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Original Article

A MORPHOLOGICAL STUDY OF SOME SPECIES OF THE GENUS *Medicago* L. (Fabaceae) IN KURDISTAN /IRAQ.

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ABSTRACT

This study provides a thorough morphological analysis of Medicago L. species in Iraq's Kurdistan Region, with the aim of discriminating taxa using a range of vegetative and reproductive traits. Variations in petiole size, leaflet morphology, floral attributes, and pod characteristics were highlighted in morphological examinations of the collected specimens. All the characteristics that were looked at showed distinct interspecific differences. *Medicago polymorpha's* petiole length ranged from 3.8–5.3 mm, while *M. rigidula's* ranged from 19–39 mm. with length-to-width ratios of 1.22 for *M. radiata* and 1.80 for *M. noeana*, there were notable variation in leaflet proportions, indicating significant shape variation. Peduncle length, in example, differed significantly between *M. radiata* and *M. noeana*, measuring 3–8 mm and 10–30 mm, respectively. As pod sizes ranged from 2.5–5.5 mm in M. minima to 13–18 mm in M. radiata, pod shape proved highly diagnostic. Additionally, species identification was made easier by variations in coil number (5–7 coils in *M. minima*). The identification of *M. rigidula* subsp. *sinskiae* as a new distributional record for the Kurdistan Region of Iraq is a significant result of our research. Note that the taxon formerly known as *M. sinskiae* now has a recognized scientific designation, *M. rigidula* subsp. *sinskiae.* All things considered, the observed morphological variety highlights the genus *Medicago's* ecological difference and offers crucial baseline information for further taxonomic, ecological, and conservation research.

KEYWORDS: *Fabaceae, Medicago L., morphology, Medicago rigidula subsp. Sinskiae*

1. INTRODUCTIONS

The Fabaceae (legume family) is the third-largest family of Angiosperms, with 751 genera and 19,400 species worldwide (LPWG, 2017). This very diverse family is of immense economic worth, and plants from this family are responsible for a range of crops from cuisine staples to money-spinning fodder crops, contributing about a third of the world's human protein intake (Jones *et al*., 2007). One of the features of legumes is that they can improve soil fertility via the symbiotic fixation of atmospheric nitrogen by Rhizobium bacteria, which plays a vital part in the global nitrogen cycle (Mandal *et al.,* 2008). Among the six legume subfamilies, Papilionoideae is the largest in terms of species number and has been best studied, with 476 genera and 13,860 species (Wojciechowski *et al*., 2004; Araújo *et al*., 2015). This subfamily includes the large genus *Medicago* L., a major component of Mediterranean warm-temperate grassland and shrubland ecosystems, which consists of 14 sections and 87 species worldwide, including annual and perennial forms (Prosperi *et al*., 2001; Steele *et al*., 2010). Morphologically, *Medicago* excels in pods and compound stipules (Rahman & Parvin, 2014). The growth habit of *Medicago* is highly diverse, ranging from procumbent to erect, and is strongly influenced by local growing conditions (Small, 2011a).

This might be related to the soil variation, which ranges from neutral to alkaline, as well as salt content (Piano & Francis, 1992; Bounjemate *et al.,* 1992; Skinner *et al.,* 1999; De Varennes *et al*., 2001). Furthermore, climate factors, including altitude and annual precipitation, vary considerably from the mountains to the plains. (Ehrman & Cocks, 1990; Piano *et al*., 1991). In Iraq, most of the annual species can be found in open, dry, and disturbed habitats. This is because many low-lying or disturbed sites of perennials often occur in moist, closed communities, which are often found in more elevated and stable ecological habitats (Townsend & Guest, 1974; Al-dabbagh, & Fathulla, 2022). The genus is native to the Fertile Crescent, including Iraq and specifically the Kurdistan Region (Maxted & Bennett, 2001). It is estimated to comprise around 16-17 species in the broader Iraqi flora (Townsend & Guest, 1974), contributing significantly to the region's plant biodiversity. The primary objective of this study is to identify and classify species using the morphological characteristics of selected *Medicago* L. taxa.

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2. MATERIALS AND METHODS

Plant Material Collection and Preparation:

Extensive field surveys were conducted across the different physiographic zones of the Kurdistan Region of Iraq to collect *Medicago* taxa (Figure 1). Sampling was conducted in selected districts, namely Zakho, Dohuk, Erbil, and Sulaymaniyah, which represent a variety of habitats, including steppe landscapes and mountain areas. For each specimen, precise collection data were documented, including GPS coordinates, elevation values (summarized in Table 1), and habitat descriptions. Collected plant specimens were carefully pressed and dried following standard herbarium techniques, after which they were deposited in the local herbarium. Taxonomic identification of the collected *Medicago* specimens was achieved through critical examination of authoritative taxonomic references. Floristic works from neighboring regions, including Iraq, Iran, Turkey, Syria, and Palestine, were consulted to ensure reliable and accurate species identification

