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REVIEW

Systematic studies on the Zygothylaceae of Saudi Arabia: A new variety and new variety combination in *Tetraena*



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Abstract During 2013–2014, fresh material of *Tetraena alba* was collected from two localities in Saudi Arabia. Detailed morphological examination of these specimens revealed that there is a new variety of this species, for which the name *T. alba* var. *arabica* is proposed. Fresh material of *Zygothylum amblyocarpum* was also collected from a different locality, and based on its characteristics is transferred to *Tetraena* with the new combination *T. alba* var. *amblyocarpa*. *T. alba* and its varieties are illustrated and morphological characters supplied to differentiate among them. © 2015 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Contents

1. Introduction	1575
2. Materials and methods	1575
3. Taxonomy	1575
3.1. <i>Tetraena alba</i>	1575
Key to the varieties	1575
4. Discussion	1578
Acknowledgements	1578
References	1578

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1. Introduction

Zygophyllaceae is a large cosmopolitan family and currently including five subfamilies, namely Zygophylloideae, Tribuloideae, Seetzenioidae, Larreoidae and Morkillioideae (Sheahan and Chase, 2000; Beier et al., 2003; Bellstedt et al., 2008). Zygophylloideae is the largest subfamily and currently consists of six genera, namely *Zygophyllum*, *Fagonia*, *Augea*, *Roepera*, *Tetraena* and *Melocarpum* (Beier et al., 2003; Bellstedt et al., 2008).

Until recently, *Tetraena* was a monotypic genus, and its only species, *Tetraena mongolica*, is a restricted-range species confined to western Inner Mongolia in China. Based on the combined analyses of morphological and molecular data, Beier et al. (2003) transferred 35 species from *Zygophyllum* to *Tetraena* as new combinations; these species are from Africa and Asia. Subsequently, many authors (e.g. Norton et al., 2009; Sakkir et al., 2012; Louhaichi et al., 2011; Mosti et al., 2012; Azevedo, 2014; Ghazanfar and Osborn, 2015) followed the new classification proposed by Beier et al. (2003). Thus, *Tetraena*, as currently circumscribed, is widespread in China, as well as in the arid and semi-arid parts of tropical and subtropical Africa and Asia. Currently, ten species of *Tetraena* are known from Saudi Arabia (El-Hadidi, 1977; Migahid, 1978; Hosny, 1988; Beier et al., 2003; Ghazanfar and Osborn, 2015).

In the present work, which is based on the detailed morphological study of fresh and herbarium specimens, *Tetraena alba* is described from Saudi Arabia. However, in one location named Umluj, Saudi Arabia (Fig. 1), a plant was found growing in the same area with *T. alba* (L.f.) Beier and Thulin, both sharing some morphological characters, but differing in others, including length of leaflet petiole, flower size, capsule shape and size, and the capsule pedicel length. This entity is here described as a new variety, named *T. alba* var. *arabica*. In addition, *Zygophyllum amblyocarpum* is transferred to *Tetraena* as a new variety combination, namely *T. alba* var. *amblyocarpa*.

2. Materials and methods

During 2013–2014, plant material was collected from Umluj and Shuaibah in Saudi Arabia (Fig. 1). Several duplicate herbarium specimens were made and additional samples were preserved in 70% ethanol. For each taxon herbarium specimens from different herbaria were examined: Saudi Arabia National Herbarium, Riyadh (RIY); King Saud University Herbarium, Riyadh (KSU); Herbarium of Flora and Phytotaxonomy, Research Agricultural Museum, Dokki, Cairo, Egypt (CAIM); Royal Botanic Gardens, England, Kew (K); and Royal Botanic Garden, Edinburgh (E). Material was studied with the aid of a Novex AP-20 stereo microscope and $\times 10$ -hand lens. The average measurements for ten mature leaves, flowers and fruits were taken for each sample. Measurements for leaves, flowers and fruits of dried herbarium specimens were supplemented by rehydrating material in boiling water. Measurements are given in millimetres, except where indicated. Conservation threat assessments follow the International Union for Conservation of Nature (IUCN, 2014). Voucher specimens are deposited in KAUH.

