

Taxonomic revision of genus *Prosopis* L. in Egypt

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ABSTRACT

The aim of this work was to survey the new record invasive alien *Prosopis juliflora* and clarifies the taxonomic relationships among genus *Prosopis* L. in Egypt. The wild species are *Prosopis farcta* (Banks & Sol.) Macbride and *Prosopis juliflora* (Sw.) DC. The cultivated species are *Prosopis cineraria* (L.) Druce; *Prosopis glandulosa* Torr. and *Prosopis strombulifera* (Lam.) Benth. Based on morphological traits, the numerical analysis divided the *Prosopis* species into three clusters. Cluster one included: *Prosopis glandulosa* and *Prosopis juliflora*. Cluster two included: *Prosopis farcta* and *Prosopis cineraria*. Cluster three included: *Prosopis strombulifera*. According to the degree of similarity, the species of cluster one had the highest ratio (75%) followed by (55.6%) between the species of cluster two. Moreover, the highest ratio (33.3%) was recorded between *Prosopis strombulifera* and *Prosopis juliflora*, while the lowest ratio (20.8%) was recorded between *Prosopis strombulifera* and *Prosopis cineraria*. This work recoded *Prosopis juliflora* to the Flora of Egypt.

Key words: Taxonomy, *Prosopis*, alien species, numerical analysis, similarity level, Egypt.

Introduction

The genus *Prosopis* L. belongs to the family Leguminosae, subfamily Mimosoideae, tribe Mimosae (Burkart, 1976; Sherry *et al.*, 2011). It comprises 44 species and five sections based on observed morphological differences among studied taxa (Burkart, 1976). The five sections included: *Prosopis*; *Anonychium*; *Strombocarpa*; *Monilicarpa* and *Algarobia* (Burkart, 1976; Landeras *et al.*, 2004; Elmeer and Almalki, 2011). Section *Prosopis* included 3 species which have internodal prickles. Each of section *Anonychium* and *Monilicarpa* included 1 species. Section *Strombocarpa* included 9 species which have spiny stipules. Section *Algarobia* included 30 species, which have axillary thorns (Burkart, 1976).

The genus *Prosopis* L. is thought to have originated in tropical Africa at the end of the Mesozoic or the beginning of the Tertiary period (Burkart, 1976). *Prosopis* have a wide distribution, occurring in South, North and Central America, Africa and Western Asia (Burkart, 1976; Llanes *et al.*, 2011; Sherry *et al.*, 2011). *Prosopis* species were introduced in various areas primarily to combat desertification and improve the quality and quantity of the arid regions (El Fadl and Luukkznen, 2003; Mosweul *et al.*, 2013). Some of the species are of major economic importance; pods are utilized as food and fodder and wood as fuel and timber (Pasicznik *et al.*, 2001; Sherry *et al.*, 2011). Invasive alien species can destroy natural pasture and reduce grazing potential of natural rangeland and can directly or indirectly affect the food security (Van Wilgen *et al.*, 2008; Van den Berg *et al.*, 2013).

In Egypt, genus *Prosopis* was represented by 5 species; *Prosopis glandulosa* and *Prosopis juliflora* (section *Algarobia*); *Prosopis cineraria* and *Prosopis farcta* (section *Prosopis*) and *Prosopis strombulifera* (section *Strombocarpa*) (Burkart, 1976). *Prosopis juliflora* has escaped from cultivation sites and distributed through the natural habitats in the coastal areas of Red Sea and Northern part of Sinai. The aim of this work was to survey the new record invasive alien *Prosopis juliflora* and clarifies the taxonomic relationships among genus *Prosopis*. Moreover, the constructed artificial key was used to distinguish among studied species. Further investigation on the effects of invasive alien *Prosopis juliflora* on the natural biodiversity of Egypt is needed.

Materials and Methods

Taxon sampling and nomenclature:

Field trips were carried out to collect the available studied taxa from different localities in Egypt (Figure 2) during years 2013-2014. A total of 5 species were recorded during this study. The identification of

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the wild species was based on (Täckholm, 1974 and Boulos, 1999), while the identification of cultivated ones was based on (Burkart, 1976). The updated names of the studied species were checked by (Boulos, 1995 & 2009; Angiosperm Phylogeny Group (APG III) 2009; Chase and Reveal, 2009; Haston *et al.*, 2009). Voucher specimens were kept at herbarium of Flora and Phytotaxonomy Researches Department (CAIM), Horticultural Research Institute, Agricultural Research Center, Giza, Egypt.

