Review
26

Egypt. J. Bot. **Vol. 64,** No. 2, pp. 467 - 495 (2024)

Egyptian Journal of Botany
http://ejbo.journals.ekb.eg/

A Spotlight on *Retama* spp., The Mediterranean Evergreen Stem-assimilating Xerophyte

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GENUS *Retama* L. (Leguminosae, Tribe Genisteae), is a Mediterranean genus, it naturalized in the new world recently. It includes four (*Retama dasycarpa*, *R. monosperma*, *R. raetam* and *R. sphaerocarpa*) xeromorphic, stem assimilating species. The associated species to the *Retama* spp. are variable and controlled by the spatial distribution and geographic location of each species. The pollen grain of *Retama* spp. is monad, trizono-colporate, some *Retama* spp. flowers are lacking nectar, *others* are nectar-producing species and insect pollinated. *Retama* spp. utilize a combination of defense mechanisms, acclimatization and adaptation strategies including the stress response genes, physiological and microbiological adaptations to both drought and salinity stresses. Soil and endophytic microbes play an important role in improving establishment of *Retama* species under environmental stresses. Genus *Retama* is eutetraploid with homogeneous karyologic chromosomes, the genome size is an adaptive trait correlated to environmental situations.

This review covered the taxonomy of *Retama* species and their potentialities in arid lands particularly for their role in soil protection, stability, fertility, and desert rehabilitation. The phytochemistry of *Retama* species including flavonoids, essential oil, alkaloids, terpenes, steroids, fatty acids, polysaccharides, and mineral composition was elaborated. In addition to its multipurpose uses as fodder, ethnobotanical uses, and pharmacological activities its active compound possess anticancer, antioxidant, hypoglycemic, anti-inflammatory, analgesic, antileukemic, antiarrhythmic, antibacterial, antifungal activities, and others. This study aimed to highlight the potentialities of the C3 shrubby-leguminous species and its adaptive strategies to the arid-desert stresses, to offer interesting trends to improve the economic crops.

Keywords. Assimilating stem, Mediterranean species, *Retama dasycarpa*, *R. monosperma*, *R. raetam*, *R. sphaerocarpa*.

Introduction

Taxonomic description

Genus Retama Raf.

Genus Retama belongs to family Fabaceae; which is one of the most prevalent families in the North Africa of the Mediterranean region (Samala et al.; 2023). Unarmed, much branched shrubs (Jafri, 1980; Boulos, 1999) or small trees (Boulos, 1999). Branches erect or ascending, silky-hairy or glabrous, with slender, green (Zohary, 1972), grooved twigs (Zohary, 1972; Jafri, 1980). Leaves simple, small (Jafri, 1980; Boulos, 1999), exstipulate, (Zohary, 1972), soon deciduous (Jafri, 1980; Boulos, 1999). Flowers white or yellow (Jafri, 1980). Racemes lateral (Boulos, 1999), few- to many flowered (Zohary, 1972; Jafri, 1980). Calyx spathe-like with hemispherical tube (Zohary, 1972) and 5 teeth (Jafri, 1980), ± bilabiate (Jafri, 1980). Corolla much longer than the calyx (Zohary, 1972; Jafri, 1980; Boulos, 1999). Claws of petals adnate to staminal tube. Standard plicate, oblong to obovate-orbicular; wings longer than keel (Zohary, 1972; Jafri, 1980). Stamens 10 Monadelphous (Jafri, 1980), all connate into a closed tube (Zohary, 1972; Boulos, 1999). Ovary sessile or short-stipitate, 2- to few ovules (Zohary,

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Received 09/07/2023; Accepted 03/01/2024
DOI: 10.21608/ejbo.2024.222012.2402
Edited by: Prof. Dr. Francisco Huerta Martinez, University of Guadalajara, Mexico.

1972; Jafri, 1980). Style filiform (Zohary, 1972), glabrous. Stigma papillose (Zohary, 1972; Jafri, 1980). Pod indehiscent (Zohary, 1972; Jafri, 1980; Boulos, 1999) or dehiscent (Boulos, 1999), dilated, ovoid to globose (Jafri, 1980), 1- to 2-seeded (Zohary, 1972; Jafri, 1980; Boulos, 1999). Pericarp leathery or fleshy (Zohary, 1972). Seeds spherical (Boulos, 1999) or globular, yellow or brown (Jafri, 1980), radicle thick, less than half as long as cotyledons (Zohary, 1972), without caruncle (Jafri, 1980; Boulos, 1999).

Genus Retama Raf. in Egypt

Genus *Retama* Raf. in Egypt was subjected to taxonomic revision by Youssef et al. (2023), however, the close morphological similarity between the studied *Retama* taxa hinder their taxonomical identification. Youssef et al. (2023), study was able to resolve several questions concerning genus *Retama* in Egypt among them (1) What are the taxa representing this genus? (2) What are the distinguishing morphological traits? (3) What is the geographic distribution of each taxon? (4) What is molecular fingerprinting/ taxa? The study covered by field and herbarium work using 94 macro-morphological characters and the molecular fingerprinting using ISSR markers to clarify the addressed questions. This revision revealed the identification of two species: *Retama raetam* and *R. monosperma* this is consistent with the records given earlier by Boulos (2009); in addition to five Forms (needs complete genome analysis for accurate taxonomic judgement) under *R. raetam* (Form 2, 4, 6, 7, and Form 8). And only Form 5 under *R. monosperma*. The conducted morphological cluster was confirmed with the molecular one, and significant differences were recorded between these taxa. The geographic distribution of the identified *Retama* forms indicates its localization in South Sinai, this is consistent with the postulation given earlier by Täckholm (1974). This study emphasizes that *Retama* spp. are important fodder species, which now susceptible to climatic change and requires urgent conservation effort.

Nomenclature history of the Retama spp.

Genus *Retama* is belonging to family Leguminosae and Tribe Genisteae. *Retama* species was first termed as *Genista raetam* by Peter Forsskål in 1775. The epithet was named based on the Arabic name "rætæm beham" that was transcribed by Forsskal. *Retama* was given to this species in the year 1842 by Philip Barker-Webb and Sabin Berthelotthe. In Canary Islands this species named *R. rhodorhizoides*, this name later was known as *R. raetam* (Al-Sharari et al., 2020).

Retama raetam (Forssk.) Webb

Common names: Retem in Arabic, While Weeping Broom or White Broom.

Synonyms: *Genista raetam* Forssk., *Lygos raetam* (Forssk.) Heywood and *Spartium raetam* (Forssk.) Spach.

Intraspecific taxon: According to IUCN, red list (Roskov et al., 2020; Al-Sharari et al., 2020), this species includes two subspecies namely: *R. raetam* subsp. *raetam* and *R. raetam* subsp. *gussonei* (Webb) Greuter (Al-Sharari et al., 2020). While (POWO, 2023) recorded three subspecies: *R. raetam* subsp. *bovei* (Spach) Talavera & P.E. Gibbs, subsp. *raetam* and subsp. *gussonei* (Webb) Greuter (Al-Sharari et al., 2020).

Species description

Retama dasycarpa Coss.

Synonyms: *Genista dasycarpa* Ball , *Lygos dasycarpa* (Coss.) Jäger

Retama dasycarpa is an endemic and native to Morocco particularly in the semi-arid cold bioclimates region of the Elevated Atlas Mountains (Lamrabet et al., 2023). Other references expand its range to include Spain beside Morocco (GBIF, 2020). It grows chiefly in the subtropical biome and in Africa grows in the Mediterranean-Sahara transition zone (POWO, 2023). To the date of issue there is a lack of sufficient morphological description covered this species, based on the herbarium specimens deposited in Kew website (POWO, 2023) and Flora online (WFO, 2023), the species description is as follows: numerous branched shrubs with assimilating stem. Branches ribbed, rush-like, flexible. Leaves are simple, alternate, and soon deciduous. Flowers in short inflorescence with 1-8 flowers. Fruit one seeded pod.

R. monosperma (L.) Boiss.

Synonyms: *Genista monosperma* (L.) Lam., *Lygos monosperma* (L.) Heywood, *Retama webbii* (Spach) Webb, *Spartium monospermum* L., *S. clusii* Spach (Muñoz Vallés et al., 2013).

Retama monosperma is shrub up to 4.5 m high and have numerous branching green stems (Quezel & Sant, 1962; Herrera, 2001; Muñoz Vallés et al., 2013). Branches are unarmed, juvenile branches silvery-sericeous and glabrescent with age (Herrera, 2001; Muñoz Vallés et al., 2013). Branches pendent (Tutin et al., 1968), ribbed, rush-like, silky-haired, flexible (Polunin, 1969). Leaves are simple, alternate, stipulate, very shortly pedunculated, sericeous to pubescent, deciduous. Leaf lamina is 4–8 mm x 0.7–1mm, lanceolate or oblanceolate to linear-lanceolate, pubescent allover (Tutin et al., 1968; Herrera, 2001; Muñoz Vallés et al., 2013), apex obtuse (Barker-Webb & Berthelot, 1836). Stipules narrow, acute, absent or caducous, inconspicuous (Barker-Webb & Berthelot, 1836). Inflorescences are lax axillary racemes, with 10–26 flowers (Tutin et al., 1968; Herrera, 2001; Muñoz Vallés et al., 2013). Bracts and bracteoles are 2.5–2mm x 0.7–1.7mm, sericeous, caducous. Flowers zygomorphic, 14-15mm (Quezel & Sant, 1962). Calyx length 3–4mm, campanulate-cylindrical, glabrous, reddish, nearly bilabiate caducous after anthesis (Tutin et al., 1968). Corolla clawed white, 9–13 mm long, papilionate, zygomorphic. Corolla white, papilionaceous, standard rhombic-ovate (Webb, 1853), shorter than the wing (Quezel & Sant, 1962) and the keel (Polunin, 1969), or wing as long as or shorter than the keel (Tutin et al., 1968), Keel about half shorter than the wings, lanceolate to ovate, recurved (Barker-Webb & Berthelot, 1836), apex cuspidate -acuminate (Tutin et al., 1968). Androecium monadelphous, 10 stamens united below with 4- short stamens with basifixed anthers, and 5- medium stamens with dorsifixed anthers, and one larger basifixed anthers (Herrera, 2001; Muñoz Vallés et al., 2013). Ovary not pedunculated, glabrous, with four to seven seminal rudiments (Herrera, 2001; Muñoz Vallés et al., 2013), ovate (Barker-Webb & Berthelot, 1836), unilocular, indehiscent, leathery, shiny, wrinkled or reticulate, exserted from calyx, short mucronate directed towards ventral suture style terete, stigma capitate, forward (Webb, 1853) or backward sloping (Barker-Webb & Berthelot, 1836). Pericarp is fleshy and sugary when ripe. Fruit legume, 10-16mm (Tutin et al., 1968; Polunin, 1969), 10–22mm single seed (rarely 2–3), more or less globose (Herrera, 2001; Muñoz Vallés et al., 2013), with dilated ventral suture (Quezel & Sant, 1962). Flowering from January to June (Domínguez, 1987; Muñoz Vallés et al., 2013). Flowering from February to May (Jahandiez & Maire, 1932; Polunin, 1969) and fruiting from late May to early September (Muñoz Vallés et al., 2013).

