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ORIGINAL ARTICLE

Systematic studies on the Zygophyllaceae of Saudi Arabia: Two new subspecies combination in *Tetraena* Maxim

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KEYWORDS

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PCoA;
UPGMA;
Saudi Arabia

Abstract *Tetraena propinqua* (Decne.) Ghazanfar and Osborne ssp. *propinqua* Alzahrani, and *Tetraena propinqua* (Decne.) Ghazanfar and Osborne ssp. *migahidii* (Hadidi ex Beier & Thulin) Alzahrani, are described and illustrated as new subspecies combination nova from Saudi Arabia. The diagnostic characters, description, detailed illustrations, geographical distribution, key to subspecies and taxonomic discussion are provided. The similarities and significant differences between the two subspecies are confirmed by PCoA and UPGMA analyses. The World Conservation Union (IUCN) threatened category and observations on the population are noted.

1. Introduction

Zygophylloideae, in the classification by Sheahan and Chase (1996, 2000), are the largest subfamily in Zygophyllaceae, and consist of about 180 species of shrubs, subshrubs and herbs mainly distribute in arid and semi-arid of areas especially in saline all over the tropics and subtropics regions. At that time, these species were grouped in 4 genera namely *Zygophyllum* L. (c. 150 species, widespread), *Fagonia* L. (c. 30 species, widespread), *Augea* Thunb. (monotypic, southern Africa) and *Tetraena* Maxim. (monotypic, China).

Beier et al. (2003) used morphological characters and non-coding *trn*L plastid data to investigate the phylogenetic relationships within the subfamily Zygophylloideae. Their results indicated that *Fagonia* and *Tetraena* are nested within *Zygophyllum*. Therefore, they transferred 61 and 35 species from *Zygophyllum* to *Fagonia* and *Tetraena*, respectively as new combinations. However, they resurrected *Roepera* A. Juss. as a valid genus (originally described from Australia) and proposed *Melocarpum* as a new genus (previously *Zygophyllum* sect. *Melocarpum*). Moreover, they morphologically distinguished *Zygophyllum* from *Tetraena*; the fruit being a loculicidal capsule and the staminal appendages undivided in the former, whereas in the latter the fruit is a schizocarp and the staminal appendages sometimes split. Generally, Zygophylloideae, in the classification by Beier et al. (2003) comprises of 6 genera, namely *Zygophyllum* L. with ±50 species in Asia, *Fagonia* L. with ±30 species in the Old and the New Worlds, *Augea* Thunb. with a single species in southern Africa, *Roepera* A. Juss. with ±60 species in Australia and southern Africa,

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Tetraena with ±40 species mainly in Africa and Asia and *Melocarpum* (Engl.) Beier and Thulin with two species in the Horn of Africa. Subsequently, many authors (e.g. Norton et al., 2009; Sakkir et al., 2012; Louhaichi et al., 2011; Mosti et al., 2012; Azevedo, 2014; Symanczik et al., 2014; Alzahrani and Albokhari, 2016, 2017; Ghazanfar and Osborne, 2015) followed the classification proposed by Beier et al. (2003).

Prior to 2003, *Tetraena* was treated as a monotypic genus and its only species, *T. mongolica* Maxim. is a restricted-range species confined to western Inner Mongolia in China. Currently, *Tetraena* comprises about 40 species with a distribution extending from the Canary Islands in the west, South Africa in the south to China in the east; of which 8 species are found in Saudi Arabia (Ghazanfar and Osborne, 2015).

Zygophyllum migahidii Hadidi, 1977 is known from Saudi Arabia and Iraq, and is one of the species transferred by Beier et al. (2003) from *Zygophyllum* to *Tetraena* to be *T. migahidii* (Hadidi) Beier and Thulin. In the original description of this species, El-Hadidi (1977) stated that it is closely allied to *Z. propinquum* Decne., 1835, but flowers and fruits are solitary in the former and arranged in clusters in the latter. Several authors considered *Z. migahidii* a valid species (e.g. Hosny, 1988; Mandaville, 1990; Migahid, 1996; Chaudhary and Al-Jowaid, 1999; Collenette, 1998, 1999; Al-Arjany, 2011; Waly et al., 2011), while other authors (e.g. Thomas and Chaudhary in Chaudhary, 2001) treated it as a subspecies of *Z. propinquum* [*Z. propinquum* ssp. *migahidii* (Hadidi) Thomas and Chaudhary in Chaudhary, 2001)] due to some differences in the morphology of their leaflets and capsules.

Zygophyllum propinquum Decne. 1835 is known from Egypt (Sinai), Jordan, Syria, Palestine, Saudi Arabia, Kuwait, Iraq, south Iran, Afghanistan and Pakistan. Through a recent typification, Ghazanfar and Osborne (2015) redescribed this species and transferred it to *Tetraena* to be *T. migahidii* (Decne.) Ghazanfar and Osborne (2015). They also examined the original material that identified by El-Hadidi (1977) as *Z. migahidii* at Kew Herbarium (K) and the Natural History Museum Herbarium (BM), observing that it is very difficult to distinguish this material from that of *Z. propinquum* and the specific taxonomic difference used by El-Hadidi (1977) to distinguish these two species from each other were not true. Therefore, they considered *Z. migahidii* as a synonymy of *T. propinquum*.