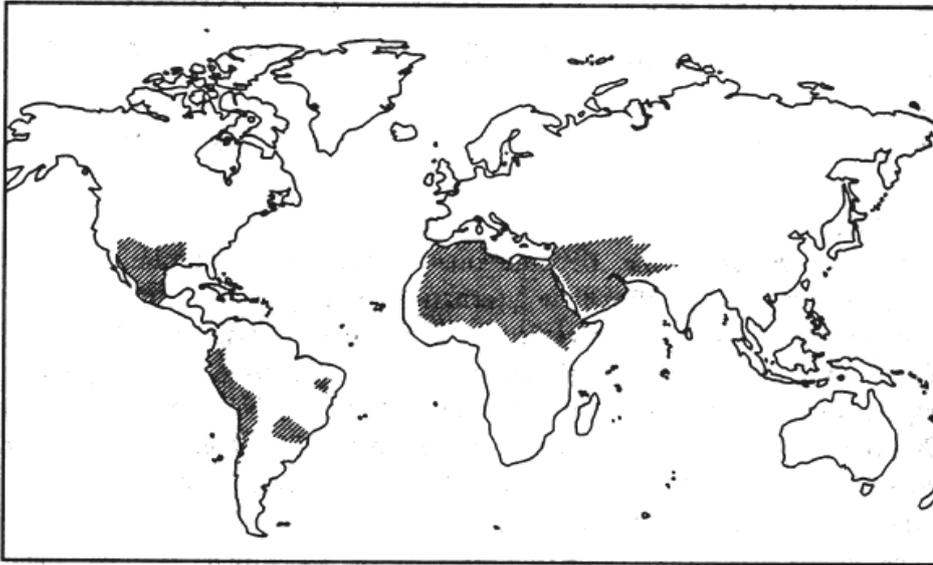


Fig. 1. Global distribution of genus *Prosopis* (after Pasiecznik *et al.*, 2001 and Catalano *et al.*, 2008)