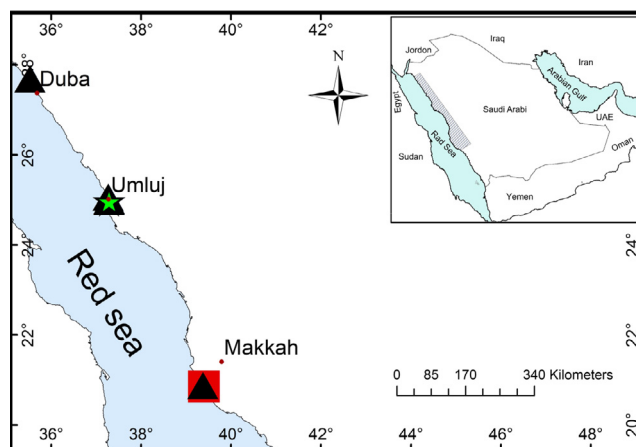


Figure 1 Distribution of *Tetraena* varieties in Saudi Arabia: ▲ *T. alba* var. *alba*, ★ *T. alba* var. *arabica*, ■ *T. alba* var. *amblyocarpa*.

3. Taxonomy

3.1. *Tetraena alba*

Perennial shrubs, green or greenish grey, 50–60 cm high, 40 cm wide. Stems pubescent, with unicellular simple trichomes. Leaves: 2-foliolate, 7–12 mm long, 3–5.5 mm wide, cylindrical or elliptic, apex acute, fleshy; petiole 10–18 long; stipules triangular, herbaceous, 1×1.5 mm, pubescent. Flowers arranged in clusters (sometimes solitary), bisexual, white, $4-5.5 \times 3-5$ mm; pedicel 1–2 mm long. Sepals 5, rounded-obtuse at the apex, herbaceous, yellowish green, obovate, $3-4 \times 2-3$ mm, pubescent, aestivation imbricate. Petals 5, white, spatulate, $3.5-6 \times 1-2$ mm, aestivation open. Stamens 10, 3–4 mm long; staminal appendages undivided, 2–2.5 mm long, 1 mm wide; anthers 2-lobed, yellow, dorsifixed, longitudinally dehiscent; disc smooth. Ovary 5-locular, pubescent; style single, 1 mm long. Capsules a schizocarp, obconical or oblong-obconical, star-shaped or obconical-acute, with keeled lobes $8-13 \times 7-12$ mm, pubescent, endo- and exocarp extending as wings, pedicel 2–6 mm long, pubescent.

Key to the varieties

- (1) Leaflets petiole up to 15 mm long; flowers $4-4.5 \times 3-4.5$ mm; capsules obconical star-shaped, with thick broad lobes $8-10 \times 7-10$ mm; pedicel up to 3 mm long.....
var. *alba*.
- (2) Leaflets petiole up to 18 mm long; flowers 5.5×5 mm; capsules oblong obconical star-shaped, with slightly narrow lobes $11-13 \times 8-10$ mm; pedicel up to 6 mm long.....
var. *arabica*.
- (3) Leaflets petiole up to 10 mm long; flowers 4×4 mm; capsules obconical-acute, with keeled lobes $9-13 \times 8-12$ mm; pedicel up to 6 mm long.....
var. *amblyocarpa*.