In the present study, *Tetraena propinqua* (Decne.) Ghazanfar and Osborne (2015) and *T. migahidii* (Hadidi) Beier and Thulin (2003) are considered as two subspecies of *T. propinqua* based on the morphological characters of leaf, flower and capsule, and their qualitative and quantitative analyses.

2. Materials and methods

During 2013–2014, plant material was collected in Saudi Arabia at central, eastern and western Saudi Arabia (Fig. 1). Four samples of *Tetraena propinqua* were collected from Shuaibah, Umluj and 13 samples were collected from different locations in Central region of Saudi Arabia: Wadi Tarabah; Al-Qaeid road, Hail; Alkhadrah, Taif-Riyadh road; Almuzahmeiah, West of Riyadh; Khurais Road, 150 km before Al Ahsa; Shedgum, next to the cement factory, Al Ahsa-Dammam road; Al Ahsa-Dammam road; Buqaiq, Al Ahsa-Dammam road; Riyadh, King Khaled International

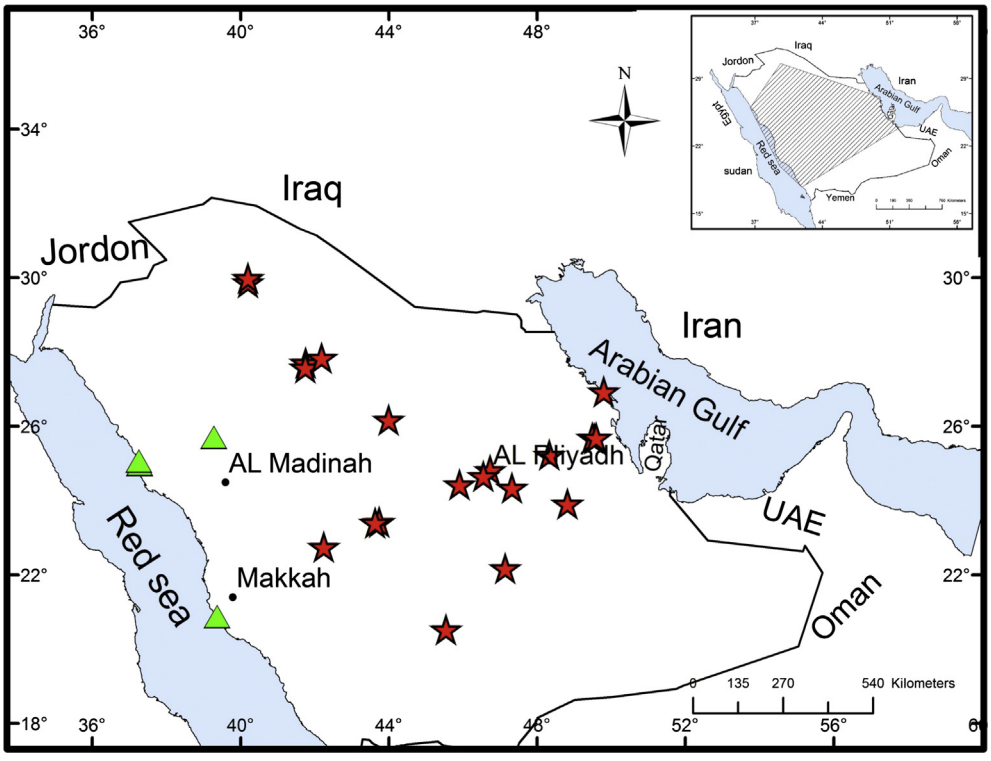

Figure 1 A distribution map of *Tetraena propinqua* subspecies in Saudi Arabia: *T. propinqua* ssp. *propinqua* ▲, *T. propinqua* ssp. *migahidii* ★.

Table 1 Seven quantitative morphological characters of 25 Saudi Arabian *Tetraena propinqua* subspecies plants.

No. of characters	Characters
1	Length of leaflet petiole
2	Width of leaflet
3	Length of leaflet
4	Length of fruit pedicle
5	Length of fruit
6	Width of fruit-upper end
7	Width of fruit-lower end

Airport road; Alsharamiah, Riyadh-Taif road; Dhalam, Riyadh-Taif road; Beirut Street, Hail; Before Alhumiat, Riyadh-Taif road. In each case, several duplicate herbarium specimens were made, and additional samples were preserved in 70% ethanol. Herbarium specimens of *T. propinqua* from different herbaria were critically examined: the National Agriculture and Water Research Center and National Herbarium of Saudi Arabia, Riyadh (National Herbarium, RIY); King Saud University Herbarium, Saudi Arabia, Riyadh (KSU); Herbarium of Faculty of Science, Cairo University, Cairo, Egypt (CAI); Royal Botanic Gardens, England, Kew (K); and Royal Botanic Garden, Edinburgh (E). Drawings were based on both fresh and herbarium specimens (17 and 8 samples). Microscopic examination and measurements of 10 (7 quantitative and 3 qualitative) morphological characteristics (Tables 1 and 2), including both vegetative and reproductive features, such as leaf, flower and fruit characters were estimated with the aid of a *Novex* AP-20 streomicroscope and ×10 hand lens. The average measurements for ten mature leaves, flowers and fruits were taken for each sample was scored. Measurements of dried herbarium specimens were boiled in distilled water. Measurements are given in millimeters, except where indicated.