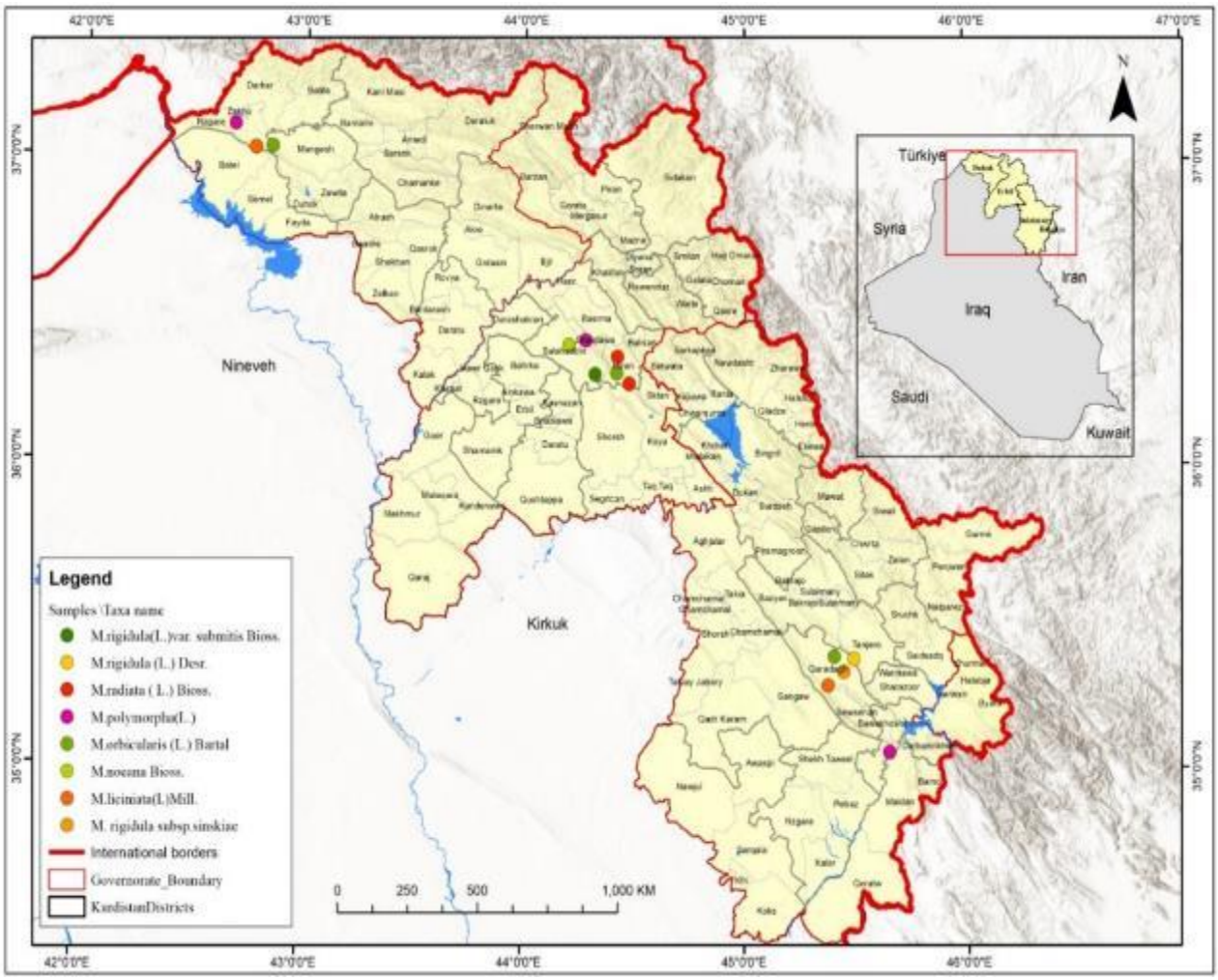

Figure 1: The geographical distribution of the *Medicago* species investigated across the Kurdistan Region of Iraq.

Morphological Characterization:

For morphological analysis, a representative subset of well-preserved *Medicago* specimens was selected. Measurements of various plant parts were taken using a ruler, where appropriate. The following key morphological characters were quantitatively assessed:

1. Leaflet dimensions: The Length and width of the central leaflet from mature leaves were measured.
2. Stipule length: Measured from the point of attachment to the apex.
3. Inflorescence type: Described (e.g., raceme, head).
4. Flower dimensions: Calyx length, corolla length (standard, wing, and keel petals), and pedicel length were measured.
5. Pod morphology:

A. Pod length and width: Measured for mature pods.

B. Pod coiling: Described as straight, curved, or coiled (e.g., number of coils).

C. Pod surface ornamentation: Described (e.g., spiny, reticulate, smooth).

6. Seed dimensions: Length, width, and thickness of individual seeds were measured.

Qualitative morphological traits, such as leaflet shape, stipule, flower color, and pod shape, were also observed and documented. These detailed morphological assessments facilitated a comprehensive understanding of *Medicago* diversity in the study area and enabled comparisons with established taxonomic descriptions. Additionally, herbaria throughout Iraq were visited and checked for previously collected specimens to provide a historical context for the observed morphological variations

Table 1: Field collection of *Medicago* species was carried out in various physiographical settings across the Kurdistan Region, Iraq.

Taxa	Locality	Altitude	Latitude	Longitude
***Medicago radiata* L.**	Sulaymaniyah/Azmar	1200m	36°18'9.075"N	44°25'8.404"E
	Zakho/Harina	701.8m	37°2'24.580"N	42°50'34.716"E
	Erbil /Bnari Safin	1200m	36°18'9.075"N,	44°25'8.404"E
***Medicago orbicularis* (L.) Bartal.**	Sulaymaniyah/ Qaradagh road	1100m	35°21'33.091"N	45°29'13.720"E
	Erbil /North of Safin Mt.	1400m	36°18'27.312"N	44°25'18.989"E
	Zakho/harina	701.8m	37°2'24.580"N	42°50'34.716"E
***Medicago rigidula* (L.) All.**	Sulaymaniyah/Dara rash	931.5m	35°22'4.182"N	45°29'40.307"E
	Zakho/Armshte	703.2m	37°2'37.147"N	42°49'15.341"E
	Erbil /Koya Road	868.9m	36°13'39.470"N	44°15'56.264 "E
***Medicago minima* (L) Bartal.**	Sulaymaniyah/Goshan village	860.6m	35°16'48.105"N	45°22'37.746"E
	Erbil /Hujran	831.8m	36°24'28.872"N	44°15'46.682"E
	Zakho/Armshte	703.2m	37°2'37.147"N	42°49'15.341"E
***Medicago noeana* Bioss.**	Hawler/Hujran	831.8m	36°24'28.872"N	44°15'46.682"E
***Medicago rigidula* (L.) var. *submitis* Bioss.**	Erbil /Tausoka Road	858.8m	36°18'10.518"N	44°19'25.204"E
***Medicago polymorpha* L.**	Zakho/Zakho university	444.7m	37°6'44.028"N	42°40'16.428"E
	Sulaymaniyah (Darbandikhan)	408.9m	35°3'35.881"N	45°39'8.939"E
	Hawler/Safin Mt.	1100m	36°24'52.822"N	44°16'54.963"E
***Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.**	Sulaymaniyah/Qaradagh road	1100m	35°21'33.091"N	45°29'13.720"E

3. RESULTS:

This study examined the morphological characteristics of *Medicago* L. taxa, occurring in Kurdistan, Iraq, and documented clear variations in vegetative, floral, pod, and seed traits. Notably, *Medicago rigidula* subsp. *sinskiae* was recorded for the first time in the Kurdistan region, representing, a new distributional record for the flora of Iraq (Figure 1).