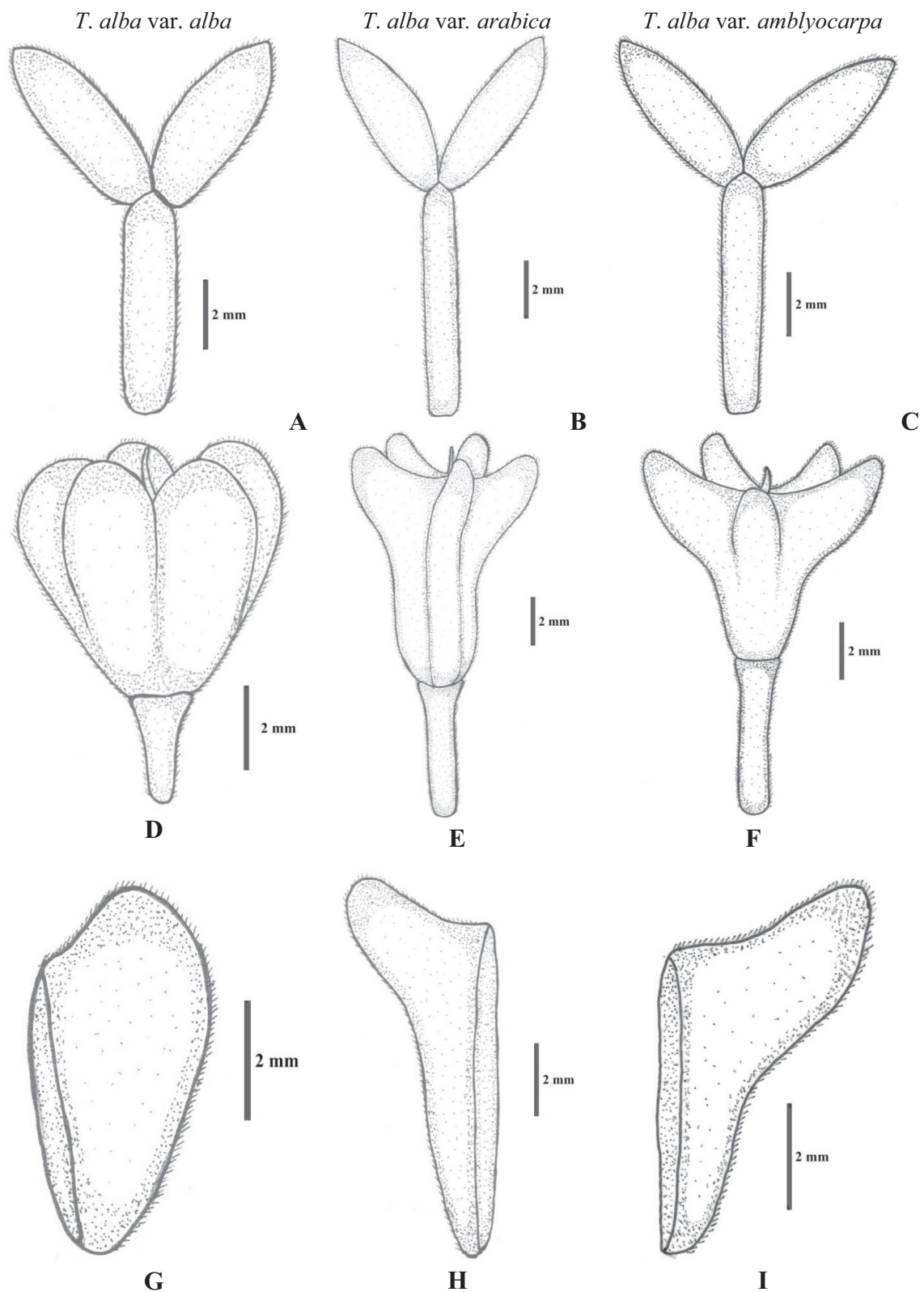


Figure 2 (A–I): (A) Leaf of *T. alba* var. *alba*, (B) leaf of *T. alba* var. *arabica*, (C) leaf of *T. alba* var. *amblyocarpa*, (D) fruit of *T. alba* var. *alba*, (E) fruit of *T. alba* var. *arabica*, (F) fruit of *T. alba* var. *amblyocarpa*, (G) capsule lobe of *T. alba* var. *alba*, (H) capsule lobe of *T. alba* var. *arabica*, (I) capsule lobe of *T. alba* var. *amblyocarpa*.

