

Morphological Characterization and Taxonomic Assessment of *Micromeria* Bentham from Jordan: Key Species and Their Taxonomic Significance

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Abstract

This study investigates the taxonomic status of the genus *Micromeria* in Jordan, focusing on the morphological features variation within five species: *M. nervosa*, *M. fruticosa*, *M. myrtifolia*, *M. sinaica*, and *M. danaensis*. Key morphological features, such as leaf shape, stem indumentum, floral structure, and nutlet texture, were used to distinguish these species. The study found that these features provide reliable characters for species identification, with no evidence of *M. graeca* in Jordan.

A key for identifying the species is provided, contributing to the systematic understanding of *Micromeria* in the region. These findings have important implications for species identification and conservation efforts in Jordan

Keywords: *Micromeria*, Systematics, Lamiaceae, Plant Taxonomy, Jordan

1. Introduction

Jordan, located in the Eastern Mediterranean, with a total area of 89,287 km² and acts as a bridge between the Mediterranean region and Arabia peninsula. Its climatic zones support distinct biogeographical regions, namely the Mediterranean, Irano-Turanian, Saharo-Arabian, and the Sudanian (sub-Tropical) regions, which collectively host 13 major vegetation types (Al-Eisawi 1996). This diversity has resulted in over 2,500 plant species, belonging to 142 families and 868 genera (Al-Eisawi, 2013). Despite this richness, taxonomic uncertainties persist for several taxa, including those in the genus *Micromeria*

The genus *Micromeria* (Lamiaceae) comprises approximately 69 species, native to regions ranging from the Mediterranean Basin to southern Africa and parts of Asia (Kew, 2021).

Micromeria species are known for their ecological adaptability and medicinal properties, with several species traditionally used in herbal medicine. In Jordan, six species are recorded: *M. danaensis*, *M. fruticosa*, *M. graeca*, *M. myrtifolia*, *M. nervosa*, and *M. sinaica* (Al-Eisawi, 2013). Of these, *M. danaensis* is endemic to Jordan and restricted to the Dana Biosphere Reserve, contributing to its designation as a Key Biodiversity Area (KBA, 2017). Additionally, *M. nervosa* and *M. myrtifolia* have shown antiproliferative potential against cancer cell lines (Oran *et al.*, 2022).

Historically, the taxonomy of *Micromeria* has been complex. Initially described by Bentham (1834) as part of *Satureja*, the genus was later divided into distinct genera based on morphological and ecological traits (Boissier,

1879; Feinbrun-Dotan, 1978). Earlier works in the Middle East region, such as those by (Post and Dinsmore, 1933) and (Feinbrun-Dotan, 1978), highlighted inconsistencies in species identification and descriptions.

Morphological features remain a primary tool in plant taxonomy despite advancements in molecular and genetic methods (Stuessy, 2009; Duminil & Di Michele, 2009). These traits are particularly valuable for distinguishing closely related species in *Micromeria*. However, the absence of a comprehensive taxonomic key for *Micromeria* in Jordan has hindered efforts to resolve ambiguities and assess recently discovered taxa like *M. danaensis*.

This study provides a systematic study for the genus in Jordan and establish an updated taxonomic key that will assess the identifying of *Micromeria* taxa in Jordan based on their morphometric features.

This study provides a systematic revision of the genus *Micromeria* in Jordan. By integrating morphological, ecological, and taxonomic analyses, we aim to develop an updated taxonomic key to facilitate species identification and contribute to the understanding of *Micromeria* species diversity and distribution of Jordan.

2. Materials and Methods

A total of 30 *Micromeria* specimens representing the whole plant, including all plant parts, were collected during seven field trips conducted from March to May 2021. The specimens were pressed and dried, and then were poisoned chemically using a mixture of 150 g mercuric chloride (HgCl₂) and 350 g ammonium chloride (NH₄Cl) dissolved in as little water as possible, and 10 L

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of 96% ethanol. After processing, the specimens were identified, labeled, and mounted. Voucher specimens of each species were deposited at the herbarium of the Royal Society for the Conservation of Nature (RSCN). Additionally, 37 *Micromeria* specimens deposited at two

herbaria in Jordan, were consulted and examined in detail: the Biological Sciences Department herbarium at the University of Jordan (AMM) and the herbarium of the Royal Society for the Conservation of Nature (RSCN) (Table 1).

Table 1. Specimen details and collection sites of *Micromeria* species in Jordan.

Species	No. of field specimens	A voucher number	Date of collection	Locality	No. of herbarium specimens	A voucher number
<i>M. nervosa</i>	11	33856	8. March. 2021	Jarash – Sakeb	14	18
		33857	9. March. 2021	Ajloun – Ajloun Forest reserve		31
		33858	9. March. 2021	Ajloun – Ajloun Forest reserve		67
		33859	1. April. 2021	Irbid – Yarmouk Forest reserve		73
		33860	26. April. 2021	Tafilah – Dana Biosphere reserve		107
		33861	26. April. 2021	Tafilah – Dana Biosphere reserve		125
						139
						183
						232
						545
						1973
<i>M. myrtifolia</i>	9	33862	8. March. 2021	Jarash – Sakeb	9	93
		33863	9. March. 2021	Ajloun – Ajloun Forest reserve		140
		33864	1. April. 2021	Irbid – Yarmouk Forest reserve		5844
		33865	1. April. 2021	Irbid – Yarmouk Forest reserve		6272
		33866	26. April. 2021	Tafilah – Dana Biosphere reserve		7477
						7748
						31397
						32850
						35617
						5950
<i>M. sinaica</i>	4	33867	26. April. 2021	Tafilah – Dana Biosphere reserve	8	7237
		33868	16. May. 2021	Tafilah – Dana Biosphere reserve		7700
		33869	16. May. 2021	Tafilah – Dana Biosphere reserve		11249
						30337
						31169
						31397
<i>M. fruticosa</i>	4	33870	24. April. 2021	Irbid- Judayta	4	10133
		33871	24. April. 2021	Irbid- Judayta		
		33872	29. April. 2021	Ajloun- Alhashmeh		
		33873	29. April. 2021	Ajloun- Alhashmeh		
<i>M. danaensis</i>	2	33874	26. April. 2021	Tafilah – Dana Biosphere reserve	2	236
		33875		Tafilah – Dana Biosphere reserve		
<i>M. graceca</i>	0		-	-	0	0