Vegetative Characteristics:

As shown in Table 2, petiole length varied markedly among the examined taxa. *M. polymorpha* L. had the shortest petioles, ranging from 3.8 to 5.3 mm, whereas *M. rigidula* (L.) All. exhibited the longest, measuring between 19- and 39-mm. Leaflet dimensions also differed, substantially among species. In *M. radiata* L., leaflet length ranged from 3 to 13 mm and width from 6 to 10 mm, resulting in the lowest length-to-width ratio (1.22). In contrast, *M. noeana* Boiss. Displayed a higher ratio (1.80) with leaflet lengths of 6-13 mm and widths of 3-8 mm, indicating an elongated shape. Most of the species shared a cuneate-obovate leaflet shape with some variations, including obovate, obcordate, or ovate forms. Apex shape was predominantly apiculate, truncate, or retuse, though *M. noeana* Bioss. Uniquely presented obtuse or acute apices. Indumentum on leaf surfaces varied by species: *M. orbicularis* (L.) Bartal, *M. minima* (L.) Bartal., and *M. polymorpha* L. were glabrous, while *M. radiata* L. was densely appressed-hairy, and *M. noeana* Bioss. and *M. rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin. The long appressed hairy Stipule length ranged from 2 to 5 mm in *M. rigidula* subsp. *sinskiae* (Uljanova) Mehregan & Rahimin to 6.1-9.8 mm in *M. polymorpha* L.

Floral Features:

Table 3 summarizes the observed floral features. The number of flowers in an inflorescence typically ranged from 1 to 5 in most *Medicago* taxa, with *M. polymorpha* L. being an exception, having up to 10 flowers. Peduncle length showed considerable variation, from 3-8 mm in *M. radiata* L., from 10-30 mm in *M. noeana* Bioss. Pedicel length was relatively consistent across most species, typically ranging from 1 to 2 mm. Calyx length exhibited slight variations, from 1.5-2 mm in *M. orbicularis* (L.) Bartal to 3.5-4 mm in *M. rigidula* subsp. *sinskiae* (Uljanova) Mehregan & Rahimin and *M. noeana* Bioss. The calyx shape was predominantly campanulate or tubular-campanulate, with *M. rigidula* subsp. *sinskiae* uniquely presenting a broadly turbinate-campanulate form. Standard length ranged from 4-5 mm (*M. minima* (L.) Mill., *M. rigidula* subsp. *sinskiae* (Uljanova) Mehregan & Rahimin) to 5.5-6 mm (*M. rigidula* (L.) All.). Similarly, standard width varied between 1.5-2 mm (*M. noeana* Bioss.) and 3.5-4 mm (*M. radiata* L., *M. rigidula* (L.) All., *M. rigidula* var. *submitis* Bioss., *M. polymorpha* L.). Wing length and keel length generally followed similar trends, with *M. polymorpha* L. having shorter keel lengths (2-3 mm) compared to other species.

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Table 2: leaf quality and quantity characteristics.

Taxa	Petiole Length	Leaflet Length	Leaflets Width	Leaflets Length /Leaflets Width	Shape	Apex	Adaxial Indumentum	Abaxial Indumentum	Stipule Length
***Medicago radiata* L.**	10-31	3-13	6-10	1.22 14	Cuneate-obovate	Apiculate or truncate	Thinly appressed-hairy	Densely appressed-hairy	3.40-3.59
***Medicago orbicularis* (L.) Bartal**	12.5 - 24.7	6.1-12	5.1-10	1.17 28	Shortly cuneate-obovate Or obovate	Rounded to retuse-apiculate	Glabrous	Thinly appressed-hairy	3-5
***Medicago rigidula* (L.) All.**	19-39	5-13	4-8	1.43 33	Shortly cuneate-obovate Or obovate	Rounded to retuse-apiculate	Appressed -hairy	Appressed-hairy	3.5-7.3
***Medicago minima* (L) Bartal.**	7.9-24.3	3.5-11	3.15-5.91	1.70 78	Shortly cuneate-obovate To obcordate or obvate	Truncate to retuse - apiculate	Glabrous	Appressed hairy	3.05-4.95
***Medicago noeana* Bioss.**	26-34	6-13	3-8	1.80 39	Shortly cuneate-obovate To obvate or ovate	Obtuse or acute	Long appressed hairy	Long appressed hairy	5.1-7
***Medicago rigidula* (L.) All. var. *submitis* Bioss.**	20-30	4-6	3-5	1.27 12	cuneate-obovate	Truncate to retuse	Appressed -hairy	Appressed-hairy	3-6
***Medicago polymorpha* (L.)**	3.8-5.3	6.1-19.8	5.1-14.5	1.12 92	cuneate-obovate	Truncate to retuse	Glabrous or very few scattered appressed hairs	Glabrous or very few scattered appressed hairs	6.1-9.8
***Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.**	10-20	3-7	3-6	1.09 47	Cuneate to obovate-orbicular	Truncate	Long appressed hairy	Long appressed hairy	2-5

Table 3: Flowers quality and quantity characteristics.