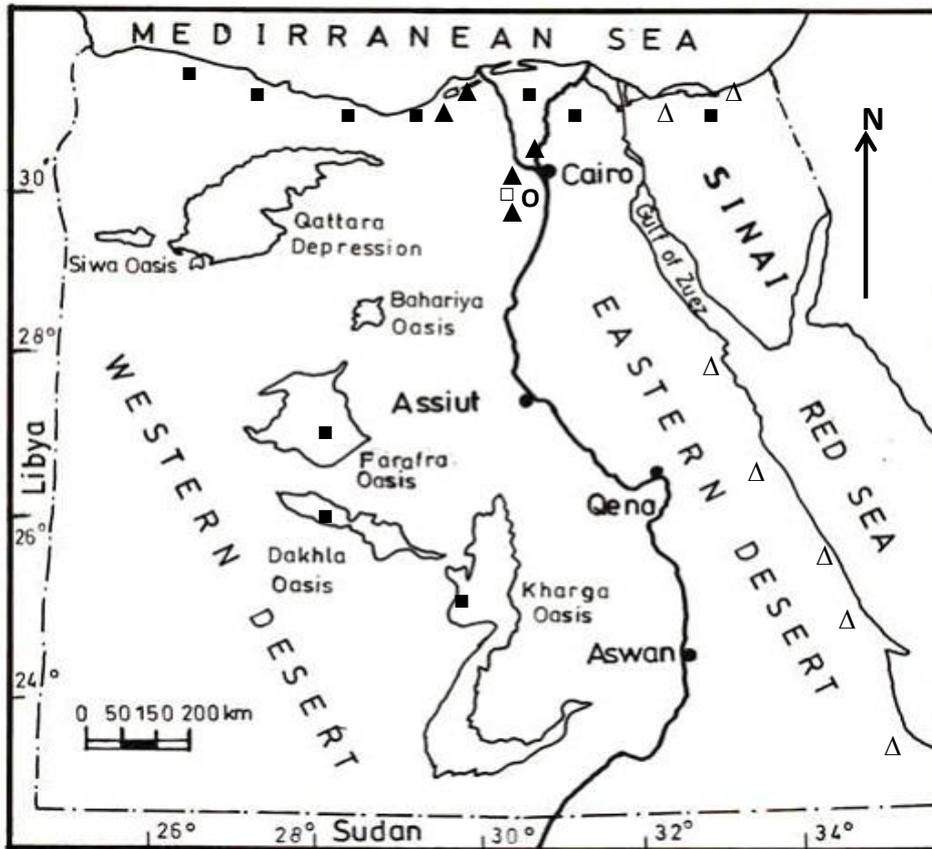


Fig. 2. Local distribution of genus *Prosopis*: *P. farcta* (■), *P. cineraria* (□), *P. glandulosa* (▲), *P. juliflora* (△) and *P. strombulifera* (○) in Egypt.

Morphological data:

Morphological data were recorded from the collected fresh samples and deposited herbarium sheets at the herbarium of Flora and Phytotaxonomy Researches Department (CAIM), Horticultural Research Institute, Agricultural Research Center, Giza, Egypt. A total of 28 morphological characters were recorded (Table 1). Additional information was gathered from the literature (Sherry *et al.*, 2011; Mosweul *et al.*, 2013). The terminology used follows (Pasicznik *et al.*, 2003; Catalano, 2008). Classification of accepted sections and studied species was based on (Burkart, 1976). Global and local distributions of genus *Prosopis* were mapped (Figures 1 and 2). Each taxon was provided with detailed line drawing (Figure 4).

Numerical analysis:

Numerical analysis of the differential characters was based on hierarchical cluster analysis. The retrieved output was used to construct specific taxonomic relationships among the studied taxa. The substantial numbers (1 = presence and 0 = absence) of 28 characters were used for the studied species (Table 1). For the numerical analysis, the data were treated as a binary character in a data matrix using SPSS version 10 (SPSS, 1999). The output was plotted in the form of dendrogram (Figure 3). The dendrogram was based on average linkage (between groups) and rescaled distance cluster combine.

Results

Diagnostic features of the studied *Prosopis* species in Egypt

Prosopis L., Mant. 1: 10. (1767).

Habit: unarmed or armed trees or shrubs with prickles, axillary spines or spinescent stipules. Leaves: bipinnate, pinnae 1-4 pairs, leaflets few or many paired; stipules small, or absent. Inflorescence: axillary cylindrical spike or globose heads. Flowers: 5-merous. Calyx: shortly dentate. Petals: connate below the middle. Stamens: 10, free, anthers with or without a deciduous gland. Ovary: sessile or stipitate. Pod: linear, thick and compressed, straight or falcate, indehiscent. Seeds: ovate, compressed.

Key to the studied *Prosopis* species in Egypt

- | | | |
|---|---|-------------------------------|
| 1 | Pinnae 3-4 pairs; rachis glabrous; flowers whitish----- | <i>Prosopis cineraria</i> |
| + | Pinnae 1-2 pairs; rachis pubescent; flowers yellowish----- | 2 |
| 2 | Leaf imparipinnate; leaflets apex mucronate; pod falcate- ----- | <i>Prosopis glandulosa</i> |
| + | Leaf paripinnate; leaflets apex obtuse; pod straight- ----- | 3 |
| 3 | Pod coiled; rachis 1-2cm long; leaflets whitish-glaucous----- | <i>Prosopis strombulifera</i> |
| + | Pod non coiled; rachis 3-4cm long; leaflets green----- | 4 |
| 4 | Prickles on internodes; stipules non-spiny; pods blackish----- | <i>Prosopis farcta</i> |
| + | No prickles on internodes; stipules spiny; pods yellowish----- | <i>Prosopis juliflora</i> |

***Prosopis farcta* (Banks & Sol.) J.F. Macbr.** in Contrib. Gray Herb. N. S. 59: 17. (1919).

Synonyms: *Mimosa farcta* Banks & Sol. in Russell, Nat. Hist. Aleppo ed. 2(2): 266. (1794).

Mimosa stephaniana M.-Bieb., Tablean des prov. sit. sur la Cote occid. mer. Gasp. 720. (1794).