R. raetam (Forssk.) Webb

Synonyms: *Genista raetam* Forssk., *Lygos raetam* (Forssk.) Heywood, *Retama duriaei* (Spach) Webb, *R. raetam* subsp. *raetam, R. raetam* is a North African shrub up to 3.0m (Zohary, 1972; Benhouhou, 2005; Al-Sharari et al., 2020), 0.5-2.0m (Boulos, 1999), and may reach up to 6.0m (Al-Sharari et al., 2020), spartoid shrub with furrowed stem (Zohary, 1972; Boulos, 1999). Richly branching (Boulos, 1999), ascending spreading branches (Barker-Webb & Berthelot, 1836), mainly vertical and yellowish-green (Zohary, 1972). Young stems covered with silky-silvery sparse to dense trichomes (Boulos, 1999), become glabrous with age (Al-Sharari et al., 2020). Leaves 1.0-23.0 x 0.25- 3.0 (8.0) mm (Zohary, 1972; Jafri, 1980); soon deciduous; narrow elliptical (Al-Sharari et al., 2020), alternate (Ahmed et al., 2016; Al-Sharari et al., 2020), simple, subsessile (Ahmed et al., 2016), linear to lyrate or lanceolate (Barker-Webb & Berthelot, 1836), covered with dense trichomes; apex acute-obtuse; margin entire (Boulos, 1999). Inflorescences are dense racemes (Ahmed et al., 2016; Al-Sharari et al., 2020), raceme lax-dense 1.0 to 15- flowered (Jafri, 1980). Flower bisexual, in clusters of 3 – 15 flowers (Al-Sharari et al., 2020), flower 8 -10cm (Fig. 1 & Al-Sharari et al., 2020), 7-16mm, becoming creamy-colored on drying (Jafri, 1980), zygomorphic and short pedicellate (Ahmed et al., 2016). Flower pentamerous, 5-gamosepalous, caducous after anthesis, pale to dark purple occasionally with purple spots (Tutin et al., 1968). Corolla 5-papilionate, standard white or white with purplish tips or spots (Boulos, 1999; Ahmed et al., 2016) or with one purple main vein (Barker-Webb & Berthelot, 1836). Standard 7-15 x 5-11mm, equal or longer (Boulos, 1999), occasionally shorter than the wings, elliptical to orbicular (Zohary, 1972; Jafri, 1980) or ovate to oblong (Tutin et al., 1968), clawed and arched (Barker-Webb & Berthelot, 1836). Wings 7-15 x 1.5-4mm, acinaciform (Barker-Webb & Berthelot, 1836) or oblong with one main vein, obtuse apex. Keel 7-13 x 3-5mm, somewhat shorter than wings (Zohary, 1972), lanceolate (Barker-Webb & Berthelot, 1836) or oblong, apex obtuse or acute, densely hairy along occasionally with purple mid main vein (Zohary, 1972; Jafri, 1980). Stamens 10, monadelphous, connate below into a closed tube, 6-13mm, nearly equal in lengths, random in lengths or 1 long and the rest nearly equal (Boulos, 1999). Ovary superior, sessile, with one ovule with capitate stigma (Ahmed et al., 2016). Fruit indehiscent legume (Ahmed et al., 2016) or tardily dehiscent (Zohary, 1972), 10– 15mm diameter (Al-Sharari et al., 2020), 3.0-10mm (Zohary, 1972; Jafri, 1980), green or black (Barker-Webb & Berthelot, 1836), ventral suture filiform to dilated, glabrous, elliptical-ovoid-globose (Zohary, 1972) or to oblong (Barker-Webb & Berthelot, 1836; Jafri, 1980), legume apex attenuate into a gradually or abruptly short erect or curved beak (Zohary, 1972). Fruit includes 1-2 kidney-shaped, yellow to brown seeds (Al-Sharari et al., 2020). Pericarp thin, smooth or wrinkled, leathery or fleshy horny (Täckholm, 1974), smooth, glabrous, yellow to orange, olive green to brown or black (Tutin et al., 1968). 2n=48 (Zohary, 1972). Flowering from February up to May (Al-Sharari et al., 2020), from end of January to April (Zohary, 1972).

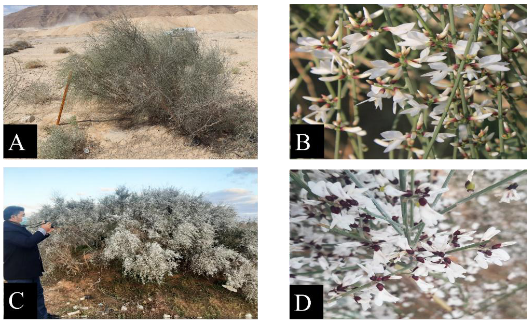

Fig. 1. Field image for *Retama* species in Egypt [A & B, *R. raetam* in Wadi Hagoul, Eastern desert; C & D, *R. monosperma* in sand dune at the western Mediterranean stripe, near Marsa Matruh. (Photograph by Dr. Omran Galy)]

R. raetam subsp. gussonei (Webb) Greuter: low shrub (Fig. 1 & Täckholm, 1974), diffusely branching, with silky-silvery indumentum and deflexed upper branches (Zohary, 1972). Flowers as in type, but the pod is dehiscent (Täckholm, 1974) or tardily dehiscent. Fruit short ellipsoidal or ovoid, with more or less abrupt, short, straight or recurved beak (Zohary, 1972). Fruit pericarp fleshy, shiny, wrinkled. Seed lemon to yellow, rarely green (Zohary,1972).

R. sphaerocarpa (L.) Boiss.

Synonyms: *Boelia sphaerocarpa* (L.) Webb, *Lygos sphaerocarpa* (L.) Heywood, *Retama atlantica* Pomel, *R. lutea* Raf., *R. sphaerocarpa* f. *atlantica* (Pomel) Batt, *Spartium sphaerocarpum* L.

R. sphaerocarpa is a leguminous shrub with evergreen assimilating stems, up to 4.0m height (Haase et al., 1996; Prieto et al., 2010), to 5.0m in height (Rodríguez-Echeverría & Pérez-Fernández, 2003). It possesses a dimorphic root system, with root system grows up to 30 m deep, with long lateral roots and deep roots (Haase et al., 1996; Prieto et al., 2010). Flower yellow papilionaceous corolla and bilabiate calyx (Rodríguez-Riaño et al., 1999c). Androecium is 10 dimorphic anthers, monadelphous, the upper whorl with oblong to linear-oblong basifixed stamens, and the lower whorl with similar morphology but the apex is a triangular-acuminate and the anther is dorsifixed (López et al., 1999; Rodríguez-Riaño et al., 1999c). Ovary is glabrous with a linear-curved style terminated with tufted stigma. Fruit indehiscent legume, single seeded. Plant flowering in spring (Rodríguez-Riaño et al., 1999b, c).

Seed morphology in Retama spp.

Different colors were reported for *R. raetam* seed among them yellow-brown (Zohary, 1972; Jafri, 1980), black (Barker-Webb & Berthelot, 1836; Webb, 1853), brownish (Boulos, 1999) and brown -black (Täckholm, 1974). While seeds of the *R. monosperma* are reniform, with dark-green to black or smooth integument (Barker-Webb & Berthelot, 1836; Webb, 1853; Morsy et al., 2015) or reddish-brown or olive green (Boulos, 1999). The seed dimensions are 5.7–7.2mm x 4.2–5.7mm, and 93.1 ± 2.1mg seed mean weight (Morsy et al., 2015). The *R. raetam* subsp. *gussonei* seeds are sub-reniform with uniform feature and smooth integument (Ferrauto et al., 2015). Different colors were reported by earlier authors, among them lemon yellow to yellow color (Zohary, 1972; Täckholm, 1974), rarely green (Zohary, 1972), and varying in color from olive-green to golden-yellow, occasionally brown spotted (Ferrauto et al., 2015). Mean seed size is 5.94 (± 0.72) mm x 5.70 (± 0.67) mm with classical embryo with two cotyledons (Ferrauto et al., 2015).

Seeds of Retama spp.: production, dispersion and germination

Retama monosperma possesses one- rarely two seeds/fruit. The seed production/shrub varied from year to other, ranged from 335 - 2800 fruits/m^2 beneath canopy of the full mature shrubs of 6-7 years old (Muñoz Vallés et al., 2013). Seeds of this species lake the special mechanism for seed dispersal, seeds fall down under the shrub canopy and become available for dispersers or stay in the soil for the coming season (Muñoz Vallés et al., 2013). Wild rabbit (Oryctolagus cuniculus) is among the active important dispersers of *R. monosperma* seeds (Dellafiore et al., 2006; Muñoz Vallés et al., 2013). On the other hand, seeds consumed as goat fodder and this cause loss of seeds and no record about the bird disperser while, rain runoff sometimes act as seeds dispersers (Muñoz Vallés et al., 2013). The seedling pairing two fleshy cotyledons, while the juvenile leaves are alternate covered with trichomes from both sides even in mature shoots (Muñoz Vallés et al., 2013). *R. monosperma* stabilizes the coastal sand forming dunes of medium- high levels which limits the seedling establishment (Muñoz Vallés et al., 2013). Despite lacking vegetative reproduction in this species, the populations expand and become denser due to the effective dispersal mechanisms and high seed productivity (Fernández et al., 2010; Muñoz Vallés et al., 2013). A comparable effect has been reported in *R. raetam* forming nebkhas (accumulations of wind-borne sand) in Mediterranean coastal dunes around the shrub canopy (El-Bana et al., 2002; Muñoz Vallés et al 2013). Abdenour et al. (2020) reported that *R. sphaerocarpa*, *R. raetam* and *R. monosperma* stabilize the dunes, leading to soil fixation and the rebuilding of the plant cover of semi- and arid ecosystems (Muñoz Vallés et al., 2013; Kheloufi et al., 2020).

