. diarrhena* (Schult and Schult.) Steud*., E. diplachnoides* Steud*., E. pilosa* (L.) P.Beauv., and *E. poaeoides* P. Beauv (Townsend *et al*., 1968). However, in 2012, a report stated the addition of a new species of iso-type *E. japonica* named *E. mossullensis* Steud (Plants.jstor, 2012).

The Iraq flora is still under research, and therefore, it barely exists. Field surveys are still underway to collect the different accessions for further identification because of the lack of local taxonomists and complete material. The latest study's focus does not deal on devising a new exterior classification. Rather, it aimed to answer the basic questions about how to place its segregate species assigned to this genus and display several unique characteristics, including a membranous ligule and a distinctive panicle form. On a gross morphological scale, these differences showed significance for some agrostologists to suggest these species require grouping in their own genus. However, the morphological data suggested this genus, in fact, belonged within *Eragrostis*.

MATERIALS AND METHODS

Plants' collection

In clarifying the monocot plants, particularly *Eragrostis*, field surveys proceeded in the Iraq Provinces of Diyala, Dohuk, Erbil, and Sulaymaniyah from April 2019 to November 2023, with five field trips yearly to every province. The said research was under the management of the University of Diyala, Baqubah, Iraq. Based on the flora of India, Iran, Iraq, Syria, Orientalis, and Turkey, with checklist of National Herbarium of Iraq (BAG), College of Education, University of Baghdad herbarium (BUE), Baghdad University Herbarium, College of Science (BUH), National History Research Center and Museum(BUNH), Musel university herbarium (MOS), and Sulamania university herbarium (SUH), careful investigations continued. Every specimen from the field survey bore careful study by dissecting the spikelets' parts of the duplicate specimens under dissection and compound microscopes. Detailed study of the dried specimens ensued, with their identification carried out in the Botanical Survey of Iraq.

Taxonomic treatments of genus *Eragrostis*

Identifying and investigated species based on taxonomic treatments of the genus *Eragrostis* in Iraq progressed by using the keys for isolation of the different species based on phenology, habitat, local, national, and global distribution, and to formulate the identification.

RESULTS AND DISCUSSION

The presented research showed the presence of eight new species not previously mentioned in the checklist of the Iraqi flora. However, some of them existed in the flora of other countries surrounding Iraq. The results showed the species *E. mossullensis* has the longest spikelets (13 mm), while the species *E. atrovirens* was shorter (3 mm), *with* uniqueness in *E. cilianensis* for a large width (1.8 mm) (Table 1). However, the species *E. poaeoides* and *E. tenuifolia* have the lowest spikelet width (0.5 mm). Although, these were contrasting with the findings of Chaisongkram *et al*. (2013), who mentioned *E. tenuifolia* has wide spikelets (1-1.5 mm), which may be due to environmental factors.

Spikelets color varied, from yellowish-brown to red (Table 1). In the species *E. barrelieri, E. ciliate,* and *E. mossullensis,* their spikelets' color was beige to green. In species *E. boriana* and *E. cilianensis Partner,* the observed color was beige to white. The species *E. collina* appeared with a beige to yellow, while *E. diarrhena* showed green spikelets. The beige to purple spikelets were visible in the species *E. pilosa and E. unioloides*. These results greatly analogous to the fact that *E. unioloides* is a member of *E. pilosa* complex (Wróbel *et al*., 2017). The microscope photo revealed the beige to brown color for spikelets in the species *E. poaeoides,* while the species *E. tenuifolia* exhibited with yellow to green spikelets. The isolated species *E. tremula* manifested with yellowish-brown to pink spikelets.

Dense spikelets were prominent in the species *E. aspera, E. barrelieri, E. cilianensis, E. diplachnoides, E. mossullensis, E. pilosa,* and *E. tremula* (Table 1). The spikelets attained loose shape in the species *E. ciliate, E. collina, E. poaeoides,* and *E. tenuifolia.* Conjunction was semi-loose in the species *E. atrovirens*, *E. basedowii, E. boriana*, and *E. unioloides*. The species *E. diarrhena* estrange from the rest of the species by having semi-dense spikelets. Spikelets may disarticulate from the top or the bottom, or as a unit. The latest results also agreed with past findings that the density of spikelets due to genetic characters and the genus *Eragrostis* showed many modes of spikelet disarticulation (Amarasinghe and Watson, 1990).