Table 3 Three qualitative morphological characters and character states used in morphometric analysis of the *Tetraena propinqua* subspecies plants.

Character	Character state	Code
Leaf character		
Leaf apex	Rounded	1
	Acute	2
Flower character		
Colour of flower	White creamy	1
	White	2
Fruit character		
Fruit shape	Obovate oblong 5-angled	1
	Obconical 5-angled	2

Qualitative and quantitative characters of *T. propinqua* were analyzed by the Principal Coordinates Analysis (PCoA) and the Unweighted Pair Group Method with Arithmetic Algorithm (UPGMA), based on the similarity matrix generated using Gower's general similarity coefficient (Gower, 1966). Both analyses were performed using the package MVSP version 3.1 (Kovach, 1999). Qualitative characters were coded as binary characters (Table 3). Conservation threat assessments follow the International Union for Conservation of

Table 2 Three qualitative morphological characters and character code (Ch) of 25 Saudi Arabian *Tetraena propinqua* subspecies plants.

No. of samples	Taxon	Character code		
		Ch 1	Ch 2	Ch 3
1	*T. propinqua* ssp. *migahidii* 143	1	1	1
2	*T. propinqua* ssp. *migahidii* 145	1	1	1
3	*T. propinqua* ssp. *migahidii* 5	1	1	1
4	*T. propinqua* ssp. *migahidii* 6	1	1	1
5	*T. propinqua* ssp. *migahidii* 7	1	1	1
6	*T. propinqua* ssp. *migahidii* 27	1	1	1
7	*T. propinqua* ssp. *migahidii* 31	1	1	1
8	*T. propinqua* ssp. *migahidii* 32	1	1	1
9	*T. propinqua* ssp. *migahidii* 33	1	1	1
10	*T. propinqua* ssp. *migahidii* 36	1	1	1
11	*T. propinqua* ssp. *migahidii* 37	1	1	1
12	*T. propinqua* ssp. *migahidii* 53	1	1	1
13	*T. propinqua* ssp. *migahidii* 29	1	1	1
14	*T. propinqua* ssp. *migahidii* s.n.	1	1	1
15	*T. propinqua* ssp. *migahidii* s.n.	1	1	1
16	*T. propinqua* ssp. *migahidii* s.n.	1	1	1
17	*T. propinqua* ssp. *migahidii* s.n.	1	1	1
18	*T. propinqua* ssp. *propinqua* 109	2	2	2
19	*T. propinqua* ssp. *propinqua* 133	2	2	2
20	*T. propinqua* ssp. *propinqua* 137	2	2	2
21	*T. propinqua* ssp. *propinqua* 141	2	2	2
22	*T. propinqua* ssp. *propinqua* s.n.	2	2	2
23	*T. propinqua* ssp. *propinqua* s.n.	2	2	2
24	*T. propinqua* ssp. *propinqua* s.n.	2	2	2
25	*T. propinqua* ssp. *propinqua* s.n.	2	2	2

Nature (IUCN, 2014). Voucher specimens are deposited in the King Abdulaziz University herbarium.

3. Results

3.1. Morphological analyses

3.1.1. Principal coordinates analysis (PCoA)

Gower's general similarity coefficient (Gower, 1966) was used for PCoA based on morphological data and shown in Fig. 2. The first three principal coordinate axes accounted for 46.233%, 14.636%, and 8.173% of the total variation in the data, respectively. The variance of the first two principal coordinates explained 60.869% of the total variation and the ordination of these two axes showed two groups (Fig. 2A). The variance of the first and third principal coordinates accounted 54.406% of the total variation and the two-dimensional plots of these two axes revealed two groups (Fig. 2B).

3.1.2. Cluster analysis (UPGMA)

In order to investigate the relationships among the Saudi Arabian *T. propinqua* accessions, the UPGMA analysis was examined based on Gower's general similarity coefficient (Gower, 1966). The UPGMA separate Saudi Arabian *T. propinqua* into two clusters (Fig. 3).

Tetraena propinqua plants are distributed in different locations in Saudi Arabia (Fig. 1). However, during field collection, some morphological varieties, especially in the leaf, flower parts and capsule characters (Figs. 4 and 5, Table 4), were observed among individuals' plants of this species. The PCoA and the UPGMA examination showed significant difference for qualitative and quantitative morphological characters studied. Individuals of *T. propinqua* accessions were split off in the PCoA of morphological data as two clusters in both first two axes and in the first and third axes (Fig. 2A and B). In cluster 1, seventeen individuals with characters entirely overlapping those of *T. propinqua* ssp. *migahidii* were grouped