The morphological features studied for all collected taxa of *Micromeria* included plant length; stem indumentum and color; leaf type, width, length, shape, margin, petiole, apex, marginal vein, and indumentum; floral leaf shape, length, and indumentum; inflorescence type, number of flowers, peduncle, and pedicel; calyx shape, teeth, and indumentum; corolla color and indumentum; nutlet shape and surface texture. In each

sample of the specimens studied, at least 4 readings were taken for each morphological character. Characters, such as hair type and the presence or absence of glands, were studied using a stereomicroscope at different magnifications (10x, 20x, and 40x). All measurements were taken using a Vernier caliper for accuracy.

3. Results

Five different *Micromeria* species were identified in Jordan. These are *M. nervosa* (Desf.) Benth., *M. fruticosa* (L.) Druce, *M. myrtifolia* Boiss. and Hohen, *M. sinaica* Benth. and *M. danaensis* Danin. Three species were distributed within the Mediterranean region; *M. fruticosa*, *M. danaensis*, and *M. nervosa*. The *M. myrtifolia* was distributed within the Mediterranean and Irano-Turanian region. The fifth species, *M. sinaica*, was distributed within the Saharo-Arabian region-Desert plant (Fig. 1).

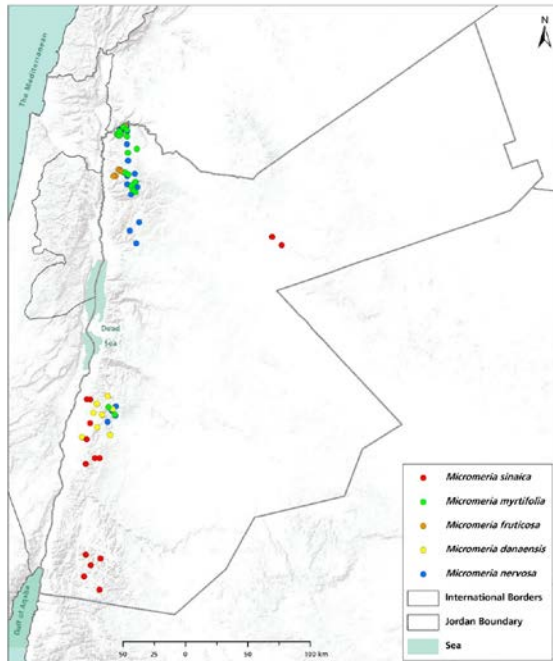


Figure 1. A Map of the Localities of the studied *Micromeria* specimens (Fresh and Herbarium specimens).

The morphological results of similarities and differences were summarized for each species in Table 2. The study species were described as follows:

3.1. *Micromeria fruticosa*

Description: Chamaephyte, 25_50 cm, divaricately branched, yellowish when dry (see Fig. 2- A&B). Stems erect, long _ paniculate, covered with densely puerulent hairs (see Fig. 3- E), glandular.

Leaves: Petiolate, entire, or crenate, 0.5 _ 2 cm x 0.5 _ 1 cm, ovate, obtuse to subacute, with thin margins, glandular and covered with short hairs (see Fig. 4- A&B). floral leaves lanceolate, shorter than calyx.

Verticillasters: Lax, many flowered (4_7), long pedunculate cymes (2_4 cm), without Pedicle, glandular and covered with short hairs (see Fig 5-A).

Calyx: Cupuliform, pedunculate, glandular, and covered with short hairs (tomentose), teeth short and equal (see Fig. 6-A).

Corolla: White, tube exserted, 2_labiate, hairy, lower lip somewhat longer than the upper.

Nutlet: Oblong (spheroidal), hairy and shiny (see Fig. 7-A).

Flowering time: February _ June.

Habitat: Mediterranean region and among rocks

Distribution: Irbid, Um Qais, Alsholah, Ajloun mountains.

Specimens examined.

Irbid, Alal, 7 km North of Irbid towards the borders with Syria, waste places & uncultivated segments & roadsides; 10. May. 1983; D. Al-Eisawi. Irbid, Alsholah; 15. May. 1987; D. Al-Eisawi. Nablus; September. 1991; D. Al-Eisawi. Ajloun, Ishtafena, 25. April. 1999; D. Al-Eisawi. Irbid, Judayta; 13. April. 2021; B. Ayasrah. Irbid, Judayta, along the road to Irbid; 24. April. 2021; B. Ayasrah. Ajloun, Alhashmeh; 29. April. 2021; B. Ayasrah.

3.2. *M. danaensis*

Description: Chamaephyte, 5_10 cm, many stemmed from base (see Fig. 2- I&J). Stems erect, short paniculate, covered with densely puberulent hairs (see Fig. 3-D), glandular.