Additionally, whether the paleas remained on the rachilla or fall with the lemmas can be an important character, as can the persistence of the rachilla (Table 2). These characters revealed considerable variations in the genus *Eragrostis* and occurred in several different combinations (Table 2). Unfortunately, these qualities were generally irrelevant, as one might hope. There may be

Table 1. Spikelets and seeds characteristics of *Eragrostis* species in Iraq.

No.	Name of species	Spikelets*						Seeds*		
		Length (mm)	Widith (mm)	Color	Shape	Seeds/ Spikelet	Note	Length (mm)	Color	Shape
1.	*E. aspera*	8-11 (10)	0.8-1.2(1.0)	Beige to red	Dense	15-18(17)		0.5-1.1(0.8)	brown	
2.	*E. atrovirens*	2-5 (3)	0.9-1.3(1.0)	Beige	Semi loose	8-10(8)		0.5-1.0(0.7)	brown	elongated
3.	*E. barrelieri*	6-10 (8)	1.0-1.6(1.3)	beige to green	Dense	10-14(12)		0.6-1.1(0.8)	brown	elongated
4.	*E. basedowii*	4-6(5)	1.1-1.5(1.1)	Beige	Semi loose	8-12(10)		0.3-0.8(0.5)	brown	elongated
5.	*E. boriana*	3-(4)	1.7-1.2(1.0)	Beige to white	Semi loose	7-11(9)		0.8-1.3(1.0)	Light brown	elongated
6.	*E. cilianensis*	9-12(10)	1.3-2.1(1.8)	Beige to white	Dense	15-25(18)		0.5-1.2(0.7)	Red brown	globose
7.	*E. ciliate*	3-5(4)	1.0-1.4(1.2)	beige to green	Loose	8-12(9)	Hiars	0.8-1.4(1.2)	brown	elongated
8.	*E. collina*	3-6(4)	1.5-2.3(1.2)	beige to Yellow	Loose	6-11(8)		0.7-1.4(1.0)	brown	elongated
9.	*E. diarrhena*	3-6(5)	1.0-1.3(1.1)	Green	Semi dense	10-16(13)		0.4-1.3(1.0)	Green brown	elongated
10.	*E. diplachnoides*	7-11(9)	0.9-1.1(1.0)	Beige	Dense	14-20(17)		0.7-1.3(1.0)	Dark brown	elongated
11.	*E. mossullensis*	9-16(13)	0.9-1.2(1.0)	beige to green	Dense	20-47(38)		0.5-1.0(0.7)	brown	elongated
12.	*E. pilosa*	6-10(8)	1.0-1.2(1.0)	Beige to purple	Dense	9-14(11)		0.6-1.1(0.8)	brown	globose
13.	*E. poaeoides*	4-7(5)	0.5-0.7(0.5)	Beige to brown	Loose	6-9(7)	branched	0.7-1.3(1.0)	brown	ovoid
14.	*E. tenuifolia*	3-5(4)	0.5-1.2(1.0)	Yellow to green	Loose	7-14(10)		0.5-1.2(0.7)	brown	elongated
15.	*E. tremula*	4-7(5)	0.3-0.8(0.5)	Beige to pink	Dense	15-28(23)		0.6-1.4(1.0)	Blond	ovoid
16.	*E. unioloides*	3-6(5)	0.5-0.7(0.6)	Beige to purple	Semi loose	10-20(14)		0.6-1.1(0.8)	Light brown	elongated