Prosopis stephaniana (M. Bieb.) Kunth ex Sprengel, Syst. 2: 328. (1825).

Lagonychium farctum (Banks & Sol.) Bobrov in Komarov, Fl. SSR 11:14 (1945).

Habit: dwarf shrub 0.5-2.5 m tall, branches downy, slender, whitish, with pointed prickles distributed on internodes. Leaves: 3-6 cm long, compound paripinnate, stipules non-spiny, 2-3 mm long. Rachis: 3-4 cm long, pubescent. Pinnae: 1-2 pairs, 4-6 cm long. Leaflets: subsessile, 9-13 pairs, 5-10 mm long, 2-3 mm broad, green, lanceolate, margin entire, tip obtuse. Spike: 6-10 cm long; flower yellowish. Pedicel: 1 mm. Calyx: 2-3 mm long, glabrous, truncate. Corolla: 2-4 mm long. Pod: oblique (asymmetrical sides), oblong, 2.5-4 cm long, 1.5-2.5 cm thick, blackish, rugose (rough and wrinkled), obtuse, contracted abruptly into the stalk. Seeds: 10-15.

***Prosopis juliflora* (Sw.) DC.,** Prodr. 2:447. (1825); Jafri, Fl. Kar. 150 (1966).

Synonyms: *Mimosa juliflora* Swartz, Prodr. Veg. Ind. Occ. 85 (1788).

Mimosa salinarum Vahl, Eclog. Am., 3: 35 (1794)

Acacia juliflora (Sw.) Willd., Sp. Pl., 4: 1076 (1805).

Prosopis domingensis DC., Prod., 2: 447 (1824).

Habit: tree, 5 m tall, no prickles on internodes, branches often zigzag-shaped. Leaves: alternate, compound paripinnate. Pinnae: 1-2 pairs, 4-8 cm long. Rachis: 3-4 cm long, pubescent. Leaflets: subsessile, 10-14 pairs, 1.5-2 cm long, 4-5 mm broad, entire, oblong, green, apex obtuse. Stipules: spiny, generally 1 cm in pair. Inflorescence: dense axillary pedunculate, spikes 4-8 cm long, peduncle 6-12 mm long. Flowers: yellowish, pedicel 1mm. Calyx: 2-3 mm long, bell-shaped. Petals: 5, free, 3-4 mm long, tip and margin hairy. Pod: stalk, 15-25 cm long, 1-1.2 cm broad, straight to semi-circular, symmetrical, yellowish, glabrous; stalk 5-7 mm long. Seeds: 10-18.

***Prosopis cineraria* (L.) Druce** in Rep. Bot. Exch. Club. Brit. Isles. 3: 422. (1914).

Synonyms: *Mimosa cineraria* Linn., Sp. Pl. ed. 2. 1500. (1763).

Prosopis spicigera Linn., Mant. 1: 68 (1767).

Habit: a medium sized tree up to 10 m tall, branches with pointed prickles distributed on internodes. Leaves: alternate, compound paripinnate. Pinnae: 3-4 pairs, 4-8 cm long. Rachis: 2.5-3 cm long, glabrous. Leaflets: sessile, 9-12 pairs, 5-10 mm long and 2-3 mm broad, oblong, green, oblique, apex obtuse. Flowers: whitish in pedunculate spikes, peduncle 1-2.5 cm long. Calyx: 1-1.5 cm long, truncate, 5 toothed. Petals: 3-4 mm long, oblong. Pods: 12-20 cm long, 0.5-1 cm broad, yellowish, slender, symmetrical, pendulous, cylindrical, turgid, stalked. Seeds: 10-15.

***Prosopis glandulosa* Torr.** in Ann. Lyc. N. Y. 2:192. (1827).

Synonyms: *Algarobia glandulosa* (Torr.) Torr. & A. Gray, Fl. N. Amer., 1(13): 399: (1840).

Prosopis odorata Torr. & Frém., Rep. Exped. Rocky Mts. 313-314, pl. 1 (1845).