Leaves: Sessile, entire, 0.2 _ 0.4 x 0.1 _ 0.2 cm, oblong to lanceolate, acuminate, with thick margins, somewhat revolute, glandular, and covered with short hairs (see Fig. 4- I&J). floral leaves linear, shorter than calyx, as long as Pedicle.

Verticillasters: Lax, few flowered (1_2) (-4), cymes short pedunculate (0.2 _ 0.4 cm), flowers pedicellate, half as long as calyx, glandular and covered with short hairs (see Fig. 5-E).

Calyx: Tubular, covered with short hairs, glandular, teeth erect, short and equal (see Fig. 6-E).

Corolla: Cream-colored, lilac spotted, tube exserted, 2_labiate, hairy.

Nutlet: Ovoid(elliptical), minutely puerulous on the upper surface (see Fig. 7-E).

Flowering time: March_ May.

Habitat: Mediterranean region; crevices of smooth_faced white sandstone outcrops.

Distribution: Dana Biosphere Reserve.

Specimens examined:

Dana reserve; 5. April. 1997; RSCN. Team. Dana reserve, Wadi Araba; 11. April. 1997; RSCN. Team. Dana reserve, Wadi Barra, 2Km SE of the visitor center; 14. May. 1996; RSCN. Team. Tafila, Dana Biosphere Reserve, Al-Barrah, East Southeastern side of the reserve; 5. April. 2021; B. Ayasrah. Tafila, Dana Biosphere Reserve, Khunaq Al-Arz, Middle North of the reserve, near Ain Lahtha; 6. April. 2021; B. Ayasrah.

3.3. *M. nervosa*

Description: Chamaephyte, 15_25 (-45) cm, many stemmed from base (see Fig. 2- C&D). Stems are mostly purplish, simple, or sparingly branched, covered with long hooked hairs (see Fig. 3-C), glandular.

Leaves: Petiolate, entire, 0.6 _ 0.9 x 0.4 _ 0.6 cm, ovate, acuminate, with thick margins, somewhat revolute, glandular, and covered with long hairs (see Fig. 4- E&F). Floral leaves linear, as long as verticillaster.

Verticillasters: Long hairy, many flowered (7_10), pedunculate (1cm), forming spike-like inflorescences, glandular, flowers Pedicellate (see Fig. 5-C).

Calyx: Tubular, longer than pedicle, glandular and covered with long hairs as long as or exceeding in length of the calyx_tube, teeth not equal, lower teeth longer than upper as long as calyx (see Fig. 6-C).

Corolla: Purplish_ pink, tube sub-included, 2_labiate, hairy.

Nutlet: Oblong, smooth (see Fig 7-C).

Flowering time: March_ May.

Habitat: Mediterranean region and among rocks

Distribution: Ajloun mountains, Jarash, Amman, Salt, Dana and Petra.

Specimens examined:

Al-Aloak; 14. April. 1983; S. Abdulhadi. Ajloun, Qalaet elrabath; 17. May. 1972; D. Al-Eisawi. King Talal Dam; 14. April. 1983; R. H. Jayyosi. King Talal Dam, along the road to Jarash; 14. April. 1983; N. Al-Najjar. Wadi Um Rakham between Mersa Matruh and Agiba; 21. March. 1975; T. Hadidi. Salt, Sbahi; 12. April. 1984; S. Alkhateeb. Amman, Naour, 200 the main road; 22. April. 1993; H. Alkhatib & M. Abu- Hammour. Salt- Near Zai National Park; 12. April. 1984; W. Jabri. Salt, Sbahi; 22. April. 1993; Y. Al- Mograbe. Salt. Rabad Fortress, near Ajlun; 23. May. 1974; W. Jallad, L. Boulos & J. Lahham. Jarash, Way of Ras Dabboos, 15 km south of Jarash; 16. April. 1997; T. Rawashdeh. Jarash, Zarqa eiver, 500 m N. of the river, degraded deciduous oak forest; 29. April. 1999; D. Al-Eisawi & J. Zaidan. 12 Km north Irbid, 3 Km north Sal; 26. April. 1975; W. Jallad, L. boulos & J. lahham. 15 Km north of Suweilih, along the road of Jarash; 29. March. 1984; M. Alhabash. Jarash; 17. April. 1986; D. Al-Eisawi. Jordan vally, 2-3 Km E. of Abu Obaidah, along the road to Khirbit Alwahadneh; 28. March. 1996; D. Al-Eisawi, K. Arid & I. Aziz. Amman, 13 Km west of Amman, along the road from Naur to Ghor, near Children Wood; 9. March. 1978; D. Al-Eisawi. Al-Salt, Al- wasia; 28. April. 1999; M. Abu- Hammor. Jarash, King Talal Dam; 29. March. 1984; L. Boulos & S. Darras. Ajloun, Wahadneh, 12 Km at the crossing point with Halawa; 28. March. 1996; D. Al-Eisawi. Al- Salt, Subehi; 22. April. 1993; M. Kamel & S. Abu- Romman. Tafila, Dana Biosphere Reserve, Middle of the reserve; 4. April. 2016; S. Khatatbeh, B. Ayasrah, & M. Zoubi. Jarash, Dibe'en Forest Reserve, 23. March. 2019; B. Ayasrah. Dibe'en Forest Reserve, Wadi alsoan; 14. April. 2019; B. Ayasrah. Ajloun, Ajloun Forest Reserve, Building of the reserve; 8. April. 2018; S. Khatatbeh & B. Ayasrah. Irbid, Yarmouk Forest Reserve, Wadi Ain Arkeh; 22. March .2017; A. Sabbarenie, S. Khatatbeh, B. Ayasrah & S. Malkawy.