Taxa	No. of flowers in inflorescences	Peduncle	Pedicel	Calyx length	Shape of calyx	Standard length	Standard width	Weng length	Keel length
***Medicago radiata* L.**	1-4	3-8	1.5-2	2-7	campanulate or tubular	4.5-5	3.5-4	3.5-4	3-3.5
***Medicago orbicularis* (L.) Bartal**	1-5	7-14	1.5-2	1.5-2	campanulate	4.1-5.5	2-3.5	2.5-3	3.5-4
***Medicago rigidula* (L.) All.**	1-6	15-20	0.5-1	3-4	tubular-campanulate	5.5-6	3.5-4	3-3.5	3.5-4

***Medicago minima* (L.) Bartal.**	1-3	11-23	1.5-2	2.5-3	campanulate or funnelform	4-5	1.5-3	3-4	3.5-4.5
***Medicago noeana* Bioss.**	1-4	10-30	1.5-2	3-4	Tubular-campanulate	4-5.5	1.5-2	3.5-4	4-5
***Medicago rigidula* (L.) All. var. *submitis* Bioss.**	1-5	10-20	1-1.5	3-3.5	campanulate or tubular-campanulate	5-5.48	3-4	2-3	3-30
***Medicago polymorpha* (L.)**	1-10	7-18	0.9-1.1	2.05-2.3	campanulate to tubular-campanulate	4.5-5	2.5-4	3-4	2-3
***Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.**	1-5	10-12	1-1.5	3.5-4	Broadly turbinate-campanulate or campanulate	4-5	2-3	3-3.5	3.5-4

Pod and Seed Characteristics:

The morphological characteristics of the pods are presented in Table 4. Pod diameter varied widely, ranging from the small 2.5-5.5 mm pods of *M. minima* (L.) Bartal. to the larger 11-19 mm pods of *M. orbicularis* (L.) Bartal. Pod shape was diverse, including circinate (*M. radiata* L.), discoid (*M. orbicularis* (L.) Bartal.), cylindrical (*M. rigidula* (L.) All.), spherical or ovoid (*M. minima* (L.) Bartal., *M. rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin), and barrel-shaped (*M. rigidula* (L.) All., *M. rigidula* var. *submitis* Bioss.). Pod indumentum was a key differentiating character, ranging from completely glabrous (*M. radiata* L., *M. orbicularis* L., *M. minima* (L.) Bartal.) to pubescent or velvety (*M. rigidula* (L.) All., *M. rigidula* var. *submitis* Bioss., *M. noeana* Bioss., *M. rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin). Notably, *M. radiata* L. was unique in its uncoiled pods, whereas other species displayed multiple coils ranging from 2 to 7.

Table 4: Pods and quality and quantity characteristics.

Taxa	Pod diameter	Pod shape	Indumentum	No. of pod coil
***Medicago radiata* L.**	13-18	Circinate, Broad	glabrous (hairless) or very sparsely hairy	Uncoil
***Medicago orbicularis* (L.) Bartal.**	11-19	Discoid	glabrous (hairless)	3-6 coil
***Medicago rigidula* (L.) All.**	6-13	Discoid to cylindrical (barrel-shaped to discoid)	Pubescent, velvety texture	3-8
***Medicago minima* (L) Bartal.**	2.5-5.5	shortly cylindrical, spherical or ovoid,	Glabrous	5-7
***Medicago noeana* Bioss.**	4.5-5	Shortly cylindrical, unarmed	pubescent, with the hairs being simple (non-glandular)	2-6
***Medicago rigidula* (L.) All. var. *submitis* Bioss.**	3-6	barrel-shaped to discoid	pubescent, often velvety	3-5
***Medicago polymorpha* L.**	5-9	Discoid to shortly cylindrical	thinly hairy	2-7
***Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.**	4.5-6	Ovoid, disc-shaped to shortly cylindrical	Densely Pubescent" or "Glandular Pubescent	2.5-5

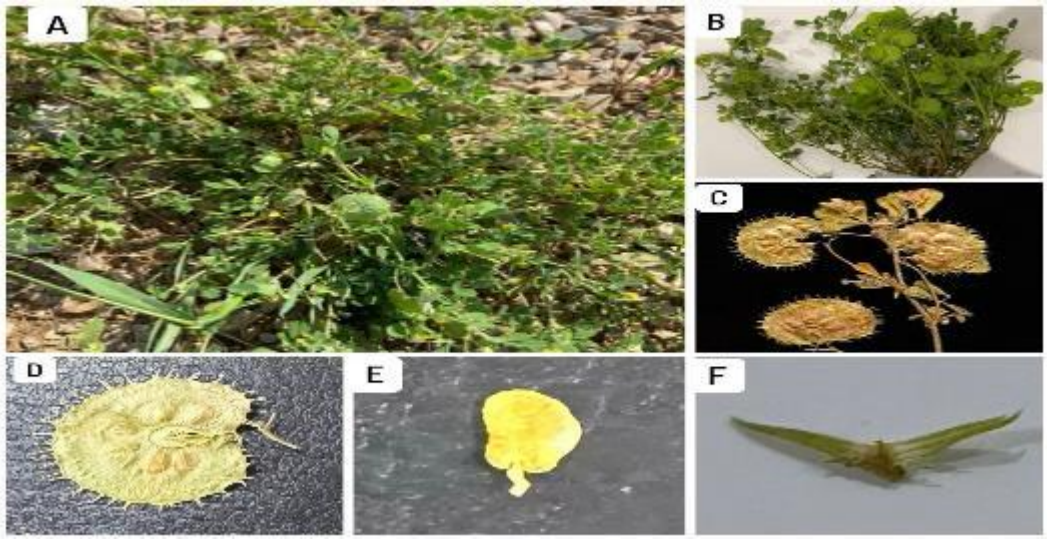
Seed lengths varied (e.g., *Medicago radiata* L. 1-3mm vs. *M. rigidula* (L.) All. 3-4mm). Width also differed significantly (*M. orbicularis* L. 0.5-1mm vs. *M. rigidula* (L.) All. /*M. minima* (L.) Bartal. 1.5-2mm). Most seeds were oblong, except for *M. orbicularis* L., which had a unique deltoid-orbicular shape. Seed

colors were generally yellowish-brown. Most seeds were smooth, but *M. radiata* L. and *M. orbicularis* L. had compressed seed