The *R. monosperma* seeds germinate in autumn throughout the rainy season, the rate of germination increases significantly after animals feeds on seeds, where the wild rabbits which rise up this percentage to 24% (Dellafiore et al., 2006; Muñoz Vallés et al., 2013). Seed viability is very high (90.0–98.8%), despite this its germination rates were ranged from 5 to 13% (Dellafiore et al., 2006; Dellafiore, 2007; Muñoz Vallés et al., 2013). The germination percentage in *Retama* sp. is caused by the seed coat impermeability (Kigel, 1995; Ferrauto et al., 2015).

The earlier reports about the germination of *R. raetam* ssp. *gussonei* (Gutterman, 1993; Izhaki & Ne'eman, 1997; Ferrauto et al., 2015; Seglie et al., 2012) showed very low of non-uniform germination owing to the physical dormancy, due to the seed coat impermeability to water (Kigel, 1995; Ferrauto et al., 2015). To improve the germination rate, various treatments have been applied to defeat dormancy. From these methods the acid scarification is the most common and effective method through which the seeds immersed in sulphuric acid for 3h at 25°C. The achieved maximum germination rate was 67.5% ± 22.17 with germination rate (T50 = 5.6± 1.2 & MGT = 8.6 ± 0.8 days). However, the manual scarification followed by boiling reduces the integument resistance, the method fails to affect the *Retama* seed dormancy (Youssef, 2009; Ferrauto et al., 2015). Relevant results were achieved in case of *R. sphaerocarpa,* where its seeds dormancy can be overcomes by immersion several methods as boiling water, conc. sulphuric acid (0min - 240min) and seed coat abrasion by sandpaper (Kildisheva, 2019; Kheloufi et al., 2020). The best of all these pretreatments was immersion in sulphuric acid for 120 min at temperature 25°C (± 2°C), this resulting 86% seed germination (Kheloufi et al., 2020).

Biological treatment can improve seed germination as a non-conventional method (Steponkus, 1982; Ouf, 1994). Microorganisms may promote germination, probably by enhancing the seed coat softening (Guttridge et al., 1984; Ouf, 1994). Referring to the fungal hydrolytic enzymes produced during biodegradation of plant materials (Ouf, 1994). Bathing of *R. raetam* seeds in the filtrate of the fungal growth media as *Penicillium capsolatum*, *P. spinulosum* and *Sporotrichum pulverulentum* this stimulating the seed germination (Ouf, 1994).

Factors influencing seed germination of Retama spp.

Salinity: Seeds of *R. raetam* are sensitive to salinity, it tolerates from 34 to 68 mM NaCl concentrations. The germination rate dropped to 3.33% on 238 and 272mM of NaCl concentrations with 272 mM threshold of tolerance (Mehdadi et al., 2017). *R. raetam* subsp. *bovei* seeds were also negatively correlated to the medium salinity. It can tolerate salinity up to 15g/L. Where germination reached up to 81% in distilled water and significantly decreased with increase in NaCl concentrations, similar behavior was reported with the increase in osmotic potential (Mechergui et al., 2017). The gemination inhibition cannot recover after the toxicity action caused by the high Na^+ and Cl^- ions concentrations, even after the removal of the higher concentrations. Contradictory behavior was noticed, and germination inhibition was reversable in case of germination inhibition related to osmotic potential (Mehdadi et al., 2017). In *R. raetam* subsp. *bovei* the seed weight plays a major factor in stimulating germination under salinity stress and the germination inhibition has notable impact on the seeds with small size (Mechergui et al., 2017).

Temperature: The germination of *R. raetam* seeds was optimum (70%) at the temperature range from 20°C - 25°C, while germination was impossible at the higher (35°C - 40°C) or lower (0°C, 5°C) temperature ranges (Mehdadi et al., 2017). While, in *R. monosperma* the optimal germination temperature was 20°C, and germination was impossible at the same temperatures range as in *R. raetam* (Bouredja et al., 2011; Mehdadi et al., 2017).

Distribution of genus Retama spp.

Genus Retama L. is mainly with Mediterranean distribution, the western part is its diversity center, particularly in NW Africa (Lems, 1960; Maire, 1987; Greuter et al., 1989; Chiapella et al., 2009). *Retama* spp. belongs to the Mediterranean endemic species, where 60% of the endemic species of this region possess narrow geographic location (Bedair et al.; 2024).

R. dasycarpa Cosson is an endemic species to the Great Atlas and Morocco (Maire, 1987; Chiapella et al., 2009).

R. monosperma distributed in the Algeria and Morocco; SW Iberian Peninsula, var. *webbii* (Spach) Maire grows along the Atlantic coast of Morocco (Maire, 1987; Talavera, 1999b; Chiapella et al., 2009). It endemic to the NW Morocco (Talavera, 1999b; Zunzunegui et al., 2017) and SW Iberian Peninsula on coastal sandy dunes and borders of saltmarshes (Muñoz Vallés et al., 2013; Zunzunegui et al., 2017). And expanded to SW Spain and in areas with Mediterranean climate in California, USA (Randall, 1997; Zunzunegui et al., 2017), and S. Australia (Randall, 2007; Zunzunegui et al., 2017).

*R. raetam (*Forssk.) Webb extends eastward to Sinai Peninsula, NW Saudi Arabia from Al-Jouf to Tabuk, and Palestine (Al-Tubuly et al., 2011; POWO, 2023; Al-Sharari et al., 2020). Recently, it naturalized in new places, including Queensland, Greece, S & W Australia (POWO, 2023; Al-Sharari et al., 2020). While *Retama raetam* (Forsskål) Webb subsp. *raetam*, is a Saharo-Arabian element, spreads in N. Africa, Arabian Peninsula, Israel, Syria and Lebanon (Chiapella et al., 2009), along the Mediterranean coast and arid deserts of Egypt (El-Bahri et al., 1999; Mittler et al., 2001; Barakat et al., 2013), and extends up to Sicilia (Al-Sharari et al., 2020).

*R. sphaerocarpa (*L.) Boiss. is distributed in the Iberian Peninsula, Morocco, Algeria and Tunisia (Chiapella et al., 2009), native to NW Africa and Iberian Peninsula (Tutin et al., 1968; Rodríguez-Echeverría & Pérez-Fernández, 2003); and C & S Spain (Rodríguez-Echeverría & Pérez-Fernández, 2003).

Soil type affecting the distribution of Retama species

The type of soil plays an important role in distribution of *R. monosperma* (Gómez González et al., 2004; Muñoz Vallés et al., 2013). It is a drought tolerant species and can modify the habitat of the coastal dunes and plant community, it can grow in the geographic areas possess Mediterranean climate (Muñoz Vallés et al., 2013). Generally, it grows in siliceous coastal soil with grain size 0.2–0.3mm and sandy soil with low organic and water content (Muñoz Vallés et al., 2013). It grows in wide pH 5.8 to 9.0 range (García Novo & Merino, 1997; Muñoz Vallés et al., 2011, 2013).

Cytogenetics of Retama spp.

Genus *Retama* is eutetraploid with homogeneous karyologic chromosomes. The basis of serologic and morphologic characters showed a greater similarity to Genista group (Polhill, 1976; Bisby, 1981; Cristofolini & Feoli Chiapella, 1984; Feoli Chiapella & Prodan, 1989; Chiapella et al., 2009). The cytogenetics study carried out by Benmiloud-Mahieddine et al. (2011) on 33 population from the three *Retama* spp. in Algeria namely *R. sphaerocarpa, R. monosperma* and *R. raetam*, using flow cytometry and molecular cytogenetics for karyotype analysis revealed that the three species have the similar chromosome number (2n= 48). Also, (Chiapella et al., 2009) study four genera of Genisteae and revealed similar chromosome numbers (x = 12 & 2n=48; with some B chromosomesup to 6 in some species). Where, *R. monosperma*, 2n= 48 + 4B, R. sphaerocarpa 2n = 48 + 2B and *R. dasycarpa* was 2n = 48 + 3B (Chiapella et al., 2009). The numbers 2n = 24 & 52 are only reported respectively for *R. raetam* subsp. *raetam* and *R. sphaerocarpa* (Chiapella et al., 2009), while *R. monosperma* (L.) Boiss. was of 2n = 24 & 48 (Muñoz Vallés et al., 2013). According to Gallego-Martin et al. (1988) and Benmiloud-Mahieddine et al. (2011), *Retama* species has two ancestral basic chromosome numbers (x=6 and x=8) with the possible polyploidy (secondary or series) of aneuploids and euploids (Gallego-Martin et al., 1988; Benmiloud-Mahieddine et al., 2011).

Genome size is among the useful traits applied for evolution and systematics studies (Godelle et al., 1993; Cerbah et al., 1999a & b, 2001; Ohri, 1998; Benmiloud-Mahieddine et al., 2011). Flow cytometry is a rapid and accurate technique used to study the genome size to assess the inter- & intraspecific variations (Biradar & Rayburn, 1993; Doležel & Bartoš, 2005; Benmiloud-Mahieddine et al., 2011). The study carried out by Benmiloud-Mahieddine et al. (2011) revealed that the chromosome structure and genome size distinguished *R. sphaerocarpa* from *R. monosperma* and *R. raetam*.

The genome size for *Retama monosperma, R. raetam* and *R. sphaerocarpa,* was 1.76 -1.89 pg, 1.88 - 1.93 pg and 1.80 pg - 1.97 pg; respectively. The genome size showed significant intraspecific difference connected to the spatial distribution of the studied populations, and also approved by rDNA organization in chromosome analysis (Benmiloud-Mahieddine et al., 2011). The genome size is an adaptive trait correlated to the environmental situations (Bennett, 1987; Benmiloud- Mahieddine et al., 2011). Benmiloud-Mahieddine et al. (2011) reported that the *R. raetam* populations collected from the lowest temperatures at the high plateau possess the highest nuclear DNA content (2C= 1.97 pg). While the smallest genome size (2C=1.80 pg) was specific for the population located in the Algerian western desert at 312m elevation. Two ribosomal genes, namely 5S and 45S were co-localized on the satellite chromosome pair distinguished *R. raetam* and *R. monosperma* from *R. sphaerocarpa*.

Anatomy of the assimilating branch in Retama raetam

R. raetam is a xeromorphic species with soon deciduous leaves, and the assimilating branches appeared with longitudinal grooved in which the anomocytic stomata are located with reticulate cell wall (Ahmed et al., 2016). The deeply placed stomata have cuticular crest from both sides enclosing very small respiratory cavity; the number of stomata per unit area in this plant is impossible to estimate (Evenari, 1938). The transverse section in assimilating branch showed the presence of very thick epidermal cells (20-25u). The assimilation parenchyma was characterized by a few intercellular spaces. The conducting system is an advantageous in its construction, its tracheids are small number wide lumen (Evenari, 1938).