* Rate of 25 replicate

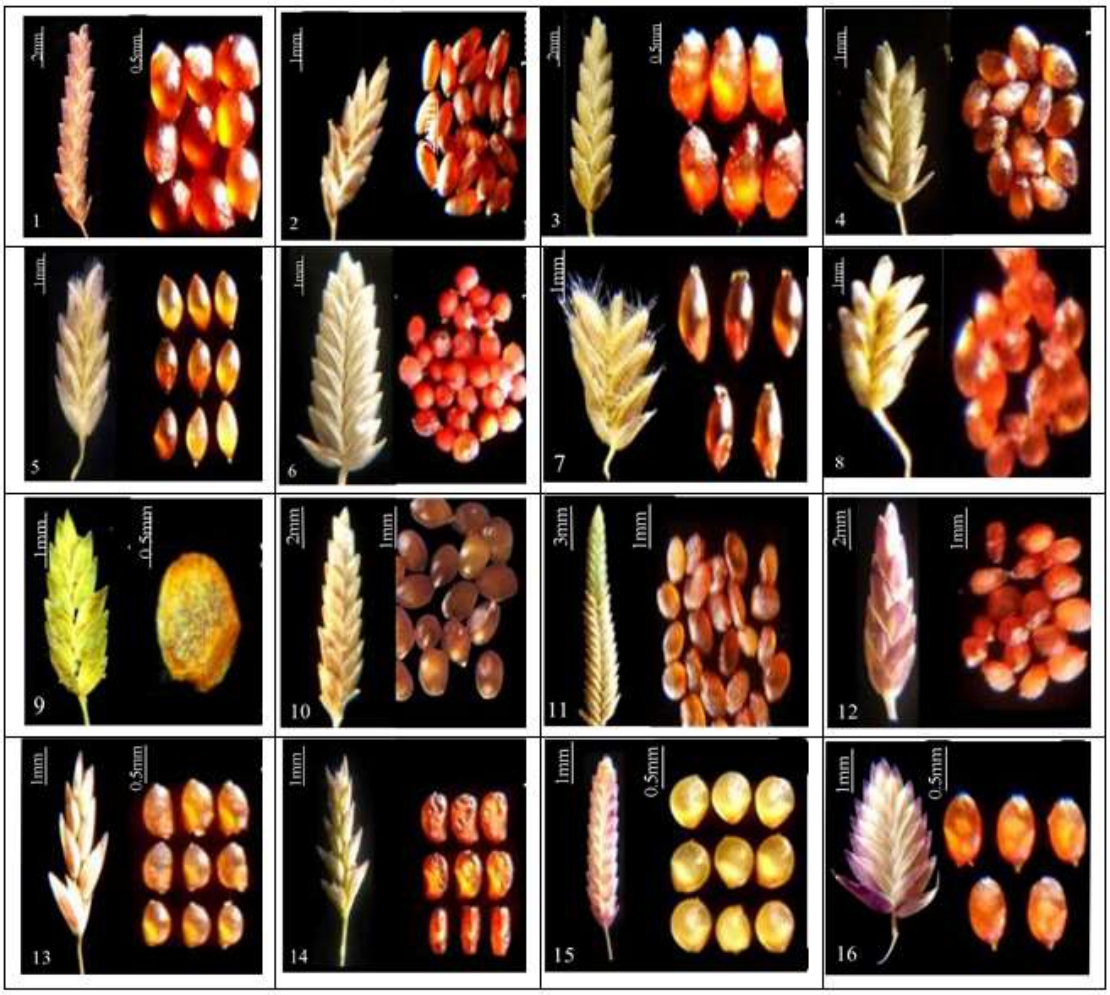

Figure 1. The spikelets and seeds characteristics of genus *Eragrostis* species in Iraq.

temporal variations that were not always obvious at the particular stages in the plant life cycle (Ingram and Doyle, 2007).

For number of seeds in the spikelet, the species *E. mossullensis* was superior with 38 seeds, while the species *E. poaeoides* contain the least seeds (7 seeds). The rest of the species fall between these two limits, and this may be due to genetic factors related to the number of seeds in those species. The species *E. ciliate* was distinct with hairs (Figure 1, Table 1). This outcome contradicts with Wróbel *et al*. (2017), whose findings showed more intermediate microhairs in *E. virescens* epidermis. However, the species *E. poaeoides* was illustrative with the long rachilla, which makes the spikelet appeared as branched (Table 2). These observations seem significant in relation to infra-generic classification (Amarasinghe and Watson, 1990; Alanbari and Zaidi,2024). The seed length ranged between 0.5 mm (*E. basedowii*) to 1.2 mm (*E. ciliate*).

The predominant color of the seeds was brown; however, the four species showed differences (Table 1). The species *E. boriana* and *E. unioloides* were with light-brown seeds. The *E. cilianensis* showed red to brown seeds, while *E. diarrhena* appeared with green-brown seeds. Dark brown appeared in *E. diplachnoides*, and deviated *E. tremula* gave blond seed color. Generally, the seed shape was elongated, except for four species—Globose in the species *E. cilianensis* and *E. pilosa*, and ovoid in the *E. poaeoides and E.*

Table 2. Key for the taxonomic treatments of the genus *Eragrostis* in Iraq.