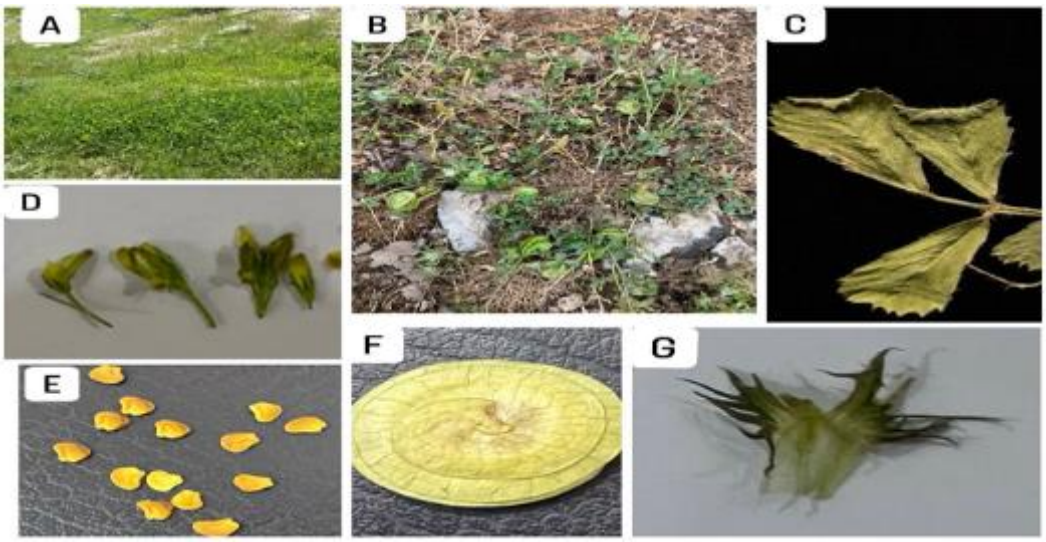
Table 5: Seed quality and quantity characteristics

Taxa	Seed Length	Seed width	Seed shape	Seed color	Seed texture
***Medicago radiata* L.**	1-3	0.8-2	oblong	Yellowish to brownish	Compressed
***Medicago orbicularis* (L.) Bartal.**	1.5-2	0.5-1	Deltoid-orbicular	Brownish	Compressed
***Medicago rigidula* (L.) All.**	3-4	1.5-2	Oblong_ovoid	Yellowish	Smooth
***Medicago minima* (L.) Bartal.**	2-2.5	1.5-2	Oblong_ovoid	Yellowish to dark brown	Smooth
***Medicago noeana* Bioss.**	1.5-2.5	1-1.5	oblong	Brown	Compressed Smooth
***Medicago rigidula* (L.) All. var. *submitis* Bioss**	2.5-3	1-1.5	Oblong_ovoid	Yellow to brown	Smooth
***Medicago polymorpha* (L.)**	3-3.5	1-1.5	Oblong_ovoid	Yellowish or brownish	Smooth
***Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.**	1.5-2	1-1.5	ovoid or broadly elliptic	yellow to yellow-brown	Smooth

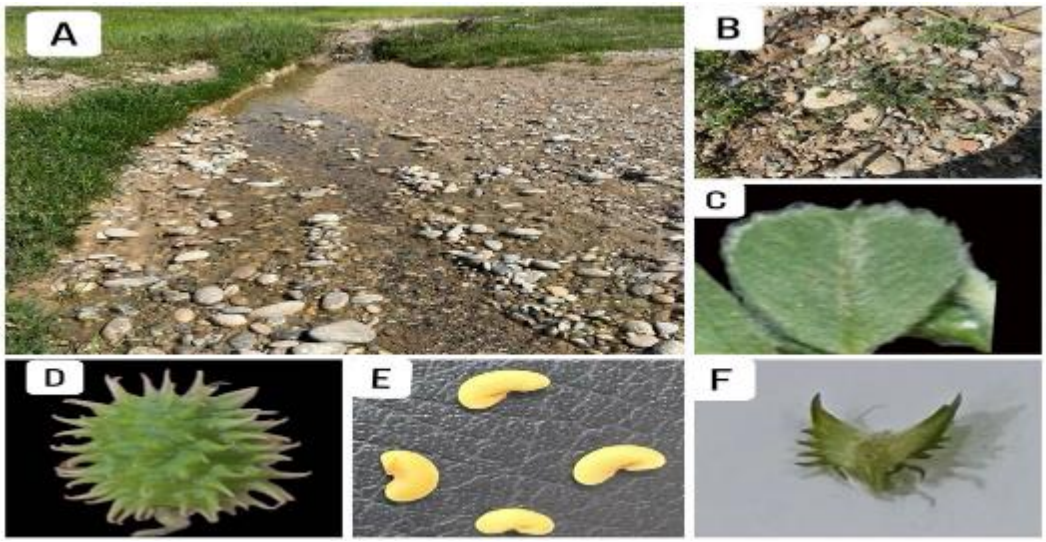
*The reported ranges for each morphological characteristic were determined from direct measurements of 20 randomly selected samples, with all values presented in millimeters.