Pollen morphology of Retama raetam

The pollen grain of *R. raetam* is monad, trizono-colporate, isoplar, triangular-obtuse in polar view and rectangular-obtuse in equatorial view. The grain size > 20um, while the exine sculpture is supra-reticulate (Sekina & Moore, 1995).

Pollen morphology of R. raetam subsp. gussonei: As seen in Fig. 2, the pollen of *R. raetam* subsp. *gussonei* is monad, trizono-colporate (sometimes trizono-colporoidate), radially symmetric, and its size ranges from small - medium (P= 23-33um). Subcircular in polar view, while, in equatorial view it is subtriangular-elliptic. The polar axis ranges from 23 - 33 um and the equatorial diameter 17 - 27 um; the pollen aperture is ora and colpi. A longitudinal parallel edge supporting the colpus, and often constricted at the equator (De Leonardis & Zizza, 1994; Ferrauto et al., 2015). Exine tectate columellate, with same thickness nexina and sexina. Tectum ornamentation is

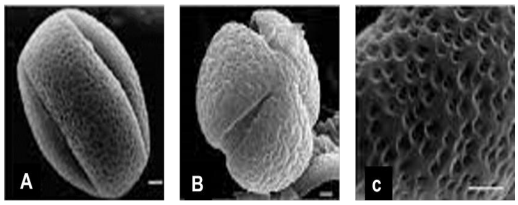

Fig. 2. Pollen grains of *R. raetam* ssp. gussonei. using SEM [A, Equatorial view; B, Polar views; C, Magnified exine. Scale bar: A–C = 2mm. (after Ferrauto et al., 2015)]

supra-reticulate under light microscope, while appeared, supramicroreticulate-perforate under the scanning electron microscope (Ghirardelli et al., 1997; Rizzi Longo et al., 2006; Ferrauto et al., 2015). The mesocolpium showed fossulate-perforate ornamentation with perforation more than one (Pardo et al., 2000; Ferrauto et al., 2015), while the aperture membrane regulate ornamentation (Ferrauto et al., 2015).

Pollination Biology

Retama monosperma: Nevertheless, the monadelphous flowers are normally lacking nectar, *R. monosperma* is an exception and nectar producing species. The flowers during pollination were visited mostly by *Hymenoptera* (Herrera, 1988), and others species from other groups like *Licaenidae* and *Syrphydae* (Muñoz Vallés et al., 2013). This species is of low biomass of pollen grain production (mean 92 dmm^3 / flower), where this value reached 624.3 ± 923.3 dmm^3/ flower in the whole *Retama* tribe (Rodríguez-Riaño et al., 1999a; Muñoz Vallés et al., 2013).

R. sphaerocarpa: Rodríguez-Riaño et al. (1999c), studied the reproductive biology of *R. sphaerocarpa* (L.) Boiss. The results revealed that this species is a nectar producing species, the nectar gland is an extra-staminal observed between the staminal column and calyx its nectar production is maximum at early morning. Where the pollinators are primarily Apis *mellifera* and minor beetle (*Heliotaurus* sp.) which made 14 visits/2 min to the flowers of the same or neighbor individuals. Honeybees can pollinate *R. sphaerocarpa*, flowers in 4-9 seconds. The genetic self-incompatibility (SI) is the rejection of male gametophyte by ovule when it carries the same alleles of the same plant. The interaction between pollen and pistil in the studied species revealed the presence of prezygotic SI- of gametophytic type. The hand-self-pollination produced very few fruits, indicating the presence of postzygotic rejection mechanism. On the other hand, the hand-cross pollination increased the fruit formation if compared to the control reflecting the pollen grains were the limiting factor in reproduction process. Rodríguez-Riaño et al. (1999c), reported that the low nectar production could be linked with the small flower-size. The less nectar production is linked with the ability of pollen grains to farther distances than the pollen produced from rich nectar producing plants (Zimmermann, 1988; Rodríguez-Riaño et al., 1999c).

Species associated with R. raetam and R. monosperma

Species associated to R. monosperma in Spain: R. monosperma colonized SW Spain and dominating the psammophyte vegetation was co-dominated by *Anisantha rigida, Artemisia*

TABLE 1. Species associated to *R. monosperma* and *R. raetam* in Egypt (Based on field collection carried out by Wafaa Amer)

Species associated to *Retama monosperma* (L.) Boiss		
Family: Amaranthaceae	**Family: Boraginaceae**	**Family: Plumbaginaceae**
• *Anabasis oropediorum* Maire	• *Echium angustifolium* Mill.	• *Limonium tubiflorum*
• *Atriplex halimus* L	**Family: Brassicaceae**	(Delile) Kuntze
Family: Apiaceae	• *Moricandia nitens* (Viv.)	**Family: Poaceae**
• *Deverra tortuosa* (Desf.) DC.	E.A.Durand & Barratte	• *Aegilops kotschyi* Boiss.
• *Eryngium creticum* Lam.	**Family: Fabaceae**	• *Hordeum murinum* L.
Family: Aspragaceae	• *Acacia tortilis* subsp.	• *Lygeum spartum* Loefl.
• *Asparagus horridus* L.	*raddiana* (Savi) Brenan	ex L.
Family: Asteraceae	• *Prosopis farcta* (Banks &	**Family: Solanaceae**
• *Achillea tenuifolia* Lam.	Sol.) J.F.Macbr.	• *Lycium europaeum L.*
• *Atractylis carduus* (Forssk.)	**Family: Lamiaceae**	**Family: Thymelaeaceae**
C. Chr.	• *Marrubium alysson* L.	• *Thymelaea hirsuta* (L.)
• *Calendula arvensis* L.	• *Salvia lanigera* Poir.	Endl.
• *Carthamus mareoticus* Delile	**Family: Nitrariaceae**	**Family: Xanthorrhoeaceae**
• *Centaurea alexandrina* Delile	• *Peganum harmala* L.	• *Asphodelus aestivus* Brot.
• *Centaurea glomerata* Vahl	**Family: Plantaginaceae**	**Family: Zygophyllaceae**
• *Echinops spinosissimus* Turra	• *Plantago crypsoides* Boiss.	• *Fagonia indica Burm.f.*
		• Tetraena alba (L.f.) Beier
		& Thulin

TABLE. 1. Cont.

Species associated to *Retama raetam* (Forssk.) Webb.

Family: Aizoaceae
- *Mesembryanthemum crystallinum* L.
- *Mesembryanthemum nodiflorum* L.

Family: Amaranthaceae
- *Aerva javanica* (Burm.f.) Juss. ex Schult.
- *Anabasis setifera* Moq.
- *Arthrocnemum macrostachyum* (Moric.) K.Koch
- *Atriplex halimus L.*
- *Haloxylon salicornicum* (Moq.) Bunge ex Boiss.

Family: Apiaceae
- *Deverra tortuosa* (Desf.) DC.
- Eryngium creticum Lam.

Family: Apocynaceae
- *Calotropis procera* (Aiton) W.T. Aiton
- *Leptadenia pyrotechnica* (Forssk.) Decne.

Family: Asteraceae
- *Achillea tenuifolia* Lam.
- *Atractylis carduus* (Forssk.) C.Chr.
- *Centaurea alexandrina* Delile
- *Centaurea calcitrapa* L.
- *Centaurea glomerata* Vahl
- *Echinops spinosissimus* Turra
- *Iphiona mucronata* (Forssk.) Asch. & Schweinf.
- *Launaea nudicaulis* (L.) Hook.f.
- *Launaea spinosa* (Forssk.) Sch.Bip. ex Kuntze
- *Otanthus maritimus* (L.) Hoffmanns. & Link
- *Pulicaria undulata* (L.) C.A.Mey.
- *Senecio glaucus* subsp. *coronopifolius* (Maire) C.Alexander

Family: Boraginaceae
- *Anchusa humilis* (Desf.) I. M. Johnst.
- *Echiochilon fruticosum* Desf.
- *Echium angustifolium* Mill.
- *Echium angustifolium* subsp. *sericeum* (Vahl) Klotz.

Family: Brassicaceae
- *Cakile maritima* Scop.
- *Diplotaxis acris* (Forssk.) Boiss.

Family: Capparaceae
- *Capparis aegyptia* Lam.

Family: Caryophylaceae
- *Gymnocarpos decandrus* Forssk.
- *Gypsophila capillaris* (Forssk.) C.Chr.

Family: Cistaceae
- *Helianthemum lippii* (L.) Dum.Cours.

Family: Cleomaceae
- *Cleome amblyocarpa* Barratte & Murb.
- *Farsetia aegyptia* Turra
- *Zilla spinosa* (L.) Prantl

Family: Euphorbiaceae
- *Euphorbia paralias* L.

Family: Fabaceae
- *Acacia tortilis* subsp. *raddiana* (Savi) Brenan
- *Astragalus spinosus* (Forssk.) Muschl.
- *Crotalaria aegyptiaca* Benth.
- *Lotus arabicus* L.
- *Lotus polyphyllos* Clarke

Family: Geraniaceae
- *Erodium oxyrhinchum* subsp. *bryoniifolium* (Boiss.) Schönb.-Tem.

Family: Lamiaceae
- *Lavandula coronopifolia* Poir.
- *Ononis vaginalis* M.Vahl
- *Trigonella stellata* Forssk.

Family: Plantaginaceae
- *Plantago coronopus* L.
- *Plantago crypsoides* Boiss.
- *Plantago notata* Lag.

Family: Plumbaginaceae
- *Limonium tubiflorum* (Delile) Kuntze

Family: Poaceae
- *Aegilops kotschyi* Boiss.
- *Ammophilia arenaria* (L.) Link
- *Elymus farctus* (Viv.) Runemark ex Melderis
- *Hordeum marinum* Huds.
- *Lygeum spartum* Loefl. ex L.
- *Panicum turgidum* Forssk.

Family: Polygonaceae
- *Rumex vesicarius* L.

Family: Posidonaceae
- *Posidonia oceanica* (L.) Delile

Family: Resedaceae
- *Ochradenus baccatus* Delile
- *Reseda decursiva* Forssk.

Family: Rubiaceae
- *Crucianella maritima* L.

Family: Scrophulariaceae
- *Verbascum letourneuxii* Asch. & Schweinf.

Family: Solanaceae
- *Hyoscyamus muticus* L.
- *Lycium europaeum* L.
- *Lycium shawii* Roem. & Schult.

Family: Tamaricaceae
- *Tamarix senegalensis* DC.