3.4. *M. myrtifolia*

Description: Chamaephyte, 15_40 cm, many stemmed from base (see Fig. 2- E&F). Stems erect or ascending, generally simple, covered with short, hooked hairs (see Fig. 3-A), glandular.

Leaves: Sessile, somewhat short petiolate, entire, 1 _ 1.5 x 0.5 _ 0.8 cm, elliptic, acute to acuminate, with thick margins, glandular and covered with short hairs (see Fig. 4- C&D). Basal leaves ovate, petiolate. Floral leaves linear, shorter than verticillaster. Verticillasters: Short hairy, many flowered (4_7), very dense, pedunculate (1 cm), sometimes part of the stems bearing few flowered sessile, Thyse (compound dichasium arranged as raceme), glandular, flowers Pedicellate (see Fig. 5-D).

Calyx: Tubular, longer than pedicle, glandular and covered with short hairs, teeth not equal, upper teeth longer than lower (see Fig. 6-D).

Corolla: Purplish_ pink, densely hairy, tube sub-included, 2_labiate.

Nutlet: Ovoid or elliptical, smooth (see Fig. 7-D).

Flowering time: March_ August.

Habitat: Mediterranean region and Irano -Turanian region.

Distribution: Irbid, Ajloun, Jarash, Amman, Salt, Dana, Petra and shoubak

Specimens examined:

Amman, near Naour, Children Forest, along the road to Ghor; 8. May. 1981; A. Khilieh & D. Al-Eisawi. Dibben National Park; 31. December.2003; M. Mahklouf & D. Al-Eisawi. 3-4 Km west Rum Rest House, 18 Km from the main road to Aqaba; 23. March. 1975; L. Boulos, W. Jallad, J. Lahham, M.A. Abu Hamaidan. Dana Reserve, Wadi Finan; 28. April. 1994; D. Al-Eisawi. Dibbin National Park; 14. December. 1973; L. Boulos & R. Hauke. Petra; 15. March. 1974; L. Boulos, D. Al-Eisawi & W. Jallad. Wadi Yutum, Upper stream, 15 Km north of Aqaba; 21. March. 1975; L. Boulos, W. Jallad, J. Lahham, & M.A.Abu Hmaidan. Irbid, Yarmouk Forest Reserve; 18. March. 2017; Sabbarenie, S. Khatatbeh, B. Ayasrah & S. Malkawy. Jarash, Dibe'en Forest Reserve; 13. March. 2018; B. Ayasrah. Tafila, Dana Biosphere Reserve, East-South of the reserve, Wadi Dana; 7. May. 2016; S. Khatatbeh & B. Ayasrah. Jarash, Sakeb; 1. April. 2021: B. Ayasrah.

3.5. *M. sinaica*

Chamaephyte, 10_35 cm, many stemmed from base (see Fig. 2- G&H). Stems erect, virgate, simple or sparsely branched, covered with short, hooked hairs (see Fig. 3-B), glandular.

Leaves: Sessile, entire, .02_ 0.5 x 0.1_0.4 cm, ovate, obtuse, with thick margins, somewhat revolute, glandular, and covered with short hairs (see Fig. 4- G&H). Floral leaves lanceolate, as long as verticillaster.

Verticillasters: Lax, short hairy, many flowered (7_10), sessile, forming spike _ like inflorescences, glandular, flowers pedicellate (see Fig. 5-B).

Calyx: Tubular, as long as pedicel, glandular and covered with short hairs, teeth not equal, upper teeth longer than lower (see Fig. 6-B).

Corolla: Purplish_ pink, short hairy, tube exserted, 2_labiate.

Nutlet: Ovoid or elliptical, minutely puberulous on the upper surface and have two curves (see Fig. 7-B).

Flowering time: March_ May.

Habitat: Sahara _Arabian region _ —arid rocky desert habitat.

Distribution: Dana, Wadi Arabah, Rum and Petra

Specimens examined:

Four Km south Rum Rest House, along the road to Rum Police Station; 23. March. 1975; L. Boulos, W. Jallad, J. Lahham, M.A. Abu Hamaidan. Ishtafena to Deir Abu Said; 11. May. 1996; S. Khaleel & V. Slageren. Tafila, 23 Km S. of Tafila, Khonaq Al- Arz, 1 Km W. of Ain Lahtha; 1. May. 1997; D. Al-Eisawi. Tafila, S. end of Tafila, along the road to Shoubak; 11. April. 1979; D. Al-Eisawi. Wadi Dana, Wadi el Jaifeh; 27. April. 1999; RSCN. Team. Wadi Dana, Wadi Al Rommanah; 11. May. 1999; RSCN. Team. Wadi Dana, Wadi Al Rommanah; 4. May. 1999; RSCN. Team. Wadi Dana, Wadi Fatmeh; 26. April. 1994; RSCN. Team. Wadi Dana, Wadi Al Barraha; 16. May. 1994; RSCN. Team. Tafieleh, Dana Biosphere Reserve, East of the reserve, Al Barraha area, wadi Al Qaraya; 17. AUG. 2016; S. Khatatbeh & B. Ayasrah. Tafila, Dana Biosphere Reserve, Wadi Feynan, Southern side of the reserve; 16.

May. 2016; S. Khatatbeh & B. Ayasrah. Tafila, Dana Biosphere Reserve, East of the reserve, Rumannah camp, Daghla area; 26. April. 2016; S. Khatatbeh, M. Zoubi & B. Ayasrah.

Table 2. Morphological characters examined for the five sampled species of *Micromeria* from Jordan.