1	Florets loss from above downward	2
	Florets loss from below upward	9
2	Lemmas ciliate on the margins	3
	Lemmas not ciliate margins	4
3	Lemmas acuminate or mucronate; stamens 2	*E. ciliate*
	Lemmas acute to obtuse : stamens 3	*E. boriana*
4	Palea keels more or less ciliate	5
	Palea keels smooth or scabrid or not ciliate	7
5	Panicle compact or spiciform	
6	Panicles thyrsiform; lemmas truncate at apex; palea rounded at apex	*E. aspera*
	Panicles linear; lemmas acute to acuminate at apex palea lobed to 3 at apex	*E. collina*
7	Plants prominently glandular at least on culms/leaves/peduncle/panicle branches/pedicels/nerves of glumes and lemmas	8
	Plants eglandular	16
8	Primary panicle branches capillary, filiform spikelets less than 1 mm wide	*E. pilosa*
	Primary panicle branches more or less stiff; spikelets more than 1 mm wide	9
9	Leaf margins glandular (at times absent in *E. maderaspatana*)	10
	Leaf margins eglandular	12
10	Caryopses elliptic-globose to orbicular	11
11	Spikelets oblong, 1.3-2.5 mm wide; lemmas 1.5-2 mm long	*E. poaeoides*
	Spikelets broadly oblong to ovate-lanceolate, 2-4 mm wide; lemmas 2-mm long	*E. cilianensis*
12	Perennials, glumes nerved/nerveless or nerves obscure	.13
	Annuals or short-lived perennials, glumes distinctly one nerved	14
13	Spikelets serrate in appearance, ellipsoid to oblongoid	*E. tenuifolia*
	Palea persistent on rachilla nodes	19
14	Annuals or short-lived perennials; spikelets 1-1.25 mm wide, lemma 1.8-2 mm; caryopsis laterally compressed	E*. barrelieri*
	Annuals; spikelets 1.3-1.8 mm wide; lemma 1.2-1.8 mm***;*** caryopsis ventrally compressed	16
15	Lemmas 1.2-1.5 mm long; caryopsis ellipsoid or narrowly oblong or ovoid to sub-globose, sometimes ventrally flattened, not grooved	*E. mossullensis*
16	Palea not persistent on rachilla nodes	17
17	Rachilla slender and clearly visible between florets; spikelets less than 1.5 mm wide; Rachilla not visible between florets; lemmas more than 1 mm long	18
	Rachilla slender and clearly visible between florets; spikelets less than 1.5 mm wide; lemmas less than 1 mm long	*E. basedowii*
	Rachilla more or less stiff and not visible between florets; spikelets more than1.5 mm wide; lemmas more than 1 mm long	20
18	Paleas narrowly winged; stamens 2; anthers less than 0.5 mm long	*E. unioloides*
	Paleas not winged; stamens 3; anthers more than 0.5 mm long	*E. atrovirens*
19	Spikelets in fascicles	20
	Spikelets not in fascicles	21
20	Panicles more or less contracted; lemmas 1.2-1.5 mm long, purplish towards the apex	*E. diplachnoides*
21	Spikelets 10-30 mm long, 10 -72 flowered	*E. tremula*
	Spikelets 3-6 mm long, up to 14-flowered	22
22	Lowermost branches whorled; long white hairs usually in the axils of the Panicle branches spikelets less than 1 mm wide	*E. pilosa*
	Lowermost branches sub-whorled; no long white hairs in the axils of the panicle branches***;***spikelets more than 1 mm wide	*E. diarrhena*

unioloides. Variations in phenotyping traits indicated association with the chemical (Aldrwesh and Alanbari, 2021) and genetic factors controlling different variables (Wendel, 2000; Al-Mathidy *et al*., 2023).

The Poaceae is one of the more difficult families, and it is impossible to make a general statement about any part of the plant, to which numerous exceptions could be uncitable (Sarajlić, 2020). Although, its composition is 10% of the plant families (Ali-Shtayeh *et al*., 2022). The presented investigations enunciated the presence of eight species not previously mentioned in the checklist of Iraqi plants, and for that, we have used a key for different species (Table 2). However, some species were prevalent in the flora of neighboring countries surrounding Iraq. Perhaps the proximity, convergence, environmental factors, and various other factors(Alnabari *et al*.,2023) including population size, human activities, and conversion of traditional to intensive agriculture, led to the transfer of these plants from their environment to Iraq (Sarajlić, 2020; Taib *et al*., 2023).

CONCLUSIONS

Examining the genus *Eragrostis* species widespread in Iraq through spikelets and seeds, and through the presented research, led to discover eight new species, which attained inclusion to the Iraqi flora.

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