Family: Thymelaeaceae
- *Thymelaea hirsuta* (L.) Endl.

Family: Xanthorrhoeaceae
- *Asphodelus tenuifolius* Cav.

Family: Zygophyllaceae
- *Fagonia arabica* L.
- *Fagonia cretica* L.
- *Fagonia mollis* Delile
- Tetraena alba (L.f.) Beier & Thulin
- *Tetraena coccinea* (L.) Beier & Thulin
- Tetraena simplex (L.) Beier & Thulin
- *Zygophyllum decumbens* Delile

campestris Maritima, Carduus meonanthus, Crucianella maritima, Erodium cicutarium, Euphorbia terracina, Hedypnois arenaria, Helichrysum italicum Picardii, Malcolmia littorea, Medicago littoralis, Paronychia argentea, Silene nicaeensis, Sonchus tenerrimus, Stellaria pallida, Thymus carnosus, Urtica membranacea, and *Vulpia alopecuros* (Table 1. Muñoz Vallés et al., 2013).

Adaptation to the environmental stresses

Climatic factors

Climatic factors are the main player out of all the environmental factors that restraint not only the plant growth but extends to include development, densities, distribution and the vegetation abundance all over the globe (Cramer et al., 2001; Booth & Grime, 2003; Scholze et al., 2006; Amer et al., 2021). Amer et al. (2021) studied the genetic variations induced by the climate change (mainly air temperature and rainfall) over the period 1975–2018 on representative Mediterranean species in the western Mediterranean stripe in Egypt. The *R. raetam* and *Vicia monantha* were representing the shrubby and annual Mediterranean species; respectively. The genetic variations were carried out using ISSR-technique, the study proved remarkable genome variability in *R. raetam* than the annual *Vicia monantha* with 77% and 91%; respectively. The study announces for the species vulnerability to climate change inducing the unidirectional genetic change in *R. raetam* shrubs; and serious conservation plan is requested (Amer et al. 2021).

Drought adaptation of R. raetam

The species utilizes a combination of numerous adaptation strategies beside its active defense mechanisms. In addition to, a combination of the stress response genes to tolerate the stressful restrictions that prevail in the desert environment in different growth seasons (Merquiol et al., 2002). It is a drought deciduous shrub where its xeromorphic adaptations include falling of leaves at the beginning of the drought season to reduce evaporation (Wickens, 1998). *R. raetam* uses the dormancy among its acclimatization strategy to resist long periods of water scarcity (< 30mm rain /year; Merquiol et al., 2002; Pnueli et al., 2002).

*During d*ormancy *R. raetam* is not exposed to severe dehydration its relative water content is about 35% in the dormant tissue accordingly it was clustered as drought-tolerant species (Pnueli et al., 2002). Notable decrease in overall metabolism such as apparent disappearance of cellular-proteins and suppression of photosynthesis was observed. During rainfall the dry plants recovered and rapidly gather the `disappeared proteins, and escapes dormancy (Mittler et al., 2001; Pnueli et al., 2002).

Adaptation of R. monosperma to salinity

R. monosperma is a leafless leguminous shrub, nitrogen fixing (Talavera, 1999b; Zunzunegui et al., 2017). It grows on semi-stabilized and stabilized sandy dunes in marsh borders and in the coast vicinity (Muñoz Vallés et al., 2013; Zunzunegui et al., 2017). The woody perennial species like *R. monosperma* are long lived, its life span can extend to 55–80 years with main stem extends inside the soil to promote its establishment (Muñoz Vallés et al., 2005 & 2013). The response of *R. monosperma* to salinity was assessed by Zunzunegui et al. (2017), in a greenhouse experiment. Where the juvenile *R. monosperma* plants were watered with NaCL saline solution in concentrations ranges from 5.0 to 600mM. The retrieved data showed that the proline content in the assimilating stems ranged from 2 µmol g–1 DM in 5mM saline to 37µmol g^{-1} DM in the 600mM saline, accordingly the proline content was 18-times higher owing to salinity stress (Zunzunegui et al., 2017). Sodium ions were accumulated in roots more than the assimilating stems in all NaCL concentrations, and the root and nodules dry weight increased, and the stem decreased significantly with the salinity increase (Zunzunegui et al., 2017).

*Positive interactions of R. monosperma***:** *R. monosperma* significantly enriching the ecosystem (Jacobsen, 2000; Muñoz Vallés et al., 2011 & 2013). It facilitates the establishment and survival of other associate species. It is able to ameliorate the extreme-temperatures under the canopy during the coldest and hottest seasons, conserve the relative humidity and effectively increase the soil organic matter that enriching the plant biomass beneath the canopy with 442% (Muñoz Vallés et al., 2011 & 2013). *R. monosperma* canopies increased the enrolment of the ruderal, nitrophilous and/or weed species, which are not recorded earlier to be specific to the dune environment. It grows below the *R. monosperma* canopy compete each other due to scarcity of water, light and other resources (Muñoz Vallés et al., 2013).

Grazing and predation of R. monosperma: light and irregular grazing by wild rabbits has been monitored in the *R. monosperma* grow in the maritime sand dune in the Iberian Peninsula grazing on the stems (Muñoz Vallés et al., 2013). Insects (e.g., *coleopterous borers*, family Bruchidae) can damage the *R. monosperma* seeds (Muñoz Vallés et al., 2013).

Response of R. monosperma to water stress: It survived after subjected to the sea water invasion of the coastal dune system (Zunzunegui et al., 2017). However, it cannot survive under long-term flooding, it is shedding its above-ground biomass, when exposed to this environment, fortunately, it can resprouting in the following year (Muñoz Vallés et al., 2013).

Invasion of R. monosperma: R. monosperma can easily expands in the lack of other competitor woody species (Muñoz Vallés et al., 2013), its spreading rate was up to 80m/y (Muñoz Vallés et al., 2005). In older *R. monosperma* populations that lasts more than 50 years the large individuals were dominating, and the juvenile individuals are rarer (Muñoz Vallés et al., 2013). This species showed invasive character and can modify the environment, its fast expansion was reported by Randall (1997), Zunzunegui et al. (2017) in many areas among them the sandy coasts with Mediterranean climate in California, USA and S. Australia. Fortunately, the species' salinity tolerance is a limiting factor controlling its invasion to the coastal systems. Congruent reports were addressed by Wilson & Sykes (1999), Zinnert et al. (2012), Zunzunegui et al. (2017); Zunzunegui et al. (2017) confirming that salinity is the main player affecting the spatial distribution of the plant species in the coastal environments.

Microbes and drought stress: Haase et al. (1996) and Selami et al. (2014), reported that *Retama* species root systems were developed to more than 20 m deep, accordingly it increased soil fertility and stability. Its root is able to fix nitrogen by the rhizobium bacteria forming the bacterial nodules developed on lateral roots (Valladares et al., 2002; Selami et al., 2014). The drought stress is a limiting factor to the species establishment and survival (Prieto et al., 2010). Under such habitat the soil microbes can play an important role in plant establishment (Prieto et al., 2010). However, *R. raetam and R. monosperma* are nitrogen fixing species, no detailed investigation carried out to clarify the role of the soil microbes on the plant growth and establishment. On the other hand, the effect of indigenous Bacillus *thuringiensis*, and *Glomus intraradices* strain (isolated from the dry Mediterranean soil, Ph 7.2) with *G. intraradices* strain (isolate BEG 123; non-indigenous, and not adapted to drought), while the *R. sphaerocarpa* under drought stress the native drought-adapted fungus increased its physiological capabilities to colonize this area (Prieto et al., 2010). *R. sphaerocarpa* colonized by *G. intraradices* and *B. thuringiensis*, increased its root length by 140% and shoot length after 30 days similar to that developed after 150 days from sowing, compared to the non-inoculated *Retama* plants. While the inoculation of *R. sphaerocarpa* plants with drought-adapted bacterium increased the root growth by 201%, with higher relative water uptake (Prieto et al., 2010). The co-inoculation of indigenous microorganisms reduced 42% from the water requests to produce one milligram of shoot biomass. Rhizosphere bacterium, singly or in association with an arbuscular mycorrhizal (AM) fungus are efficient in increasing plant water uptake, under drought environments, and can be used as alternative strategy for the best colonization of *R. sphaerocarpa* under environmental limitations (Prieto et al., 2010).

Symbiosis of endophytic bacteria to Retama species

The symbiotic endophytes of genus *Retama* were grouped under four bacterial genera (*Agrobacterium, Bradyrhizobium, Rhizobium* and *Sinorhizobium*) and genus *Glomus* from fungi (Valladares et al., 2002; Caravaca et al., 2003; Mahdhi et al., 2008; Farida et al., 2009; Muñoz Vallés et al., 2013).

Bradyrhizobium is the principal genus of the nitrogen-fixing endophytic bacteria to *Retama* species (Rodríguez-Echeverría et al., 2003; Farida et al., 2009; Guerrouj et al., 2013; Lamin et al., 2019). Eleven haplotypes belonged to the genus *Bradyrhizobium* were identified from ***Retama*** *sphaerocarpa* and *R. raetam* inhabiting seven sites from different ecological–climatic areas in NE Algeria. One rhizobial haplotype from the identified populations was common across these sites, the rest haplotypes showed significant biogeographical difference (Farida et al., 2009).

Mahdhi et al. (2008) and Lamin et al. (2019), reported that *Sinorhizobium* sp., Sinorhizobium *kostiense* and *S. meliloti* (genus *Bradyrhizobium*) were isolated from *Retama raetam* growing in Tunisian arid area (Lamin et al., 2019). Twelve bacterial isolates were isolated from *R. raetam* root-nodules, the species growing in Tunisian arid regions. These isolates were grouped under *Agrobacterium, Rhizobium* and *Sinorhizobium* (Mahdhi et al., 2008). Zakhia et al. (2006) identified five genera, *Bosea, Microbacterium, Ochrobactrum, Paracraurococcus*, and *Starkeya* from the *R. raetam* inhabited the infra-arid areas in Tunisia, all these strains do not succeed to nodulate their host of origin (Mahdhi et al., 2008).

Bradyrhizobium retamae was isolated from *R. monosperma,* inhabiting a sub-humid region in N. Morocco (Guerrouj et al., 2013; Lamin et al., 2019), this species can nodulate also *R. sphaerocarpa* (Lamin et al., 2019). Fast growing isolates (*Sinorhizobium* and *Rhizobium* genera) were isolated from the Spanish *R. sphaerocarpa* similar isolates were isolated from the bacterial nodules in *R. raetam* growing in arid zone in Tunisia (Mahdhi et al., 2008; Farida et al., 2009).