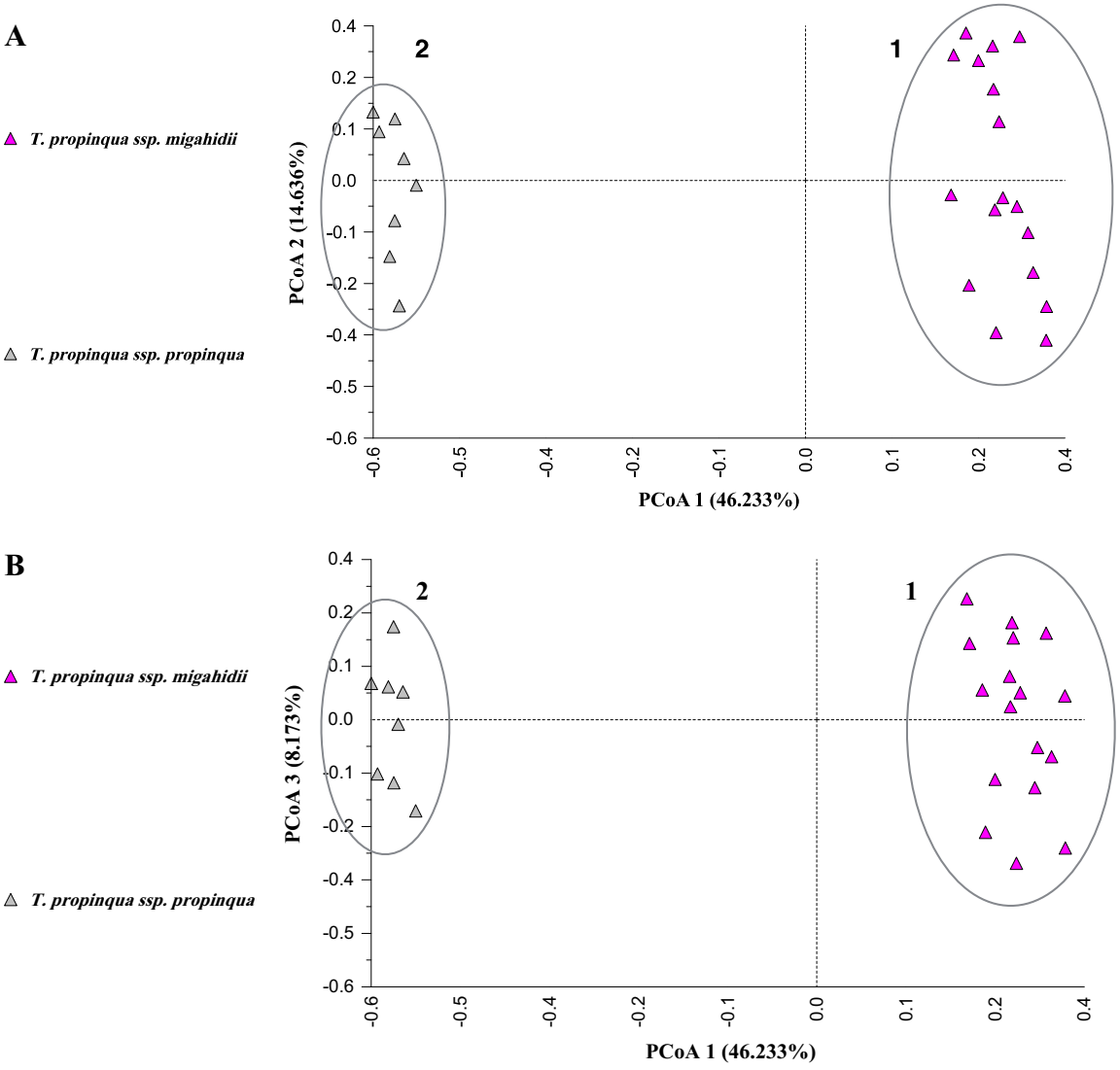

Figure 2 PCoA representation of morphological data of 25 accessions of Saudi Arabian *T. propinqua* plants using Gower's general similarity coefficient (Gower, 1966). (A) Principal coordinates axis 1 and 2. (B) Principal coordinates axis 1 and 3. Different symbols correspond to different subspecies as shown in the inserted legends. Clusters are indicated by numbers.