Taxon		<i>M. myrtifolia</i>	<i>M. sinaica</i>	<i>M. nervosa</i>	<i>M. fruticosa</i>	<i>M. danaensis</i>
Morphological characters						
Height (cm)		15_40 cm	10_35 cm	15_25 cm	25_50 cm	5_10 cm
Stems	Type of Hairs	Short hooked hairs	Short hooked hairs	long hooked hairs	puperulent hairs	puperulent hairs
	Indumentums	yellow gland	yellow gland	yellow gland	yellow gland	yellow gland
	Color	Green	Green	Red_Green	Green and yellow when dry	Green
Verticillasters	Type	Thyrse (compound dichasium arranged as raceme)	Spike like	Spike like	Cymes long pedunculate	
	Number of flowers	Many flowered (4_7) very dense	many more than 7 flowered,	many more than 7 flowered	Many flowered (4_7)	few flowered (1_2) (_4)
	Peduncle	Pedunculate (1 cm), sometimes part of the stems bearing dense flowered sessile	Sessile (0)	Pedunculate (1 cm)	Pedunculate (2_4 cm)	Pedunculate (1 cm)
	Pedicle	short (2mm)	short (2mm)	short 4 mm	0	short (2mm)
	Indumentums	Hairs short hairs gland Glandular	short hairs Glandular	Long hair Glandular	short hairs glandular	short hairs glandular
Calyx	Shape	Tubular	Tubular	Tubular	Cupuliform	tubular
	Teeth	Not equal (upper teeth longer than lower)	Not equal (upper teeth longer than lower)	Not equal (lower teeth longer than upper as long as calyx)	Short and equal	Short and equal
	Indumentums	glandular and covered with short hairs	glandular and covered with short hairs	glandular and covered with long hairs	glandular and covered with short hairs	Glandular and covered with puberulent hairs
	Long	longer than pedicle	as long as pedicel	longer than pedicle	Long	longer than pedicle
Corolla	Type	Tube, 2_labiate, subincluded	Tube, 2_labiate, exerted	Tube, 2_labiate, subincluded	Tube, 2_labiate, exerted	Tube, 2_labiate, exerted
	Color	Pink	Pink	purplish- pink	White	cream-coloured
	Indumentums	Hairy	Hairy	Hairy	Hairy	Hairy
Leaves	Shape	Elliptic	Ovoid	Ovate	Ovate	oblong to lanceolate
	Long	1 cm	0.2 _ 0.5 cm	0.6 _ 0.9 cm	0.5 _ 2 cm	0.2 _ 0.4 cm
	Width	0.5 cm	0.1 _ 0.4 cm	0.4 _ 0.6 cm	0.5 _ 1 cm	0.1 _ 0.2 cm
	Apex	acute to acuminate	Obtuse	Acuminate	obtuse to subacute	acuminate
	Margin	Entire	Entire	Entire	entire sometimes crenate	entire
	Petiole	Sessile	Sessile	Petiolate	Petiolate	sessile
	marginal vein	Thick	Thick	Thick	Thin	thick
	Indumentums	Glandular and Short hairs	Glandular and Short hairs	Glandular and long hair	Glandular and short hair	Glandular and short hair
Nutlet	Shape	ovoid(elliptical)	Ovoid (elliptical)	Oblong	Oblong (spheroidal)	Ovoid (elliptical)
	Surface Texture	Smooth	minutely puberulous on the upper surface and have tow curves	Smooth	hairy and shiny	minutely puberulous on the upper surface