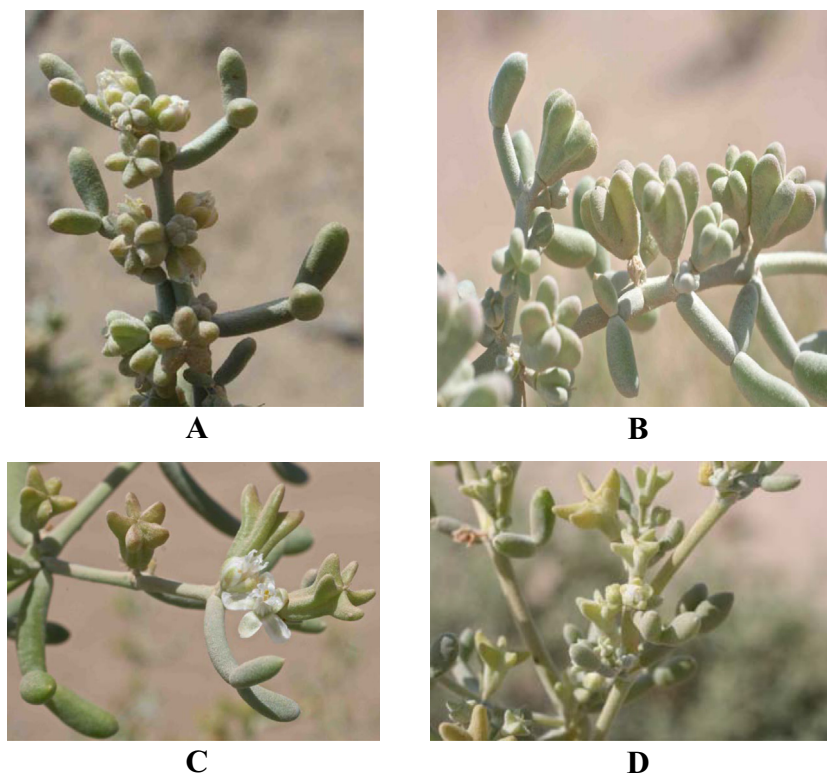


Figure 3 (A–D): (A) Leaves, flowers, and fruits of *T. alba* var. *alba*, (B) leaves and fruits of *T. alba* var. *alba*, (C) leaves, flowers, and fruits of *T. alba* var. *arabica*, (D) leaves, flowers, and fruits of *T. alba* var. *amblyocarpa*.

1. *Tetraena alba* (L.f.) Beier & Thulin var. *alba* (Figs. 2A, D, G; 3A and B).

Distinguished by the leaflets petiole being up to 15 mm long; flowers 4–4.5 × 3–4.5 mm; capsules obconical star-shaped, with thick broad lobes 8–10 × 7–10 mm, and pedicel up to 3 mm long.

Type — *Zygophyllum album* L. f. (1762:11), *Lectotype* (designated by El Hadidi in *Webbia* 33: 51, 1978): — United Kingdom. London: Linnaean Society of London Herbarium (LINN), *Linnaeus* HL544-2.

Synonyms — *Zygophyllum album* L.f., Decne. Pl. Hort. Upsal. 11 t. 6 (1762); *Z. proliferum* Forssk. Fl. Egypt. arab.: 12 (1775); *Z. album* L.f. var. *album*, Boulos in flora of Egypt checklist: 81 (1995).

Habitat — Salt marshes, coastal and inland saline sandy soils, sand dunes and plains, and saline depressions.

Phenology — Flowering and fruiting from February to June.

Vernacular names (Arabic) — Rotreyt, Qarmal, Harm.

Distribution — Saudi Arabia: along the Red Sea coast (Fig. 1). Worldwide: Egypt, Jordan, Tunisia, Palestine, Somalia, South Africa and Greece.