The inoculated *R. sphaerocarpa* seedlings with rhizobia isolated from *Retama* sp. were growing in Spain under two different fertilization levels. The inoculated seedlings growing in good fertilization showed higher photosynthetic rates and taller individuals than the non- inoculated seedling at same fertilization level (Valladares et al., 2002). The heavy metal tolerant *Ensifer aridi* were isolated from *R. monosperma* nodule growing in lead-rich mine soils and improve the plant resilience to this environment (Lamin et al., 2019).

Genetic diversity in R. raetam related to environmental conditions

Abdellaoui et al. (2014) studied the genetic diversity among and within the *R. raetam* populations, the C3 stem assimilating desert legume from different habitats in S. Tunisia using RAPD molecular marker. The results revealed that the main variations (68%) were noticed within populations and there were significant variations among populations ($\Phi PT = 0.316$, $P<0.001$). The gene differentiation coefficient was found in range from 0.490 - 4.609 and 1.42 between pair-wise and among populations; respectively. This study highlights the adaptive strategy of this important species in S. Tunisia (Abdellaoui et al., 2014).

Phytochemistry of Retama species

The phytochemistry of the *Retama* species have been subjected to detailed analysis, several chemical constituents were reported among them, the alkaloids (Abdel Halim et al., 1997; Edziri et al., 2010), essential oils (Maghrani et al., 2005a; Merghoub et al., 2009; El Hamdani & Fdil, 2015), flavonoids (Morales et al., 1971; El-Shazly et al., 1996; Kassem et al., 2000; Maghrani et al., 2005b; Edziri et al., 2010; El Hamdani & Fdil, 2015), and quinolizidine alkaloids (Eddouks et al., 2007; Cheriti et al., 2009; El Hamdani & Fdil, 2015).

Flavonoids: The flavonoids identified in *R. raetam* seeds were apigenin, chrysoeriol 7-*O*-glucoside, diadzein 7,4´-dimethyl ether, daidzein, kaempferol, kaempferol-7-*O*-glucoside, naringenin, and quercetin. In addition to orientin detected in leaves (Kassem et al., 2000; Edziri et al., 2010). Seven flavonoids were identified from the *R. raetam* and *R. sphaerocarpa* in Algeria as: four isoflavones (daidzein, daidzin, genistein and genistin), two flavones (apigenin and luteolin), and the rutin flavonol (Hammouche-Mokrane et al., 2017). Touati et al. (2015) and Leon-Gonzalez et al. (2018), reported several isoflavones identified from *R. monosperma, R. raetam* and *R. sphaerocarpa*, as genistein, genistin, daidzin, and daidzein. In addition to biochanin A, puerarin and 6´-methoxypseudobaptegenin isoflavones were also reported (Abdalla & Saleh, 1983; López-Lázaro et al., 1998; Djeddi et al., 2013; Leon-Gonzalez et al., 2018), Derrone and 5 hydroxyl-derrone, are among the identified isoflavones from *R. raetam* stem (Xu et al., 2015; León-González et al., 2018), While Quinic acid (phenolic compound) is among the main constituents of seeds and stems of *R. sphaerocarpa* (Touati et al., 2017; León-González et al., 2018).

R. raetam contains phenolic compounds (represented as Isoflavonoids) in considerable amount (23.9mg GAE·g $^{-1}$) and 27.2µg·g $^{-1}$ FW carotenoids (Saada et al., 2018). Flavonoids were varying with the plant organ, seeds containing such as quercetin, daidzein, naringenin, vicenin-2, apigenin, kaempferol, and kaempferol-7-*O*-glucoside, while leaves containing chrysoeriol 7-*O*-glucoside, daidzein 7,4´-dimethyl ether, and orientin (Xu et al., 2015). Aerial parts containing 5,4´-dihydroxy-(3″,4″-dihydro-3″,4″-dihydroxy)-2″,2″-dimethylpyrano-(5″,6″: 7,8)-flavone and luteolin 4´-*O*-neohesperidoside (Saada et al., 2018).

Essential oil: the analysis of the essential oil from the *R. raetam* flowers from Libya revealed that the 85.60% of the total oil content comprises Oxygenated monoterpenes, monoterpenes, oxygenated sesquiterpenes and other compounds, 62.0%, 10.6%, 1.6%, and 11.0%; respectively. The oxygenated monoterpene fraction containing 50.9% β-linalool comprising the main constituent followed by 6.6% 2-decen-1-ol, 2.3% cis-linalool oxide, 1.6% geraniol format and 0.6% ethyl linalool. One compound from the oxygenated sesquiterpenoid represented 1.6% (nerolidol acetate), and three monoterpenes namely limonene, terpinolene, and cis-β-ocimene with concentrations 7.4%, 1.7% and 1.5%; respectively. While *R. raetam* oil is dominated by 50.9% β-linalool, 7.4% limonene 6.6% 2-decen-1-ol and 3% oleic acid (Awen et al., 2011). The main essential oil extracted from *R. raetam* flowers is nonanal alcohol; in addition to octanal, dodecanal and undecanal aldehydes (Touati et al., 2015; León-González et al., 2018). Edziri et al. (2010), León-González et al. (2018) reported that the flowers of *R. raetam* are rich of other essential oils (α-humulene, β-linalool and nonanal). Touati et al. (2015), León-González et al. (2018) reported the identification of triterpene β-amyrin (0.06%), and steroids from *R. raetam* stem (Belayachi et al., 2014). While the stems of *R. monosperma, R. sphaerocarpa* and *R. raetam* showed the presence of Pinitol with percentages 2.3%,1.9% and 1.8%; respectively (González-Mauraza et al., 2016; León-González et al., 2018). The norterpenoids is the pleasant aroma present in a significant amount in *R. monosperma* flower (León-González et al., 2018).

Alkaloids: in Algeria, ten alkaloids were identified from the *Retama raetam* and R. *sphaerocarpa* six of them were tetracyclic quinolizidine (α-isolupanine,5,6-dehidrolupanine, dehydroretamine, lupanine, retamine and sparteine); two bipiperidyl (ammodendrine and N-formyl-ammodendrine) and two tricyclic quinolizidine (anagyrine and N-methylcytisine) (Hammouche-Mokrane et al., 2017). El-Shazly et al. (1996) identified from the quinolizidine alkaloids 28 compounds and one dipiperidine alkaloids (ammodendrine) in all plant parts of *R. monosperma, R. sphaerocarpa* and *R. raetam*, but they were present in lower concentrations in *R. raetam*. Also, Quinolizidine alkaloids and 31 bipiperydine alkaloids were identified from different parts of the same three *Retama* species (El-Shazly et al., 1996; León-González et al., 2018).

Alkaloids were more analogous in these three species of Mediterranean distribution than its profile between the organs of the same species. The major alkaloids detected in stem were retamine and sparteine; while fruits and flowers were dominated by cytisine, lupanine, N-methylcytisine and retamine (El-Shazly et al., 1996); and seeds are the storage organ of cytisine alkaloid (El-Shazly et al., 1996; Sadik et al., 2020). Sadik et al. (2020), reported that presence of three alkaloids in *R. monosperma* seeds in descending percentages as 77.60% cytisine, 13% N-methylcytisine and 9.40% dehydro-cytisine. While the stem contains ten alkaloids: Ammodendrine, Anagyrine, Cytisine, Dehydrosparteine, 5,6-Dehydrolupanine, 11,12-Dehydrolupanine, Isolupanine, N-methylcytisine, 17-Oxosparteine and Sparteine.

Lipid and fatty acids: Chemical identification analysis of *R. monosperma* hexane extract indicated that α-linolenic acid, campesterol, stigmasterol and sitosterol were the major components (Belayachi et al., 2014). The lipids component in seeds and branches/leaves of *R. monosperma* from western Morocco were 5% and 0.3 %; respectively (El Hamdani & Fdil, 2015). Fatty acids of *R. monosperma* seeds and stems revealed the identification of five unsaturated fatty acids and eleven saturated (El-Hamdani & Fdil, 2015; León-González et al., 2018). The fatty acids in seeds and branches/leaves of *R. monosperma* from western Morocco were dominated by palmitic acid, followed by stearic acid. Oleic acid is the dominant uni-unsaturated fatty acid in seeds. The major polyunsaturated acids in seeds and branches/leaves were linoleic and linolenic acid, the earlier concentrated in seeds and the later was major in branches/leaves (El Hamdani & Fdil, 2015).

Touati et al. (2015) and León-González et al. (2018), reported the identification of 14 fatty acids from *R. sphaerocarpa stems* and seeds where the unsaturated (14%) were dominant over the saturated fatty acids (2.3% w/w). From stems and seeds of *R. monosperma* and *R. sphaerocarpa*. León-González et al. (2018) and Touati et al. (2015) identified campesterol, b-sitosterol and stigmasterol. At the vegetative stage *R. raetam* has high percentage of polyunsaturated fatty acids (66.49%), and notable amount of vitamin C (645.6mg·100g^{-1} FW) and the proline content (25.4μmol·g^{-1} DW) (Saada et al., 2018).

Mineral composition: the mineral analysis of *R. monosperma* seeds and branches/leaves from western Morocco were revealed that the highest mineral constituents were Al, Ca, Fe, K, Mg, Na, P and Zn, the concentrations are mainly dependent and affected by soil nature and rock composition (El Hamdani & Fdil, 2015). *R. sphaerocarpa* shrub is rich in its mineral composition , it contains considerable amounts of Ca (8.62g.kg^{-1}), Mg (3.11g.kg^{-1}), Na (2.21g. kg^{-1}) and (P 2.24g.kg^{-1}); while zinc and Mn in leaves were 0.04g.kg^{-1} and 0.03g.kg^{-1}, respectively (Zamberlin et al., 2012; Abdenour et al., 2020). Based on their chemical composition, the leaves of *R. sphaerocarpa* showed high fiber (NDF= 598 g.kg-1 DM and ADF= 432g.kg^{-1} DM), lignin contents (ADL =178g.kg^{-1} DM) and the crude protein (CP=137g.kg^{-1}) (Abdenour et al., 2020).

Polysaccharides: two galactomannans polysaccharides were identified from *R. raetam* seeds from Libyan (Ishurd et al., 2004; León-González et al., 2018).