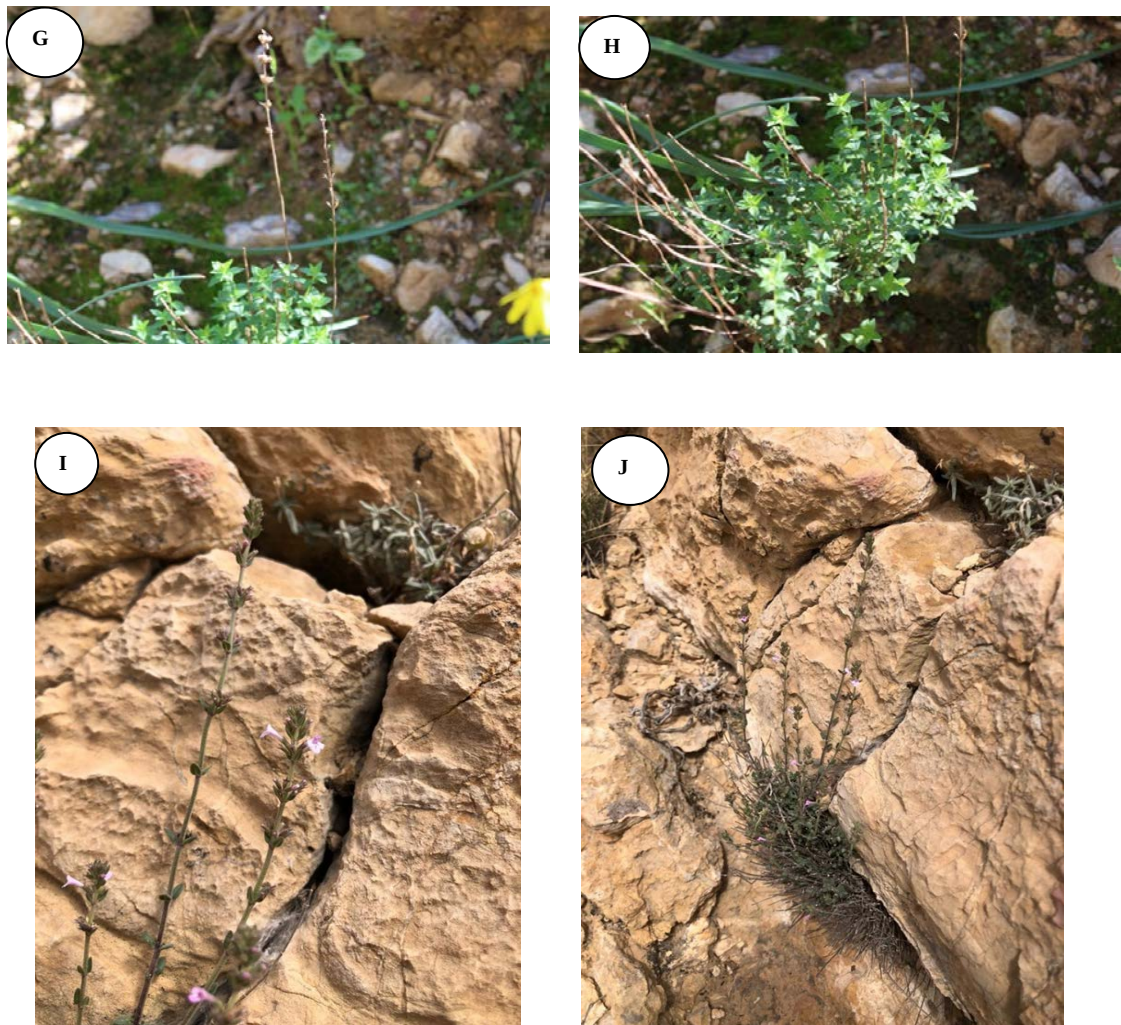


Figure 2: Wild accessions of *Micromeria* species in their natural habitats in Jordan. A&B. *M. fruticosa*, C&D. *M. nervosa*, E&F. *M. myrtifolia*, G&H. *M. sinaica*, and I&J. *M. danaensis*.



Figure 3. Types of the hairs on the stems for the five *Micromeria* species. A. *M. myrtifolia*; stem covered with short, hooked hairs (40x); B. *M. sinaica*; stem covered with short, hooked hairs (40x). C. *M. nervosa*; stem covered with long, hooked hairs (40x); D. *M. danainse*; stem covered with puberulent hairs (40x). E. *M. fruticosa*; stem covered with puberulent hairs (40x).



Figure 4. Upper and lower leaves of the five *Micromeria* species. A. the upper leaves of *M. fruticosa* (20x), B. the lower leaves of *M. fruticosa* (20x), C. the upper leaves of *M. myrtifolia* (20x), D. the lower leaves of *M. myrtifolia* (20x), E. the upper leaves of *M. nervosa* (20x), F. the lower leaves of *M. nervosa* (20x), G. the upper leaves of *M. sinaica* (40x), H. the lower leaves of *M. sinaica* (40x), I. the upper leaves of *M. danaensis* (40x), and J. the lower leaves of *M. danaensis* (40x).