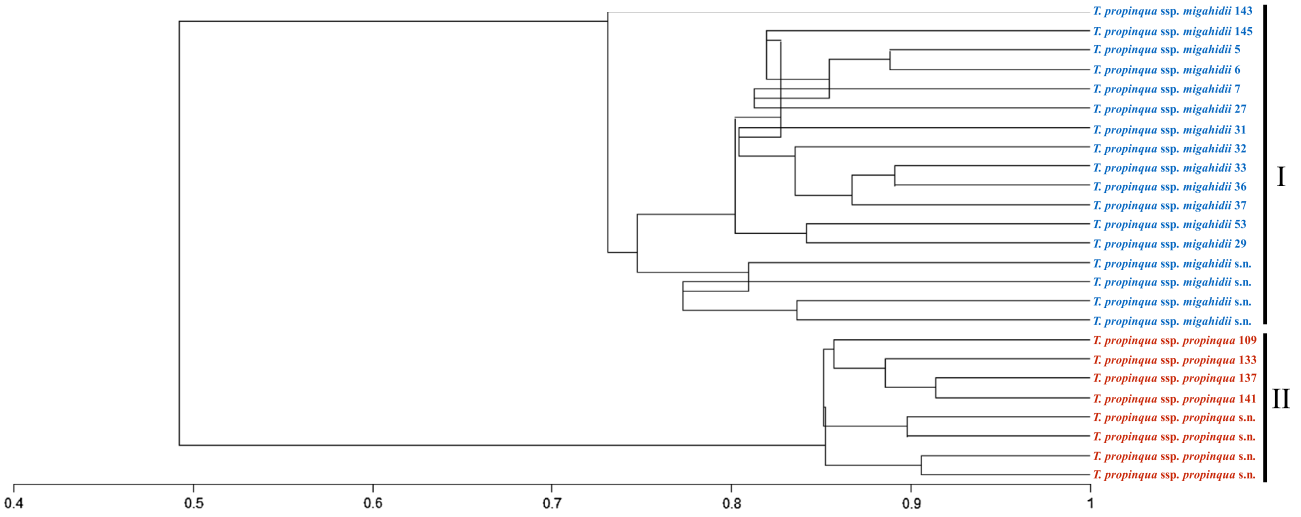

Figure 3 UPGMA analysis representation of morphological data of 25 accessions of Saudi Arabian *Tetraena propinqua* subspecies plantsusing Gower's general similarity coefficient (Gower, 1966). Roman numerals are used to identify the clusters.

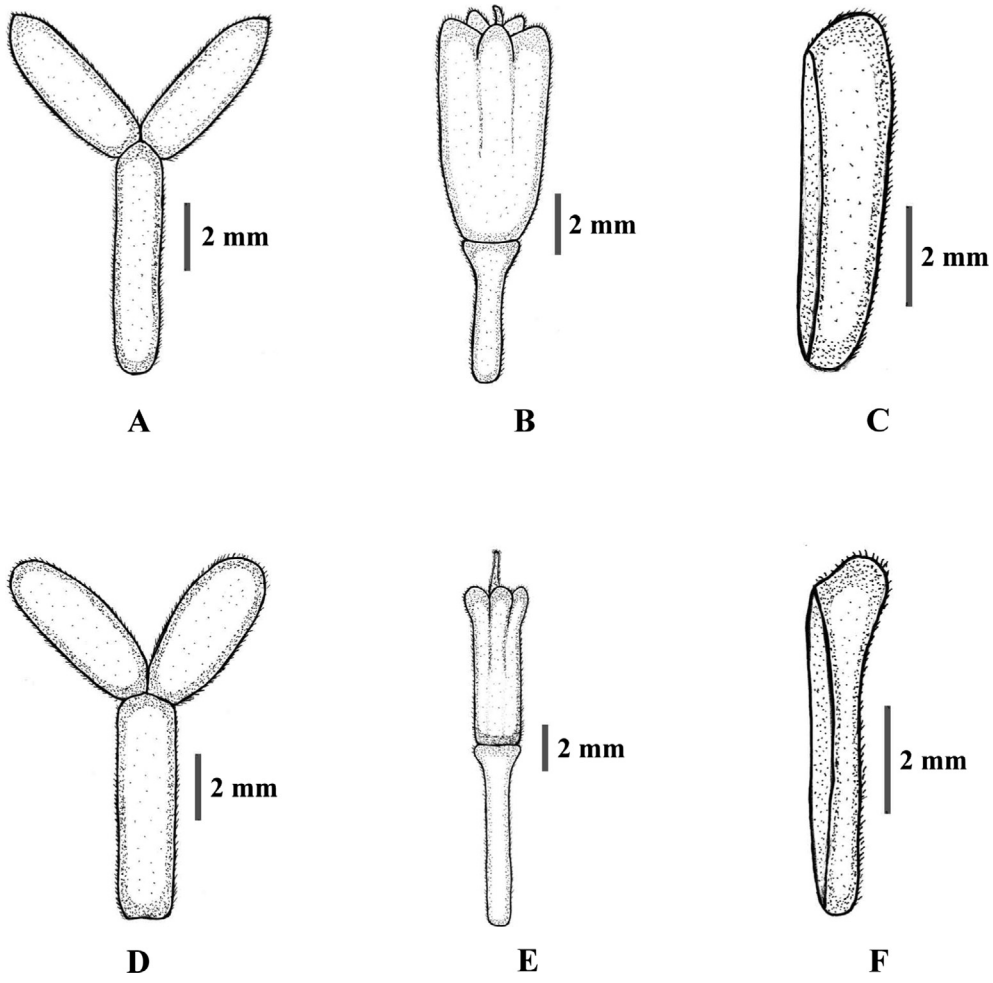

Figure 4 Morphological characters variations in leaves and fruits of *Tetraena propinqua* subspecies. (A) leaf shape of *T. propinqua* ssp. *propinqua*, (B) fruit shape of *T. propinqua* ssp. *propinqua*, (C) capsule lobe shape of *T. propinqua* ssp. *propinqua*, (D) leaf shape of *T. propinqua* ssp. *migahidii*, (E) fruit shape of *T. propinqua* ssp. *migahidii*, (F) capsule lobe shape of *T. propinqua* ssp. *migahidii*.

Figure 5 General leaves, flowers and fruits of *Tetraena propinqua subspecies*. (A) leaves, flowers and fruits of *T. propinqua* ssp. *propinqua*, (B) leaves and fruits of *T. propinqua* ssp. *propinqua*, (C) leaves, flowers and fruits of *T. propinqua* ssp. *migahidii*, (D) leaves and fruits of *T. propinqua* ssp. *migahidii*.

Table 4 Principal morphological differences between *Tetraena propinqua* subspecies.