Economic uses of Retama

Retama raetam is a leguminous shrub, that plays a significant role in arid lands, particularly in soil protection against overheating and direct irradiance (Moro et al., 1997; López-Pintor et al., 2000; Barakat et al., 2013). It stabilizes soil against water and wind erosions, and offers a valuable fodder for sheep, camels and goats, this species possesses significant nutritional value for the livestock (Laudadio, 2009; Barakat et al., 2013; Al-Sharari et al., 2020). It increases soil fertility through its nitrogen fixation and enhances the soil fertility (Dart, 1998; Barakat et al., 2013); Its wood is a fuel source (Cheriti et al., 2009; Barakat et al., 2013). *Retama* tree was used by local inhabitants in Sahara as adsorbent used to remove copper ions from aqueous polluted solutions (Cheriti et al., 2009). It also applied for remediation of heavy metal contaminated soil and mining sites (Lamin et al., 2019; Al-Sharari et al., 2020). From an environmental point of view, *Retama* is one of the most important species used for rehabilitation of the degraded and soil under desertification stress (Caravaca et al., 2003; Al-Sharari et al., 2020).

Ethnobotanical uses of the Retama spp.

Retama raetam is used in folk medicine in all the countries of its geographic range (Table 2 & Leon-Gonzalez et al., 2018; Al-Sharari et al., 2020). Leave powder used for wound healing or antiseptic for wounds or for treatment of skin irritation (Awen et al., 2011; Al-Sharari et al., 2020). *Retama* sp. was traditionally used to cure renal disorders (González-Tejero et al., 2008; Al-Sharari et al., 2020); it possesses significant diuretic activity (Kassem et al., 2000; Al-Sharari et al., 2020). Moreover, *R. raetam* is used for treatment of many diseases, among them the jaundice, sore throat, inflammation, joint pains, fever and microbial infections (Edziri et al., 2012; Djeddi et al., 2013; Al-Sharari et al., 2020). In Tunisia, it is used as medication for snake bites (El Hamrouni, 2001; Al-Sharari et al., 2020) and in some renal diseases (Edziri et al., 2010; Al-Sharari et al., 2020). Bedouins used *Retama* in treatment of arthralgia, backache, infertility and for inducing abortions (Bailey & Dannin, 1981; Al-Sharari et al., 2020). In Morocco and Saudi Arabia, it used in hypertension and diabetes treatment (Nur-e-Alam et al., 2019; Al-Sharari et al., 2020). Bedouins still used *R. raetam* to prepare slow combustion coals (Schmid et al., 2006). *R. raetam* roots are treated diarrhea, while leaves are applied to help eye troubles and aching joints back pain (Said et al., 2002; Barakat et al., 2013).

In Tunisia folk medicine, *R. raetam* is used in for treatment of several diseases in among them: renal diseases due to its significant diuretic activity (Caceres et al., 1987; Edziri et al., 2010), hypertension (Archer & Pyke, 1991; Izhaki & Neeman, 1997; Edziri et al., 2010). The flower oil showed antibacterial, antifungal for yeasts and antioxidant with IC50 = 0.800mg/mL (Edziri et al., 2010). Edziri et al. (2010) attributed the antioxidant activity of this flower-oil to the presence of monoterpenes in high concentrations, this natural oil is a potential preservative in pharmaceutical and/or food products.

Pharmacological activities of Retama spp.

Retama raetam: the *R. raetam* extract of the vegetative parts showed remarkable antioxidant activity (Saada et al., 2018; Al-Sharari et al., 2020); anti-inflammatory (González-Mauraza et al., 2016; Al-Sharari et al., 2020); hypoglycemic (Maghrani et al., 2005a; Hayet et al., 2008; Al-Sharari et al., 2020) and antibacterial activities (Hammouche-Mokrane et al., 2017; Al-Sharari et al., 2020); in

TABLE 2. Ethnopharmacological applications of *Retama* spp. species, country, used plant part in each case, preparation, and route of administration

Country/ province	Used plant part	Preparation	Traditional use	Route of administration	References
			***R. dasycarpa* Coss.**		
Morocco (Atlas Mountains)	Seeds		Nephrological disease, urological	Oral	Teixidor-Toneu et al. (2016)
			***R. monosperma* (L.) Boiss**		
Algeria	Cladodes	Decoction	Hydrophobia (rabies) prevention	Oral	Helmstädter (2016)
Morocco	Cladodes	Decoction	Purgative and Vermifuge	Rectal washings	Bellakhdar (1997)
Morocco	Cladodes	Grounded and blending with honey	Emetic	Oral	Bellakhdar (1997)
			***R. raetam* (Forsk.) Webb.**		
Algeriac¸ (M'Sila)	Cladodes	Decoction	Eczema	External use	Boudjelal et al. (2013)
Algeria (Ouanougha)	Cladodes	NS	Skin disease recovery, diarrhea, inflamed eyes, fever		Rebbas et al. (2012)
Algeria (Ouargla)	Cladodes	NS	Rheumatism, Skin wounds, Scorpion sting	NS	Ould El Hadj et al. (2003)
Algeria (Ouargla)	Seeds, fruits	Decoction, Infusion	Diabetes	Oral	Telli et al. (2016)
Algeria	Cladodes	Grounded and blending with olive oil	Back pain, skin wounds	External use	Rebbas et al. (2012)
Algeria	Cladodes	Infusion	Treat stomachache	Oral	Rebbas et al. (2012)
Algeria	NS	NS	To treat rabies	NS	Louaar et al. (2005)
Israel	Cladodes	Decoction	Joint aches, skin bruise and back pain	Bath	El-Mokasabi (2014)
Jordan	Cladodes	Decoction	Burns and fractures	Poultice	Hudaib et al. (2008)
Lebanon	Cladodes	Decoction	Joint aches	Bath	El-Beyrouthy et al. (2008)
Libya (Al-Jabal Al-Akhder)	NS	NS	Sinusitis, diabetes	NS	Said et al. (2002)
Middle East	Flowers, Cladodes	Decoction	Women infertility, syphilis	External use	Yaniv & Dudai (2014)
Morocco (Marrakech)	Cladodes	Decoction	Scabies and Antipruritic	Liniments	Bellakhdar et al. (1991); Bellakhdar (1997)
Morocco (Sahara)	Roots	Decoction	Abortive	Vaginal washings	Bellakhdar (1997)
Morocco (Sahara)	Roots	NS	Diphtheria	NS	Mouhajir (2002)
Morocco (Taounate, Tata)	Flowers, Cladodes	Decoction	Skin disease	External use	Bellakhdar et al. (1991); El-Hilaly et al. (2003); Abouri et al. (2012)
Morocco (Tata)	Cladodes	Cataplasm	Wounds healing, scorpion bite	External use	Abouri et al. (2012)
Morocco (Tata)	Cladodes	Infusion	Rheumatism	Oral	Abouri et al. (2012)

TABLE 1. Cont.

Country/ province	Used plant part	Preparation	Traditional use	Route of administration	References
Morocco (Tissint)	Cladodes	Powdered	Local wound treatment antiseptic and also sedative, Circumcision healing Skin ulcers and wounds, vulnerary	Cataplasm	Bellakhdar et al. (1991); Bellakhdar (1997)
Morocco	Cladodes	Grounded and blending with honey	Emetic	Oral	Bellakhdar (1997)
Morocco	Cladodes	Decoction	Purgative and Vermifuge	Rectal washings	Bellakhdar et al. (1991); Bellakhdar (1997)
Morocco	Flowers, Cladodes	Infusion	Abortive	Oral	Abouri et al. (2012); Bellakhdar (1997)
Palestine	Seeds, cladodes	NS	Treat stomachache, analgesic	Oral	Ali-Shtayeh et al. (1998)
Palestine	Seeds, cladodes	NS	Anti-inflammatory, sore throat treatment and treat inflamed eyes, paralysis and infertility, antirheumatic	Poultice	Ali-Shtayeh et al. (1998)
Tunisia	Cladodes	NS	Scabies	Poultice	Viegi & Ghedira (2014)
Yemen	Cladodes	Infusion	Jaundice, hepatitis	Internal use	Hehmeyer & Schönig (2012)
			R. sphaerocarpa **Boiss**		
Morocco (Errachidia)	Root	Decoction	Diabetes	Internal us	Tahraoui et al. (2007)
Morocco (Sahara)	Roots	NS	Diphtheria	NS	Mouhajir (2002)
Morocco	Cladodes	Decoction	Purgative andVermifuge	Rectal washings	Bellakhdar (1997)
Morocco	Cladodes	Grounded and blending with honey	Emetic	Oral	Bellakhdar (1997)
Spain	Flowers, Cladodes	Decoction	Rheumatism, Diabetes, warts Healing,	External and oral use	Benítez Cruz (2007)
Spain	Flowers	Crushed in water	Skin wound healing	Poultice	Benítez Cruz (2007)
Spain	Cladodes	No preparation	Luxation	Topic	Benítez et al. (2010)
Spain	Flowers	Cataplasm	Pain, contusion	Topic	Benítez et al. (2010)
Spain	Cladodes	Infusion, Decoction	Fever	Oral	Benítez Cruz (2007); Benitez et al. (2010)
Spain	Flowers	Infusion	Liver disease	Oral	Benítez Cruz (2007); Benitez et al. (2010)
Spain	Fruit	Fresh ingested	Diarrhea	Oral	Benitez et al. (2010)
Spain	Cladodes	Crushed by vinegar, salt or ash	Joint aches	Poultice	Benítez Cruz (2007)

NS: not specified.

addition to its pharmacological effect in nervous system (Al-Tubuly et al., 2011; Al-Sharari et al., 2020). Essential oils from flowers indicated antifungal, antibacterial (Edziri et al., 2010; Al-Sharari et al., 2020), antimicrobial and antiseptic activities (Awen et al., 2011; Al-Sharari et al., 2020). Flavonoids α-glucosidase showed inhibitory effect (Ghani et al., 2019; Al-Sharari et al., 2020); antidiabetic activities (Algandaby et al., 2010; Al-Sharari et al., 2020) and minimal nephrotoxic toxicity (Algandaby, 2015; Al-Sharari et al., 2020).

Retamine and sparteine are among the 30 alkaloids identified from *R. raetam* stem*;* both may be lethal to experimental animals if given in large doses by oral or intravenous mode. Retamine and sparteine are block autonomic ganglia and cardiotoxic, while the sparteine causing paralyzing respiratory muscles leading to respiratory failure (Schmid et al., 2006). The isoflavones genistein, 6-hydroxygenistein, biochanin A, 3'-O-methylorobol, pratensein, luteolin, the flavones 6-hydroxyapigenin and the flavonol kaempferol, as well as the p-coumaric acid (phenolic compound) isolated from *R. raetam* have reduce significantly the pain at dose of 1 mg/kg due to its analgesic activity. 3'-O-methylorobol and biochanin A are the most active compounds 86.19% and 75.23%; respectively (Djeddi et al., 2013).