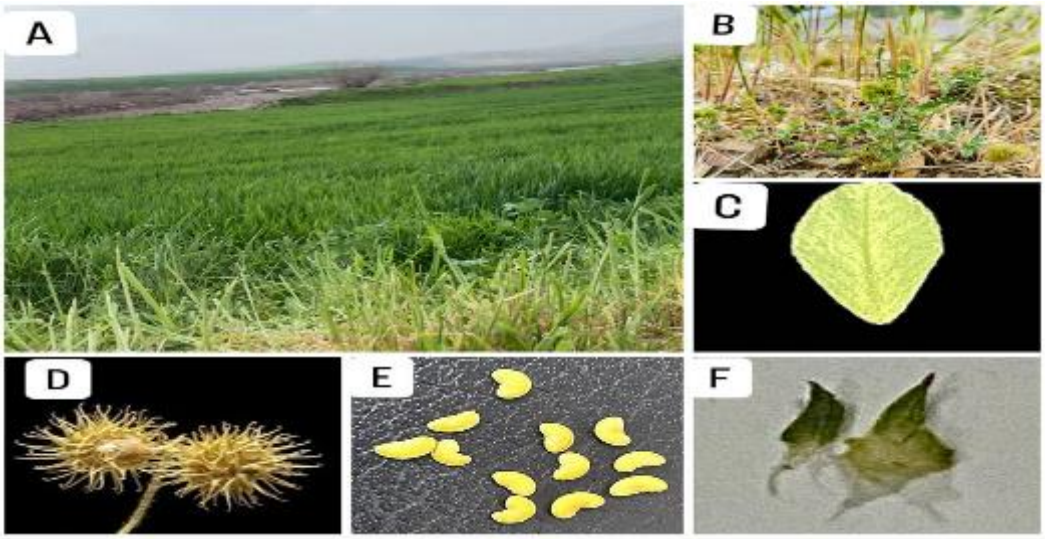
Figures 2: *Medicago radiata* L.: A Habit and Habitat, B The whole plant or collected branches, C stem with multiple dried seed pods. D, a single dried seed pod, E a single seed, G stipule.



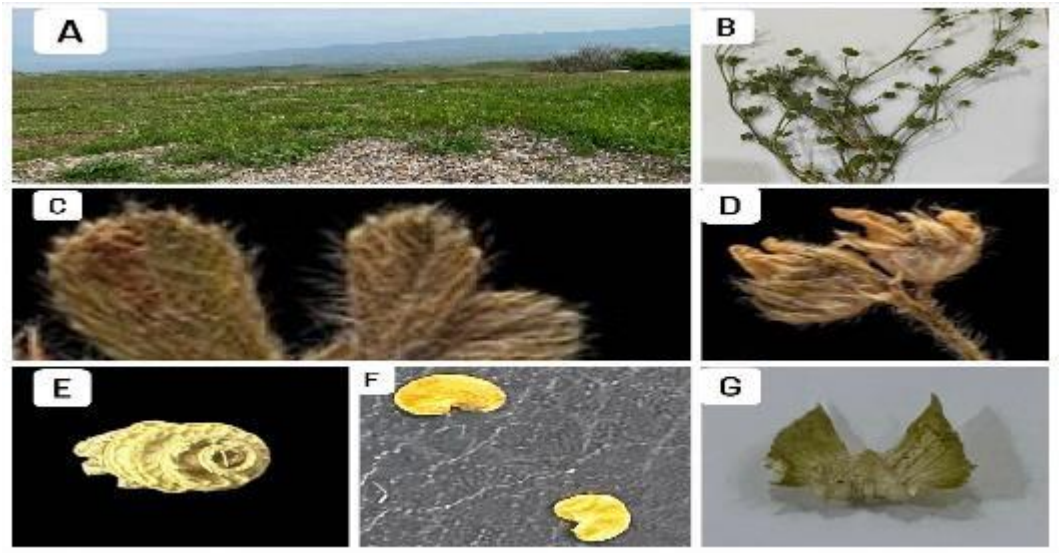
Figures 3: *Medicago orbicularis* (L.) Bartal: A, B Habit and Habitat, C leaflet shape, D flowers, E seed, F pod shape, G stipule.



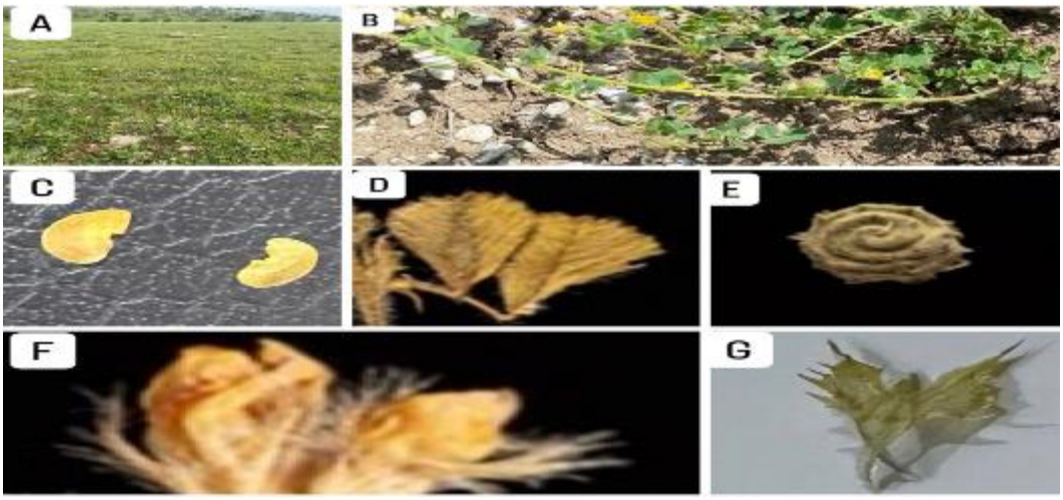
Figures 4: *Medicago rigidula* (L.) All.: A, B Habit and Habitat, C leaflet, D pod shape, E seed shape, F stipule.