No.	Morphological characters	*T. propinqua* ssp. *propinqua*	*T. propinqua* ssp. *migahidii*
1.	Apex of leaflet	Acute	Rounded
2.	Flower pedicle length	Up to 7 mm	Up to 14 mm
3.	Colour of flower	White	White creamy
4.	Capsule shape	Obovate oblong 5 angled	Obconical 5 angled
5.	Capsule size	9–13 × 4–6.5 mm	9–12 × 3–5 mm
6.	Capsule pedicle length	Up to 7 mm	Up to 14 mm

together, in cluster 2, eight individuals with characters entirely overlapping those of *T. propinqua* ssp. *propinqua* were grouped together. Likewise, in the UPGMA dendrogram (Fig. 3), individuals of *T. propinqua* split off as two clusters; cluster I includes seventeen individuals with characters entirely overlapping those of *T. propinqua* ssp. *migahidii*, cluster II comprises eight individuals with characters entirely overlapping those of *T. propinqua* ssp. *propinqua*.

3.2. Taxonomy

3.2.1. Tetraena propinqua

Perennial shrubs, green to grey-green, up to 50 cm high, 80–100 cm wide; stems erect to ascending, pubescent, with unicellular simple trichomes; leaves 2-foliolate, opposite, green to whitish green; leaflets cylindrical, up to 12 mm long, 2–4 mm wide, apex rounded or acute, fleshy, pubescent, sometimes

becoming glabrescent; petiole terete, fleshy, up to 14 mm long, green to whitish green, pubescent, sometimes becoming glabrescent; stipules triangular, herbaceous, 1 × 1.5 mm, pubescent. Flowers bisexual, white or white-creamy, 1–3 at each node, 4–7 × 3.5–5 mm, white pubescent; pedicle 7–14 mm long. Sepals 5, free, yellowish green, rounded-obtuse at the apex, deciduous, obovate, 3–5 × 2–3 mm, pubescent, aestivation imbricate. Petals 5, free, white to yellowish, spathulate, 2.5–6 × 1–3 mm, aestivation open. Stamens 10, membranous, yellowish, 3–5 mm long, staminal appendages, undivided, 2–3.5 mm long, 1 mm wide; anther 2 lobes, yellow, dorsifixed, dehiscence longitudinally. Disc smooth. Ovary 5-locular, oblong, angular, pubescent; single style, 1–2 mm long, glabrous to pubescent. Stigma simple; Capsules schizocarpic, obovate to oblong or obconical, truncate or retuse at apex, 5-angled, 7–13 mm long, 3–6.5 mm wide of upper end, 2–5 mm wide of lower end, pubescent; pedicle up to 14 mm long, pubescent. Seed 4–7 in each locule, elliptic, 1–2 mm, tuberculate, brown.

3.2.2. Key to subspecies

1- Leaflets apex acute, flowers white, pedicle up to 7 mm long, capsule obovate oblongs 5- angled, 9–13 mm long, 4–6.5 mm wide of upper end, 2–4 mm wide of lower end, pedicle up to 7 mm long ..... ssp. *propinqua*.
2- Leaflet apex rounded, flowers white-creamy, pedicle up to 14 mm long, capsules obconical 5-angled, 9–12 mm long, 3–5 mm wide of upper end, 2–5 mm wide of lower end, pedicle up to 14 mm long ..... ssp. *migahidii*.

3.2.3. Tetraena propinqua (Decne.) Ghazanfar and Osborne ssp. ***propinqua*** **Alzahrani**, *comb. nov.* (Figs. 4A–C and 5A, B)

Type: Sinai, Gallam, Tor, June 1832, Bové 172 and 173 (K!, isotype).

Syntypes: "Environs de Tor, Sinai" Bové 171, 172, 173, BM, BR, G, K, W).

Epitype (designated by Ghazanfar and Osborne): Iraq, Western Desert Distr., 200 km E of Rutba, 300 m, 24 June 1975, Omar, Kaisi and Hamad 43929 (K; isoepitype BAG). Illustration: Fl. Iraq 4 (1): 299, pl. 54, 1–8 (Townsend and Guest 1980).

Basionym: Tetraena propinqua (Decne.) Ghazanfar and Osborn, in Kew Bulletin, 70: 38 (2015).

Synonyms: Zygophyllum propinquum Decne, in Ann. Sci. Nat., Bot. sér. 2, 3: 283 (1835); *Zygophyllum propinquum* ssp. *propinquum* Decne., Chaudhary in flora of the Kingdom of Saudi Arabia vol. 2: 501 (2001); *Zygophyllum propinquum* ssp. *propinquum* Decne., Chaudhary in flora of the Kingdom of Saudi Arabia vol. 2: 501 (2001).

Conservation status: The current conservation status of the *T. propinqua* ssp. *propinqua* appears to be distributed in some localities in the north region and western central of Saudi Arabia. At the international level, this species is evaluated as Least Concern (LC) since it also grows in Egypt (Sinai), Palestine, Iraq, Iran, Afghanistan, Pakistan and India (IUCN, 2014).

Habitat: Sandy and gravel desert.

Phenology: Flowering and fruiting from February to June.