The aqueous extracts of all organs of the *R. raetam* were showed antioxidant activities, as it utilized very low free radical capturing activity if compared to the butylated hydroxytoluene (BHT) and possess lower hydrogen peroxide blocking activity compared to the gallic acid (Djeddi et al., 2013). Also, some of the isoflavonoids separated from the methanol extract of *R. raetam* showed analgesic activity, is almost equivalent to aspirin in the case of 86.9% from 3'-O-methylorobol (Djeddi et al., 2013).

Abed & Benmrabet (1981) and Maghrani et al. (2005b), reported that the active principles such as saponins, flavonoids, and organic acids in the aqueous *R. raetam* extract causing a significant diuretic effect (Maghrani et al., 2005b), it observed as increase on diuresis from the second to the fourth hours if administrated intravenous as 5 mg/kg/h in normal rats. Such compounds are acting as angiotensin converting enzyme (ACE) inhibitors that act separately or synergistically to generate this diuretic effect (Actis-Goretta et al., 2003; Maghrani et al., 2005b).

R. monosperma and others: R. monosperma is a potential source of anticancer compounds, it exhibits a significant cytotoxic effect on two cervical cancer cell lines (Merghoub et al., 2009; Muñoz Vallés et al., 2013). *R. monosperma* tissues accumulate cytotoxic alkaloids in stems and fruits (Salatino & Gottlieb, 1980; El-Shazly et al., 1996; Muñoz Vallés et al., 2013). Among these alkaloids the anagryne and ammodendrine that cause congenital diseases in pregnant animals (Keeler, 1969; Muñoz Vallés et al., 2013). The ethyl acetate extract of *R. monosperma* seeds is a potential natural source antioxidant source, it showed 197.95mg ascorbic acid equivalent (AAE)/g dry extract as total antioxidant capacity (TAA). While the butanol extract of the flower showed the lowest value it was 26mg (AAE)/g dry extract (Belmokhtar & Harch, 2014). The antioxidant activity of *R. monosperma* was attributed to the antioxidant activity of the genistein isoflavone which comprises its major flavonoid (Gonzàlez-Mauraza et al., 2013; Belmokhtar & Harch, 2014). Genistein is an efficient antioxidant as well as it increases the activity of several antioxidant enzymes among them: catalase, glutathione reductase, glutathione peroxidase, superoxide and dismutase (Qiuyin & Huachen, 1996; Trieu et al., 1999; Belmokhtar & Harch, 2014). The antioxidant activity of genistein isoflavone has potential applications for cancer prevention, and treatment of cardiovascular diseases and other human diseases (Belmokhtar & Harch, 2014). In Tunisia, the *R. raetam* containing lower content of the total phenols and flavonoids if compared to *R. monosperma* (Hayet et al., 2008; Belmokhtar & Harch, 2014). On the other hands, the hexane extract of *R. monosperma,* showed a significant cytotoxic activity against the human T-lymphocyte cells (Jurkat cells), due to its bioactive constituent namely: campesterol, α-linolenic acid, sitosterol and stigmasterol (Belayachi et al., 2014).

Quinolizidine alkaloids *were* isolated from *R. raetam*, *R. sphaerocarpa* and *R. monosperma* (El-Shazly et al., 1996). The earlier reports outlined several toxicological and pharmacological activities of these alkaloids among them antipyretic, antiarrhythmic, depressant, diuretic, hallucinogenic, hypoglycemic, hypotensive, oxytocic, respiratory stimulant and uterotonic properties (Kinghorn & Balandrin, 1984; Wink, 1993; El-Shazly et al., 1996). Quinolizidine alkaloids showed an important provision for future use to protect crops from microbial infection and herbivores feeding (El-Shazly et al., 1996). Touati et al. 1996; Fdil et al., 2012; Belmokhtar & Harch, 2014; Belmokhtar & Harch, 2014), claimed that *R. monosperma* contained high proportions of alkaloids. The pharmacological investigations showed that these compounds showed anti-inflammatory activity (González-Mauraza et al., 2013), anti-leukemic activity (Belayachi et al., 2014) and in vitro inhibition of the cervical cancer cell lines (Merghoub et al., 2011; Benbacer et al., 2012; Belmokhtar & Harch, 2014). The antidiabetic activity of *R. monosperma* may be attributed to its fatty acids composition as palmitic acid, oleic acid, linolenic acid and linoleic, the pharmaceutical indication of the latter is effective as antileukemic (El Hamdani & Fdil, 2015).

Antimicrobial activity of the Retama spp.

The ethyl acetate fraction of *R. raetam* is efficient antibacterial (MICs of 128–256mg ml^{-1}) for the *Staphylococcus aureus* the methicillin-resistant Gram-positive bacteria (Hayet et al., 2007; Awen et al., 2011). As well as for the Gram-negative bacteria with inhibition zone 8-11mm and 11-14mm for the *Staphylococcus aureus, Escherichia coli* and *Bacillus subtilis;* respectively (Ahmed et al., 2016). While, the methanol-water (50:50) fraction of *R. sphaerocarpa* stems and the polyphenol-rich fraction revealed a significant antibacterial activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Touati et al., 2017; León-González et al., 2018). The essential oil of *R. raetam* is a potential antimicrobial mediator for drugs and traditional plant-based preparations (Awen et al., 2011) The derrone and licoflavone C flavonoids isolated from *R. raetam* by ethyl acetate showed antibacterial activity against *Pseudomonas aeruginosa* and *Escherichia coli* (Edziri et al., 2012; León-González et al., 2018). The aqueous extract of *Retama raetam* and *R. sphaerocarpa* showed the antibacterial activities against the methicillin-resistant *Staphylococcus aureus* (MRSA) and *S. aureus*, where the aqueous extract of the later was more active in MIC 125µg/mL than that of *R. raetam* and bactericidal to these *Staphylococcus* strains (Hammouche-Mokrane et al., 2017). *Retama* flavonoids induce antimicrobial activity where the extract of the vegetative parts showed considerable antibacterial capacities versus human pathogens namely, *Bacillus cereus* and *Vibrio vulnificus* (Saada et al., 2018).

Antifungal activity of the Retama spp.

The seed alkaloids of *R. monosperma* have been as anticorrosive extract (Dart, 1998; El Hamdani & Fdil, 2015). While extracts of its aerial parts (stems and leaves) were found to be efficient antifungal at (500µg/mL) concentration against *Candida albicans* (16.66- and 18.66-mm inhibition zone; respectively) and *Candida tropicalis* (14.33- and 20.66-mm inhibition zone; respectively). The leaf alkaloids were more effective on *Candida tropicalis* than stems alkaloids. The antifungal of the leaves and stems alkaloids at the same concentration extends to cover *Aspergillus niger* (8.66- and 9.33-mm inhibition zone; respectively). In contrast, *A. niger* and *Candida* species were resistant to the seed alkaloids of *R. monosperma* (El Hamdani & Fdil, 2015). The antifungal activity of the stems and leaves alkaloids may be attributed to the presence of anagyrine, ammodendrine and sparteine. On the other hand, the high concentration of cytisine and its related derivatives in the seed alkaloid extracts inactivate its antifungal activity (El Hamdani & Fdil, 2015). The flavonoids (derrone and licoflavone C) isolated from *R. raetam* by ethyl acetate showed significant antifungal activity against *Candida* species (Edziri et al., 2012; León-González et al., 2018).

Conclusion

This review gathered a huge information in different disciplines about the four multipurpose Mediterranean *Retama* species. However, this genus still needs further effort concerning its genetic diversity, genetic response to environmental stresses in Arid-Mediterranean region and chromosome number as well as inter and intra-specific karyotyping this interm of research. In addition to its urgent need for a regional conservation plan.

Acknowledgements: The authors acknowledge the staff of Cairo University Herbarium (CAI), for the academic facilities given to the authors during this work.

Conflict of interest: None.

Authorship contribution: Reham A. Youssef: Data collection and prepared the manuscript. Wafaa M. Amer: supervised the whole work, and refined the manuscript. Omran N. Ghaly: helped in manuscript preparation and the field work.

Azza B. Hamed: prepare the manuscript styling and the reference section.

Ethics approval: Not applicable.

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ضوء على أنواع الرتم الصحراوية بمنطقة البحر المتوسط المستديمة الخضرة وذات السيقان التمثيلية

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جنس الرتم (الفصيلة البقولية) هو جنس من منطقة البحر الأبيض المتوسط، وقد تم توطينه في العالم الجديد مؤخرًا. وهذا الجنس يشمل أربعة أنواع من الرتم هي ديزيكاربا مونوسبرما والريتاما والسفيروكاربا. وكلها أنواع صحراوية ذات سيقان تمثيلية. أما الأنواع المصاحبة لها فدائما ما تتغير بتغير الموقع الجغرافي للنوع قيد لدراسة. أما حبوب اللقاح في جنس الريتاما فهو فردي وثلاثي الشقوق وبعض الأزهار تفتقر إلى الرحيق، والبعض الآخر منتجة للرحيق وتتلقح بالحشرات. ويتميز جنس الريتاما بانه يمتلك العديد من آليات المقاومة والدفاع واستراتيجيات التأقلم والتكيف مع ضغوط الجفاف والملوحة بما في ذلك جينات الاستجابة للضغط والتكيف الفسيولوجي والميكروبيولوجي. وتلعب ميكروبات التربة والميكروبات الداخلية دورًا مهمًا في تحسين تأقلم أنواع الريتاما تحت الضغوط البيئية. وجنس الريتاما ذات صبغيات رباعية التضاعف ويوجد بها ظاهرة الكروموسومات الكاريولوجية المتجانسة. وحجم الجينوم مرتبط بطبيعة البيئية.

غطت هذه المراجعة تصنيف أنواع الريتاما وأهميتها في الأراضي القاحلة وخاصة دورها في حماية التربة واستدامته وخصوبتها وإعادة تأهيل الصحراء. كما تم حصر المركبات الكيمياء في أنواع الريتاما بما في ذلك مركبات الفلافونويد، والزيوت العطرية، والقلويدات، والتربين، والمنشطات، والأحماض الدهنية، والسكريات، والتركيب المعدني. بالإضافة إلى استخداماته المتعددة الأغراض كعلف واستخدامات نباتية وأنشطة دوائية، وتتميز الريتاما بوجود مركبات مضادة للسرطان ومضادات الأكسدة وخافضه لسكر الدم ومضاد للالتهابات ومسكن ومضاده لسرطان الدم ومضاده للبكتيريا والفطريات وغيرها.