Habit: medium sized tree up to 9 m tall, branches thorny 5-7 cm long, stout. Leaves: compound imparipinnate, alternate. Pinnae: 1-2 pairs, 4-8 cm long. Rachis: 3-4 cm long, pubescent. Leaflets: subsessile, 9-12 pairs, 1.5-3 cm long, 4-5 mm broad, lanceolate, green, apex mucronate. Inflorescence: axillary spikes 7.5 cm long, solitary or in fascicles, peduncle 0.5-1.5 cm long, flowers yellowish. Calyx: 2-3 mm long, bell-shaped, 5-toothed. Petals: 2-3 cm long, oblong, hairy. Pods: 12.5-20 cm long, 0.5-1 cm broad, falcate, symmetrical, compressed, turgid, pendulous, narrowed into a short stalk, yellowish. Seeds: 12-20.

***Prosopis strombulifera* (Lam.) Benth., in Hook., Jour. Bot.** 4:352 (1842).

Synonyms: *Mimosa strombulifera* Lam., Encyc., 1: 15 (1783).

Acacia strombulifera (Lam.) Willd., Sp. Pl., 4 (2): 1055 (1805)

Habit: large deciduous shrubs up to 3 m tall, with whitish spines up to 2 cm long appear near the leaf bases, branches often zigzag-shaped with pointed prickles distributed on internodes. Leaves: alternate, compound paripinnate. Pinnae: 1-2 pairs, 2-3 cm long. Rachis: pubescent, 1-2 cm long. Leaflets: subsessile, opposite, oblong, 4-5 pairs, 5-10 mm long, 2-3 mm broad, covered with a whitish-glaucous film, apex obtuse. Flowers: yellowish, heads, axillary, small, 1.5 cm diameter with bell-shaped calyces, on stalks 2 cm long. Calyx: 2-3 mm long. Petals: 5, yellow, fused at base, 1-2.5 cm long. Pods: 2-5 cm long, 0.5-1 cm broad, sweet, flattened, glabrous, leathery, slightly constricted between seeds, tight-coiled, yellowish, straight. Seeds: numerous.

UPGMA dendrogram among the studied species:

The dendrogram (Figure 3) showed that, the studied species separated into three clusters (Table 3). It divided the *Prosopis* species into three clusters. Cluster one included: *Prosopis glandulosa* (SP3) and *Prosopis juliflora* (SP4). Cluster two included: *Prosopis farcta* (SP1) and *Prosopis cineraria* (SP2). Cluster three included: *Prosopis strombulifera* (SP5). On the whole, the species of clusters one and two had closed relationship to each other, while the plant of cluster three was separated as single cluster.

Intraspecific variation among the Prosopis species:

According to data of similarity matrix (Table 2), *Prosopis glandulosa* and *Prosopis juliflora* had the highest ratio of similarity (75%), followed by (55.6%) between *Prosopis farcta* and *Prosopis cineraria* then (50%) between *Prosopis cineraria* and *Prosopis juliflora*. On the other hand, the lowest ratio of similarity (20.8%) was recorded between *Prosopis cineraria* and *Prosopis strombulifera* followed by (22.7%) between *Prosopis farcta* and *Prosopis strombulifera* then (33.3%) between *Prosopis juliflora* and *Prosopis strombulifera*.