Vernacular name (Arabic): Harm, Rotreyt. رطريط ، هرم

Distribution: Saudi Arabia: Western to Northwestern of Saudi Arabia, Word wide: Egypt (Sinai), Palestine, Iraq, Iran, Afghanistan, Pakistan and India.

Specimens examined: Saudi Arabia: Shuaibah (20°52′23″N 39°22′16″E), February 2013, Alzahrani and Albokhari D&E109 (KAUH*); Umluj (24°59′05″N 37°17′09″E), March 2013, Alzahrani and Albokhari D&E133 (KAUH); Umluj (24°58′19″N 37°17′03″E), March 2013, Alzahrani and Albokhari D&E137 (KAUH); Umluj (24°58′19″N 37°17′03″E), March 2013, Alzahrani and Albokhari D&E141 (KAUH); Dhallam, May 1998, Thomas s.n. (KSU); 9 km south of Khaybar, October 1989, Collenette 7287 (K). *Iraq*: On the road near Karbala-Liwa, July 1962, Al-Ani and Mohamed 12 (K); Karbala Musseiyib, October 1947, Gillett 9968 (K). *Egypt*: Sinai. Tor, April 1836, Bové 274 and 275 (K!, isotype); Gallam, Tor, June 1832, Bové 172 and 173 (K!, isotype).

3.2.4. Tetraena propinqua (Decne.) Ghazanfar and Osborne ssp. ***migahidii*** (Hadidi ex Beier and Thulin) **Alzahrani, *comb. nov.*** (Figs. 4D, E, F and 5C, D)

Type: Saudi Arabia, Al-Hail, May 1976, Migahid, El-Sheikh and S. Awad 574/A (CAI, holotype; KSU!, isotype).

Basionym: *Zygophyllum propinquum* ssp. *migahidii* (Hadidi) Thomas and Chaudhary, Chaudhary in flora of the Kingdom of Saudi Arabia vol. 2: 501 (2001).

Synonyms: Zygophyllum migahidii Hadidi, in Publ. Cairo Univ. Herb. 7 and 8: 328 (1977); *Zygophyllum propinquum* ssp. *migahidii* (Hadidi) Thomas and Chaudhary, Chaudhary in flora of the Kingdom of Saudi Arabia vol. 2: 501 (2001); *Tetraena migahidii* (Hadidi) Beier and Thulin, in Pl. Syst. Evol. 240 (1–4): 36 (2003).

Conservation status: The current conservation status of the *T. propinqua* ssp. *migahidii* appears to be distributed in some localities in the north region and western central of Saudi Arabia. At the international level, this species is evaluated as Least Concern (LC) since it also grows in Iraq (IUCN, 2014).

Habitat: Sandy salt habitats and gravels desert.

Phenology: Flowering and fruiting from February to June.

Vernacular name (Arabic): Harm, Rotreyt. رطريط ، هرم

Distribution: Saudi Arabia: N-Saudi Arabia: Nafud Desert, WC-Saudi Arabia: Nejd Desert; Word wide: Iraq.

Specimens examined: Saudi Arabia: Alkhasrah, Taif-Riyadh road (23°24′59″N 43°43′27″E), May 2013, Alzahrani D5 (KAUH*); Almuzahmeiah, West of Riyadh (24°25′38″N 45°57′32″E), May 2013, Alzahrani D6 (KAUH); Khurais Road, 150 km before Al Ahsa (25°11′47″N 48°19′12″E), May 2013, Alzahrani D7 (KAUH); Al Ahsa-Dammam road (25°37′33″N 49°32′12″E), May 2013, Alzahrani D27 (KAUH); Shedgum, next to the cement factory, Al Ahsa-Dammam road (25°40′07″N 49°30′3″E), May 2013, Alzahrani D29 (KAUH); Buqaiq, Al Ahsa-Dammam road (26°54′03″N 49°50′09″E), May 2013, Alzahrani D31 (KAUH); Riyadh King Khaled International Airport road (24°50′57″N 46°44′14″E), May 2013, Alzahrani D32 (KAUH); Alsharamiah, Riyadh-Taif road (25°40′07″N 49°30′3″E), May 2013, Alzahrani D33 (KAUH); Before Alhumiat, Riyadh-Taif road (23°22′41″N 43°37′29″E), May 2013, Alzahrani D36 (KAUH); Dhalam, Riyadh-Taif road (22°44′17″N 42°12′48″E), May 2013, Alzahrani D37 (KAUH); Beirut Street, Hail (27°33′48″N 41°43′47″E), May 2013, Alzahrani D53 (KAUH); Wadi Tarabah, May 2013, Aldahan 1 (KAUH); Al-Qaeid road, Hail,