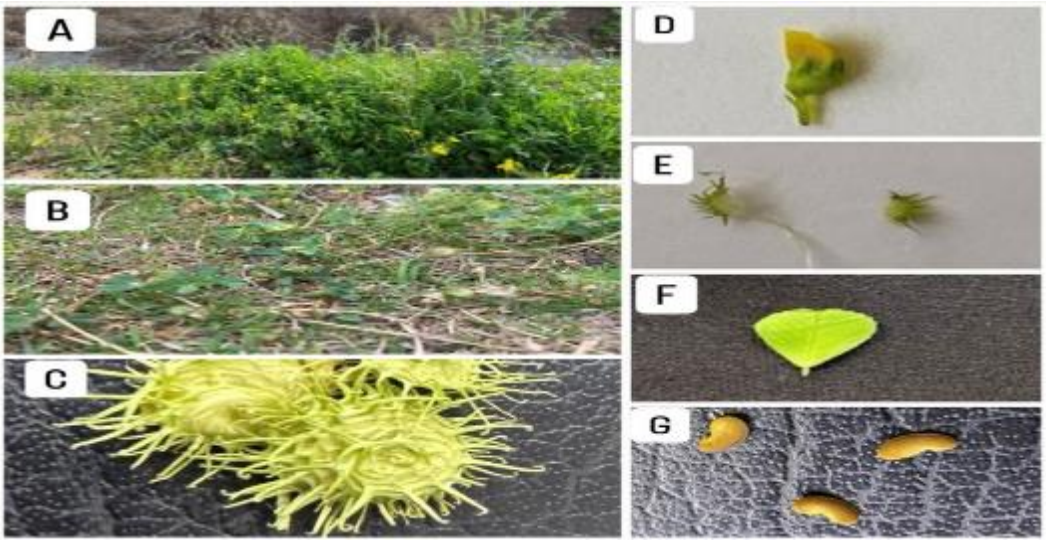
Figures 5: *Medicago minima* (L.) Bartal.: A, B Habit and Habitat, C leaflet, D pod shape, E seed shape, F stipule.



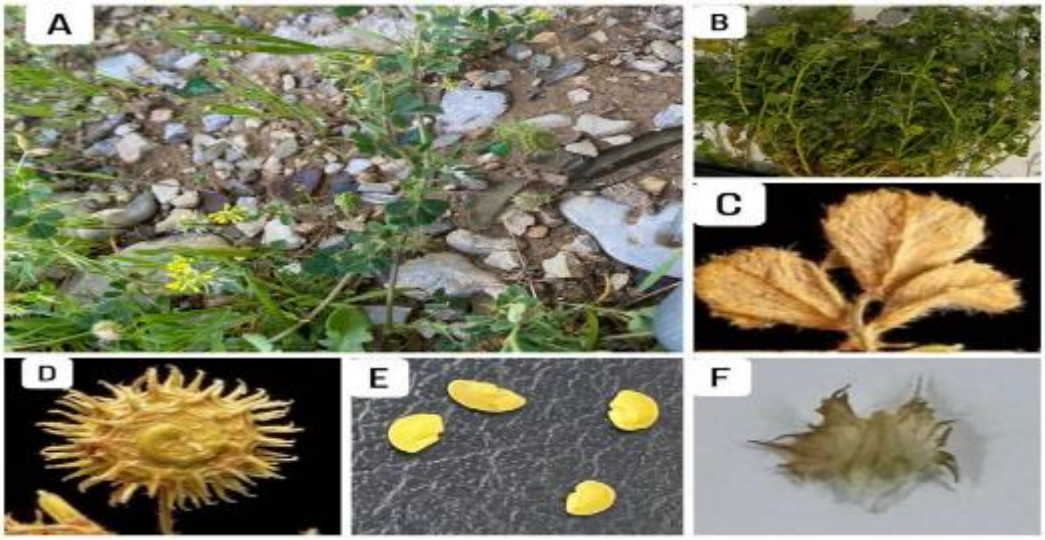
Figures 6: *Medicago noeana* Bioss.: A Habit and Habitat whole collected plant leaflet, D flowers, E pod shape, F seed shape, G stipule.



Figures 7: *Medicago rigidula* (L.) All. var. *submitis* Bioss.: A, B Habit and Habitat, C seed shape, D leaflet, E pod shape, F flowers, G stipule.



Figures 8: *Medicago polymorpha* L.: A, B Habit and Habitat, C pod shape, D flower, E stipule, F leaflet, G seed shape.



Figures 9: *Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.: A Habit and Habit, B whole plant, C leaflet, D pod shape, E seed shape, F Stipule.

The morphological characteristics of closely related taxa (*M. rigidula* (L.) All., *M. rigidula* (L.) All. var. *submitis* Bioss., and *M. rigidula* subsp. *sinskiae* (Uljanova) Mehregan & Rahimin.) were quite similar. The leaflet length-to-width and apex were varied among the taxa. The average length-to-width ratio of *M. rigidula* subsp. *sinskiae* (1.0947) was regarded as the smallest. The leaflet apex varies from truncate in *M. rigidula* subsp. *sinskiae*, truncate to retuse in *M. rigidula* var. *submitis* and rounded to retuse-apiculate in *M. rigidula*. The leaflet indumentum was appressed hairy, with some exceptions (long hairs) in *M. rigidula* subsp. *sinskiae* table (6).

The pod diameter ranged from 3-6, 4.5-6, and 6-13 in *M. rigidula* var. *submitis*, *M. rigidula* subsp. *sinskiae*. and *M. rigidula,* respectively. *M. rigidula* subsp. *sinskiae* with (1.5-2) mm seed was the shortest. The discoid to cylindrical pod shape was a consistent pattern among the mentioned taxa, with minor variations. Densely or Glandular Pubescents were the distinct pod indumentum of *M. rigidula* subsp. *sinskiae*. The seed shape of *M. rigidula*, *M. rigidula* var. *submitis* was oblong ovoid compared to the ovoid or broadly elliptic of *M. rigidula* subsp. *sinskiae*. The seed color ranges from yellowish to yellow brown.

Table 6: Comparison of morphological quality and quantity characters among *Medicago* species (*Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin., *Medicago rigidula* (L.) All. *Medicago rigidula* (L.) All. var. *submitis* Bioss.).