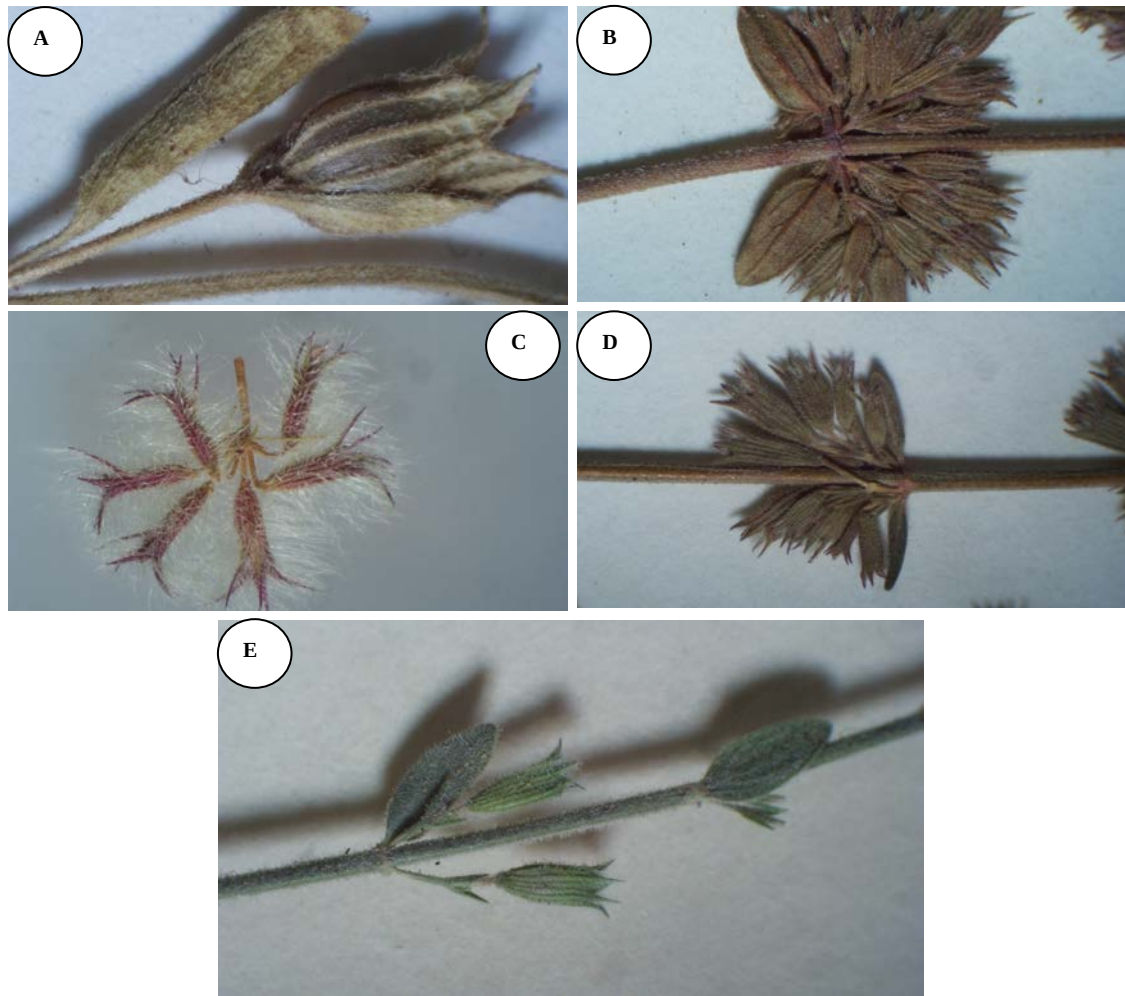


Figure 5. Verticillasters for the five *Micromeria* species under compound microscope (20x). A. *M. fruticosa*, B. *M. sinaica*, C. *M. nervosa*, D. *M. myrtifolia*, and E. *M. danaensis*.

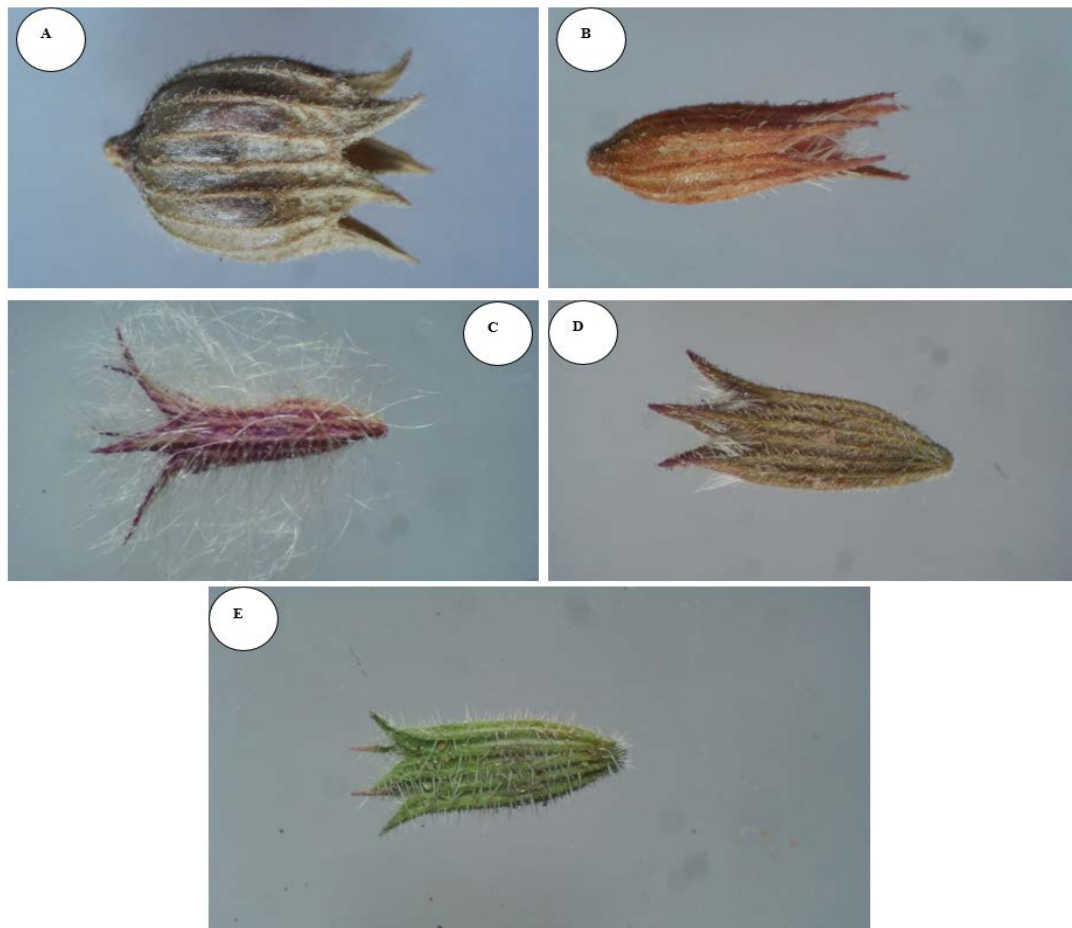


Figure 6. Calyx for the five *Micromeria* species under compound microscope (40X). A. *M. fruticosa*, B. *M. sinaica*, C. *M. nervosa*, D. *M. myrtifolia*, and E. *M. danaensis*.



Figure 7. Nutlets for the five *Micromeria* species under compound microscope (40X); A. *M. fruticosa*, B. *M. sinaica*, C. *M. nervosa*, D. *M. myrtifolia*, and E. *M. danaensis*.

The sixth species of *Micromeria*, which is *M. graceca* was not found in any field trip, and no voucher specimen of this species was found in the herbarium of the Biological Sciences Department, School of Science, at the University of Jordan, and in the herbarium of the Royal Society for the Conservation of Nature (RSCN).