April 2013, Asiri K1 (KAUH); Al-Hail, May, 1976; Migahid, El-Sheikh and S. Awad 574/A (CAI, holotype; KSU!, isotype); Riyadh, March 1993, Thomas 1253 (KSU); Riyadh, March 1994, Thomas 10802 (KSU); Riyadh, April 2003, Thomas 21393 (KSU); Al-Kharj road, April 1981, Noor 2296 (KSU); Buraidah, May 1983, Chaudhary s.n. (National Herbarium, RIY); Unaizah, May 1978, Chaudhary s.n. (National Herbarium, RIY); Unaizah, May 1978, Chaudhary s.n. (National Herbarium, RIY); Chara, May 1985, Heemstra 7428 (National Herbarium, RIY); As Sulayyil, May 1996, Chaudhary s.n. (National Herbarium, RIY); Riyadh, May 1984, Chaudhary s.n. (National Herbarium, RIY); Aflaj, June 1984, Jahangir s.n. (National Herbarium, RIY); RAWRC, 1984, Chaudhary s.n. (National Herbarium, RIY); Aarqah, May 1984, Chaudhary s.n. (National Herbarium, RIY); 30 km southwest Harad, November 1987, Mandaville 8696 (CAI); Riyadh, April 1988, Collenette 6731 (K, E); 10 km S of Unaizah-Riyadh road, March 1983, Collenette 4114 (K); Southern of Riyadh, October 1987, Collenette 6314 (K, E); 2 km SE of Khurmah, Riyadh road, July 1991, 7851 (K). *Iraq*: Habbanya, June 1966, Rawi and Alizzi 34453 (K); 40 km S. of Baghdad, road to Karbala, November 1958, Rawi 26883 (K).

4. Discussion

Ghazanfar and Osborne (2015) counted nine species of *Tetraena* that distributed in the SW of Asia including the Arabian Peninsula and Saudi Arabia, they are: *T. alba, T. coccinea, T. decumbens, T. dumosa, T. hamiensis, T. mandavillei, T. propinqua, T. qatarensis,* and *T. simplex*. They did not use *Tetraena migahidii* (Hadidi) Beier and Thulin 2003, in their comparison with *Zygophyllum propinquum* and it is not reported in the key to the species of *Tetraena* in SW Asia and it is not even mentioned as a synonym under any species either. They only treated the type specimen of *Zygophyllum migahidii* Hadidi (1977) as a synonym to *Tetraena propinqua* (Decne.) Ghazanfar and Osborne (2015).

El-Hadidi (1977) cited in the type description of the *Zygophyllum migahidii* that the main difference between the two species of *Z. propinquum* and *Z. migahidii* is the number of flowers and fruits and the size of capsule pedicle. He reported that the flowers and fruits are solitary at each node and the flower pedicle is 10–15 mm and the capsule pedicle is 8–10 mm long. However, it has been reported, in this study, in all examined specimens including the isotype of *Zygophyllum migahidii* (KSU-574/A), that the flowers are 1–3 at each node even in the apical nodes (agree with the notice of Ghazanfar and Osborne, 2015), while the capsule pedicle is up to 14 mm long, and cannot be shorter than flower pedicle as El Hadidi cited in the original description of *Z. migahidii*. Chaudhary (2001) who recognized *Z. migahidii* as subspecies to *Z. propinquum* reported that there is more than one flower in the basal nodes, and the length of flower and capsule pedicle up to 13 mm. Moreover, Ghazanfar and Osborne (2015) reported that the surface of leaflets pubescent sometimes becoming glabrous and surface of capsule is glabrous in *T. propinqua* (syn. = *Zygophyllum propinquum* Decne.) as cited in the original description of the *Zygophyllum propinquum* Decaisne (283: 1835), but the intensive examination of this work showed that they are pubescent. Additionally, Ghazanfar and Osborne (2015) stated that the leaflet width of *T. propinqua* is 0.5–2 mm, leaflet pedicle as long as or shorter than the leaflets, and the flowers are white and petals are white to yellow. Therefore, their description is inaccurate as they used herbarium specimens since the colour of the flowers can be changed over the stored time. Furthermore, the width of the mature leaflets cannot be as narrow as they reported (0.5 mm). However, it has been found that in all examined specimens of this study that the length of leaflet is up to 12 mm, the leaflet pedicle is up to 14 mm long, and the coloure of flowers in the field samples are white to white-creamy. Decaisne cited in the original description of *Zygophyllum propinquum* that the capsules are ovate-oblong, 5-angled, and glabrous. However, this work has recorded that the capsules are obovate-oblong, 5-angled (agree with Ghazanfar and Osborne, 2015 and Chaudhary, 2001) but the capsules are pubescent not glabrous as they stated.

However, *T. propinqua* differs from other *Tetraena* species in some morphological characteristics such as leaves 2-foliolate, colour of flower and fruit shape. This study has separated this species into two new combination subspecies, *T. propinqua* ssp. *propinqua* and *T. propinqua* ssp. *migahidii*, based on the results of filed observation, morphological examinations and morphometric analyses. *T. propinqua* ssp *propinqua*, can be distinguished by leaf apex acute, white colour of flower, pedicle up to 7 mm long, capsule obovate oblong, 5-angled, 9–13 × 4–6.5 mm, pedicle up to 7 mm long, while *T. propinqua* ssp. *migahidii,* can be distinguished by leaves with apex rounded, white-creamy flowers, pedicle up to 14 mm long, capsules obconical, 5-angled, 9–12 × 3–5 mm, pedicle up to 14 mm long. Additionally, The PCoA and the UPGMA examination indicated significant difference for qualitative and quantitative morphological characters studied. Individuals of each subspecies were grouped together in both first two axes and in the first and third axes of The PCoA analysis (Fig. 2A and B). Similarly, in the UPGMA analysis accessions of each subspecies were clustered together (Fig. 3).

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