Characters	*Medicago rigidula* (L.) All.	*Medicago rigidula*. (L.) Al. var. *submitis* Bioss	*Medicago rigidula* subsp. *Sinskiae* (Uljanova) Mehregan & Rahimin.
Leaflet L/W Ratio	1.4333	1.2712	1.0947
Leaflet Apex	Rounded to retuse-apiculate	Truncate to retuse	Truncate
Leaflet Indumentum	Appressed-hairy	Appressed-hairy	Long appressed hairy
Calyx Shape	Tubular-campanulate	Campanulate or tubular-campanulate	Broadly turbinate-campanulate or campanulate
Keel Length	3.5-4 mm	3-30 mm	3.5-4 mm
Pod Diameter	6-13 mm	3-6 mm	4.5-6 mm
Pod Shape	Discoid to cylindrical (barrel-shaped)	Barrel-shaped to discoid	Ovoid, disc-shaped to shortly cylindrical
Pod Indumentum	Pubescent, velvety	Pubescent, velvety	Densely Pubescent or Glandular Pubescent
Seed Length	3-4 mm	2.5-3 mm	1.5-2 mm
Seed Shape	Oblong-ovoid	Oblong-ovoid	Ovoid or broadly elliptic
Seed Color	Yellowish	Yellow to brown	Yellow to yellow-brown

4. DISCUSSION

The achieved data provides a summary of the morphological characteristics of some *Medicago* taxa to discriminate the closely related species. Interspecific and intraspecific variations are highlighted by the detected differences across vegetative, floral, pod, and seed features (Tables 2-6) and (Figures 2-9). These results significantly corroborate previous studies on Medicago morphology in some cases and provide more detailed regional insights.

Consequently, a scientific documentation of M. *rigidula* subsp. *sinskiae* as a new distributional record for the Kurdistan Region of Iraq (Figures 1 & 9), thereby extending the known range of this taxon within Southwest Asia. The distinct features such as an ovoid to discoid, densely pubescent pod, a widely turbinate–campanulate calyx, and a long, appressed, hairy indumentum on both leaf surfaces, highly supported the first diagnosis (Table 6). It is important to note that *M. sinskiae* is a synonym of *M. rigidula* subsp. *Sinskiae*.

The leaflets and petiole size, as well as the length-to-width ratio of the leaflets, were crucial for species discrimination. For example, *M. radiata's* low leaflet length-to-width ratio and characteristic uncoiled circinate pods set it apart from other species under study. Similar results were previously noted in traditional taxonomic investigation of *Medicago* (Heyn, 1963). Likewise, the glabrous leaves and pods of *M. orbicularis* and M. minima serve as significant diagnostic characters, distinguishing them from more pubescent or hairy species such as *M. rigidula* and *M. noeana*. Such, indumentum is widely regarded as an important taxonomic character in *Medicago* (Small, 2011b). These quantitative measurements presented here provide a robust basis for these qualitative observations, enhancing their utility for accurate species identification.

Furthermore, the variations in peduncle length, along with subtle differences in calyx morphology and standard dimensions, contributed to the overall morphological characterization of each species. The broadly turbinate–campanulate calyx observed in *M. rigidula* subsp. *sinskiae* represents a notable distinguishing feature within the *M. rigidula* complex. This complex (*M. rigidula*, *M. rigiduloides*, *M. sinskiae*, and *M. constricta*) is characterized by pronounced morphological plasticity and ongoing taxonomic difficulty, often necessitating careful evaluation of subtle morphological traits (Zareei *et al*., 2022). The data achieved from the *Medicago rigidula* and their closely related taxa support the recognition of infraspecific taxa based on a notable morphological variation.

Pod morphology seems to offer some of the most informative characteristics for species identification in *Medicago.* The wide variation in pod shape including discoid, cylindrical, ovoid, and barrel-shaped forms together with distinct indumentum patterns such as glabrous, pubescent, velvety, and glandular pubescent surfaces, provides valuable traits for species discrimination.

The distinct uncoiled pod of *M. radiata* is particularly diagnostic, as reported in various floristic accounts. Moreover, the number of pod coils, though varying within species, still provides a range diagnostic feature. For example, *M. minima* with 5-7 coils and small, short cylindrical pods are distinctly different from the larger multi-coiled pods of *M. orbicularis*. These pod characteristics are widely accepted as primary taxonomic markers in *Medicago* systematics (Izadpanah & Jafari, 2013). The morphological variations observed in *M. polymorpha*, particularly its pod characteristics, are consistent with its description as a species with coiled pods and thin hairs; however, significant differences in seed shape (e.g., deltoid-orbicular in *M. orbicularis*. Versus oblong ovoid in *M. rigidula* and texture (compressed in *M. radiata* and *M. orbicularis* versus smooth in others) are crucial for taxa determination (Zareei *et al*., 2022).

The achieved phenotypic disparity among *Medicago* species in the area suggests potential adaptations to local habitat. The new record of *M. rigidula* subsp. *sinskiae*, provides a significant contribution to the botanical knowledge of the region and updating existing floristic accounts. Confirmation of this taxon using molecular evidence is required to provide a robust framework for future systematic research in the region. Further studies incorporating broader molecular sampling are recommended to achieve a more comprehensive understanding of phylogenetic relationships among these species and to resolve ambiguous taxonomic boundaries, especially within species complexes such as *M. rigidula*, where morphological differences may be subtle yet taxonomically important (Zareei *et al*., 2022). This integrated morphological and molecular baseline is essential for advancing ecological research and conservation efforts, as it supports accurate species identification and diversity.

CONCLUSION

This morphological study provides valuable insights into the diversity of *Medicago* species in the Kurdistan Region of Iraq, revealing clear variations in vegetative, floral, pod, and seed characteristics. A key outcome of this research is the documentation of a new distributional record for *M. rigidula* subsp. *sinskiae,* supported by morphological evidence. The observed niche partitioning and distinct morphological traits, particularly those related to pod and seed features, highlight the adaptability of these species to a range of local environmental conditions. This comprehensive baseline is vital for advancing taxonomic knowledge, guiding future ecological investigations, and supporting conservation strategies for *Medicago* diversity in the region.

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Author Contributions:

K. J. A. conducted the research, analyzed the data, and wrote the initial draft of the paper. The study was conceived, developed, and overseen by Sh. S. A. and J. J. M. The final version of the text was reviewed and approved by all authors.

Ethical Approval:

Ethical approval was not necessary for this investigation because neither human nor animal participants were used.

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