A new key for the species of *Micromeria* in Jordan was constructed to illustrate the variations among closely related species, as following:

1. 1. Corolla white to cream- colored; stem covered with puberulent hairs.....2
2. _ Corolla purplish to pink; stem covered with hooked hairs.....3
3. 2. Verticillasters many flowered (4_7); cymes long pedunculate (2_4 cm). calyx; cupuliform.; leaves; ovate, petiolate.....*M. fruticosa*
4. _ Verticillasters few flowered (1_2) (-4); cymes short pedunculate less than 1 cm; calyx; tubular; leaves; oblong to lanceolate, sessile.....*M. danaensis*
5. 3. Hairs of calyx very long, as long as or exceeding in length of the calyx- tube; calyx teeth as long as calyx.....*M. nervosa*
6. 3- Hairs of calyx shorter than above; calyx teeth less than half as long as calyx tube
7. 4. Verticillasters very dense; Pedunculate (1 cm), part of the stems bearing dense flowered sessile. Calyx longer than pedicel..... *M. myrtifolia*
4. Verticillasters sparse; nearly sessile. Calyx as long as pedicel.....*M. sinaica*

4. Discussion

The genus *Micromeria* has been extensively studied taxonomically, with varying perspectives on its classification. Benthams (1829) first described *Micromeria* as a distinct genus, and later (Benthams 1848), he considered it a single distinct genus. However, Killick (1961) considered *Micromeria* as part of *Satureja* complex. Some taxonomists have divided this complex into several genera, *Satureja* L., *Clinopodium* L., *Calamintha* Mill., *Acinos* Mill. and *Micromeria* Benth. (Benthams 1848, Boissier 1879, Ball, et al. 1972, Davis 1982, Doroszenko 1986). While other taxonomists consolidated the group to a single genus *Clinopodium* (Kuntze 1891) or *Satureja* s.l. (Briquet 1896, and Brenan 1955, Greuter 1986). More recently, taxonomists have considered *Micromeria* as a distinct genus (Doroszenko 1986, Morales Valverde 1993,), while Harley et al. (2004) suggested four sections (*Micromeria*, *Pineolentia*, *Cymularia*, and *Pseudomelissa*) for *Satureja* complex.

This study focused on the morphological features of five *Micromeria* species in Jordan and have provided systematic evidence for distinguishing between these species. As a result of the morphometric variations observed, five species of *Micromeria* in Jordan are identified: *M. nervosa* (Desf.) Benth., *M. fruticosa* (L.) Druce, *M. myrtifolia* Boiss. & Hohen, *M. sinaica* Benth. and *M. danaensis* Danin. Key morphological features, such as differences in leaf shape, stem indumentum, floral structure, and nutlet texture, were instrumental in differentiating these species.

Boulos (2002) in his book "Flora of Egypt" reported and described five species of the genus *Micromeria*; *M.*

serbaliana, *M. sinaica*, *M. imbricata*, *M. nervosa* and *M. mertifolia*. Three of these species; *M. sinaica*, *M. nervosa* and *M. mertifolia* were recorded in Jordan. Additionally, Chaudhry (2001) reported two species in his book Flora of the kingdom of Saudi Arabia: *M. abyssinica* and *M. imbericata*, and none of them recorded in Jordan. Although Al-Eisawi mentioned the presence of *M. graceca* in his 2013 publication (Al-Eisawi, 2013), this species was not found in any of the field trips, or herbariums. Referring to Al-Eisawi (pers. Comm.), his expectation of the presence of this species was based on the records from neighboring regions, such as Egypt and Palestine, in habitats that are similar to Jordan. However, there is still no evidence of the presence of this species in Jordan.

The findings of this study contribute to the broader understanding of *Micromeria* taxonomy in Jordan and neighboring regions. The observed morphological traits align with earlier taxonomic classifications in the region but also highlight areas requiring further investigation. For instance, the absence of *M. graceca* raises questions about its actual range. Future research, incorporating genetic analyses and additional sampling in underexplored areas, could provide deeper insights into the taxonomic relationships and potential undiscovered species within the genus.

5. Conclusion

This study provides a detailed morphometric character of five *Micromeria* species in Jordan: *M. nervosa*, *M. fruticosa*, *M. myrtifolia*, *M. sinaica*, and *M. danaensis*. Key morphological features, such as leaf shape, stem indumentum, floral structure, and nutlet texture, were critical in differentiating these species. The study confirmed the absence of *M. graceca* in Jordan, despite its prior mention in neighboring regions. The findings underscore the importance of morphometric features in species identification and contribute to distinguish the taxonomic framework for *Micromeria* in the region.

The results have significant implications for the conservation of *Micromeria* species in Jordan. By providing clear diagnostic features for species identification, the study helps in monitoring and conserving these species, which are vital to the region's biodiversity. Given the potential for undiscovered *Micromeria* species in Jordan, as seen in neighboring areas such as *M. imbricata* in northern Saudi Arabia (Chaudhry, 2001; Ryding, 2007), *M. serbaliana* in Sinai (Boulos, 2002), and *Micromeria juliana* in Syria (Post & Dinsmore 1933), all in habitats similar to those found in Jordan. This observation opens the way for further research to explore and identify more *Micromeria* species that may potentially exist in Jordan.

Future research should also integrate molecular techniques alongside morphometric data to better resolve taxonomic ambiguities and phylogenetic relationships within the genus. Expanding sampling efforts to include other regions in the Mediterranean and Saharo-Arabian zones, where *Micromeria* species may overlap, could provide valuable insights into species distribution and evolutionary patterns. Additionally, investigating the ecological factors influencing species distribution will be essential for a comprehensive understanding of the genus and its conservation needs.

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Conflict of Interest

The authors declare that they have no conflicts of interest to disclose.

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