Specimens examined — Saudi Arabia: Shuaiba (20°52'23" N, 39°22' 6"E), February 2013, Alzahrani & Albokhari D and E110 (KAUH!); Umluj (24°59'05"N, 37°17'09"E), March 2013, Alzahrani & Albokhari D and E132 (KAUH); Umluj (24°59'05"N, 37°17'09"E), March 2013, Alzahrani & Albokhari D and E134 (KAUH); Umluj (24°59'05"N, 37°17'09"E), March 2013, Alzahrani & Albokhari D and E139 (KAUH); Umluj (25°03'34.87"N, 37°15'50.86"E), May

2014, Alzahrani D148 (KAUH); Umluj (25°03'34.87"N, 37°15'50.86"E), May 2014, Alzahrani D153 (KAUH); Coast 12 km north of Muweli (27°41'6.02"N, 35°29'20.33"E), September 1983, Collette 4521 (National Herbarium, RIY, K); Near Umm Sidrah 75 km north of Jeddah, January 1980, Collette 1518 (K). Egypt: Sallum east, April 1932, Shabetai 1780 (CAIM); Abu-Qir, April 1934, Shabetai 3060 (CAIM); North Abu-Zenima south Sinai, April 1962, Shalaby & Khattab 587 (CAIM); Ma'asara north Cairo, November 1928, Drar 51/837 (CAIM); Sinai. Environs de Tör, June 1832, Bové 1833 (K); Helwan, February 1944, Davis 6302 (E); North of Helwan, February 1944, Davis 6302B (E); Helwan, March 1891, Scott Elliot 3554 (E); Abukir, September 1944, Davis 7205 (E); Mariut Abu-Liq, March 1944, Davis 6478B (E); Alexandria: near Ramleh, 1881, Blomfields N (E); Alexandria: SidiGaber, April 1908, Bornmüller 10,507 (E); El-Meks, May 1908, Bornmüller 10,504 (E). Jordan: Aqaba, October 1989, Leonard 7468 (E). Tunisia: Monastir, September 1968, Davis 48,050 (E); Southeast Tunisia west of Oudref, February 1966, Archibald 884 (E). Greece: July 1950, Davis 18,109 (E); EP. Ierapetro, October 1966, Greuter 7811 (E).

2. *Tetraena alba* (L.f.) Beier & Thulin var. *arabica* Alzahrani & Albokhari, var. nov. (Figs. 2B, E and H; 3C).

Distinguished by the leaflets petiole being up to 18 mm long; flowers 5.5 × 5 mm; capsules oblong-obconical star-shaped, with slightly narrow lobes 11–13 × 8–10 mm, and pedicel up to 6 mm long.

Type — Saudi Arabia, Umluj (24°58'19"N, 37°17'03"E), March 2013, Alzahrani & Albokhari D and E138 (holotype KAUH!; isotype KSU!).

Conservation status — Based on its known distribution and abundance (one collection representing one locality), IUCN red list category (IUCN, 2014) critically endangered under the criteria B2c (i)–(iv); area of occupancy (AOO) estimated to be less than 10 km², C2 an observed, estimated, projected, number of mature individuals in each subpopulation less than 50 (a)–(i), and D number of mature individuals less than 50.

Etymology — The specific epithet is derived from Arabia, the area of its distribution.

Habitat — Found on coastal and inland saline sandy soils, and in salt marsh habitats.

Phenology—Flowering and fruiting from February to June.

Vernacular names (Arabic) — Rotreyt, Qarmal, Harm.

Distribution — Endemic to Saudi Arabia, and appears to be restricted to the western coastal of Saudi Arabia, mainly in the vicinity of Umluj (Fig. 1).

3. *Tetraena alba* (L.f.) Beier & Thulin var. *amblyocarpa* (Baker ex El-Hadidi) Alzahrani & Albokhari, comb. nov. (Figs. 2C, F, I; 3D).

Distinguished by the leaflets petiole being up to 10 mm long; flowers 4 × 4 mm; capsules obconical-acute with keeled lobes 9–13 × 8–12 mm, and pedicel up to 6 mm long.

Basionym — *Zygophyllum album* L.f. var. *amblyocarpum* (Baker) El-Hadidi, in Webbia 33: 52 (1978).

Type — Hadramout, Al Mukalla, Shary Burrock Valley, December 1893; Lunt 51 (holotype K!; isotype BM!).

Synonyms: *Zygophyllum amblyocarpum* Baker, Kew Bull. 1894: 339 (1894).

Conservation status — Least concern, locally common on the western coastal of Saudi Arabia, coastal of Yemen, Egypt and Somalia.

Habitat—Associated with salt marshes.

Phenology — Flowering and fruiting from February to June.

Vernacular names (Arabic) — Rotreyt, Qarmal, Harm.

Distribution — Saudi Arabia: Shuaibah (Fig. 1). Worldwide: South Arabia (Yemen), tropical east and North Africa (Egypt).

Specimens examined — Saudi Arabia: Shuaiba (20°51'10"N, 39°23'47"E), February 2013, Alzahrani & Albokhari D and E107 (KAUH). Yemen: Hadramout, Al Mukalla, Shary Burrock Valley, December 1893, Lunt 51 (K!, holotype); Hadramout: 81 km from Qusayir along road to Sayhut, October 1992, Thulin, Eriksson, Gifri & Långström 8247 (K). Egypt: Jamailia, February 1948, Shabetai 7730 (CAIM); Red Sea region, May 2005, Abdel-Ghani & Abdel-Fattah s.n. (CAIM); Safaga, May 2005, Abdel-Ghani & Abdel-Fattah s.n. (CAIM).

4. Discussion

Tetraena alba is one of the species transferred by Beier et al. (2003) from *Zygophyllum* to *Tetraena*, and is unique among the other species of *Tetraena* in having flowers arranged in clusters (sometimes solitary) and obconical star-shaped capsules. Several authors have recorded this species in the western and northwestern coastal regions of Saudi Arabia (e.g., Collenette, 1985, 1999; Migahid, 1996; Chaudhary, 2001; Waly et al., 2011). However, Atiqur Rahman et al. (2002) recorded it in the southwestern part of Saudi Arabia. Nevertheless, no evidence of herbarium specimens could be found

to support Atiqur Rahman's claim. In the present work, the description of *T. alba* is updated and voucher specimens were deposited in King Abdulaziz University herbarium.

The characters used for the distinction of *T. alba* var. *arabica* as a new variety are known to be taxonomically significant in the group and have been commonly used in taxonomic papers (e.g., Leach and Williamson, 1990; Schnell and Determann, 1997; Thulin, 1999; Stuessy, 2009; Sharma and Pandit, 2011).

Based on the close similarities, El-Hadidi (1978) considered *Z. amblyocarpum* Baker f. (1894) as a variety of *Z. album* (now *T. alba*), namely *Z. album* var. *amblyocarpum* (Baker f.) El-Hadidi (1978), the former differs in having fruits with a very deeply and acutely lobed capsule. Hosny (1988) recorded this variety from south Arabia (Yemen), North Africa (Egypt) and from tropical east Africa. At that time, she considered *Z. album* L.f. found in Saudi Arabia as *Z. album* L.f. var. *amblyocarpum* (Baker f.) El-Hadidi (1978), believing that *Z. album* L.f. is confined to Egypt. Thulin (1993) discussed the confusion between *Z. amblyocarpum* Baker f. or *Z. album* var. *amblyocarpum* (Baker f.) El-Hadidi and *Z. album* L.f. in the populations of tropical Arabia, Somalia and Ethiopia. He adopted *Z. amblyocarpum* Baker f. as the accepted name because the variation seems to be continuous within the populations. Beier et al. (2003) 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. *Zygophyllum album* var. *amblyocarpum* having these characters of *Tetraena*, but was not transferred to *Tetraena* by Beier et al. (2003). Therefore, *Z. album* var. *amblyocarpum* is herein transferred to *Tetraena* as *T. alba* var. *amblyocarpa* new combination.

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