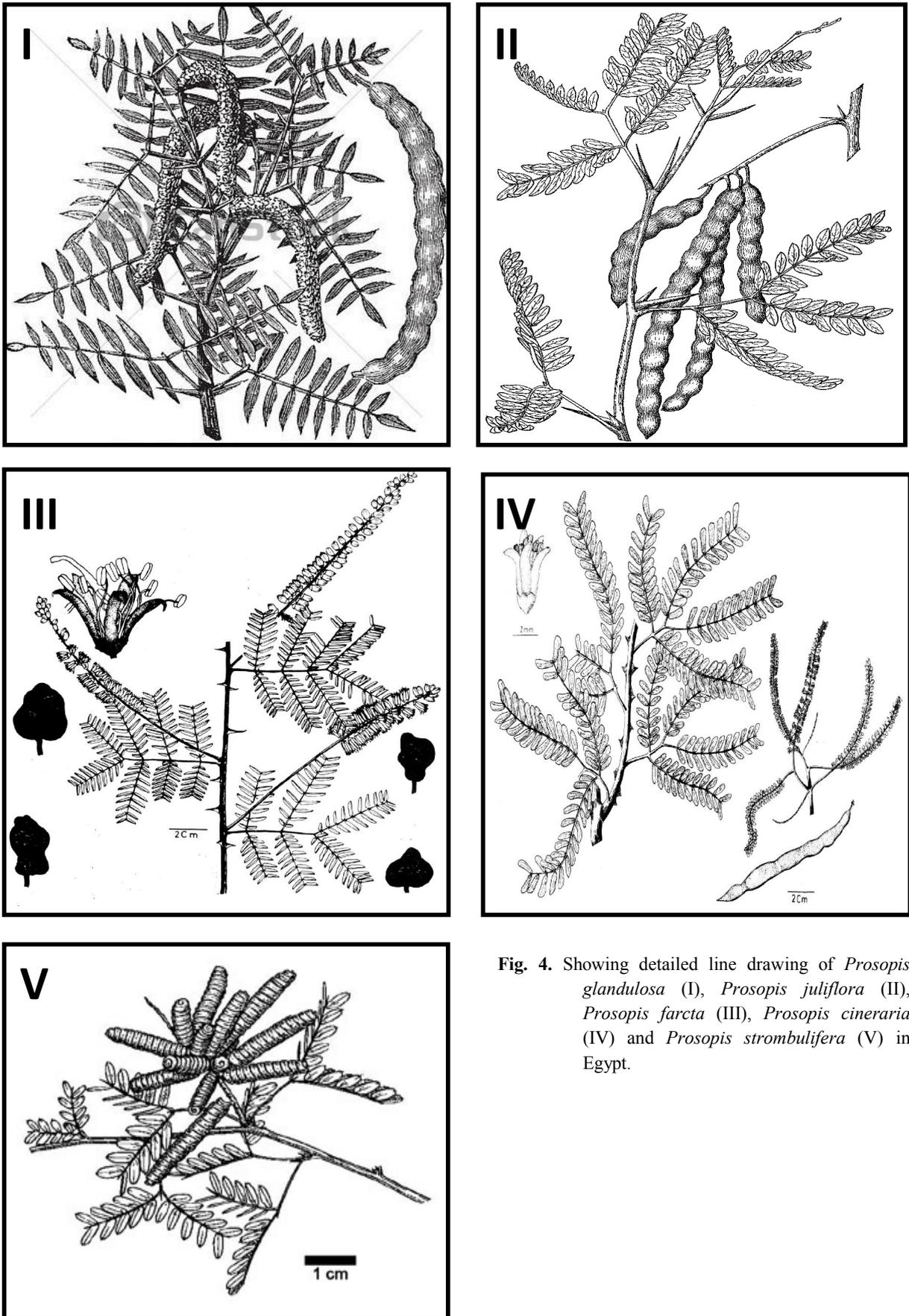


Fig. 4. Showing detailed line drawing of *Prosopis glandulosa* (I), *Prosopis juliflora* (II), *Prosopis farcta* (III), *Prosopis cineraria* (IV) and *Prosopis strombulifera* (V) in Egypt.

Table 3. Clustering of the studied *Prosopis* species based on the numerical analysis of 28 morphological characters

Studied species	Clusters
<i>Prosopis glandulosa</i> (SP3)	C1
<i>Prosopis juliflora</i> (SP4)	
<i>Prosopis farcta</i> (SP1)	C2
<i>Prosopis cineraria</i> (SP2)	
<i>Prosopis strombulifera</i> (SP5)	C3

Discussion

Genus *Prosopis* were subjected to several studies, but the taxonomic delimitation of the genus is still not satisfactorily resolved and there is still disagreement among botanists. In addition, most of these morphological features are modifiable and overlap considerably. It is worth high lighting that researchers have long sought the importance of external morphology to aid in species identification (Metcalf and Chalk 1979).

In this study, on the basis of morphological characters, both (*Prosopis glandulosa* and *Prosopis juliflora*) and (*Prosopis farcta* and *Prosopis cineraria*) were closed to each other and ranked together in clusters one and two, respectively (Figure 3 and Table 3). This was due to the similarities in some morphological traits (Table 1). The current results were in agreements with the investigations that exhibited more or less similar results by (Burkart, 1976; Bragg, 1982; Pasiecznik *et al.*, 2001; Landeras, *et al.*, 2005; Catalano *et al.*, 2008; Elmeer and Almalki, 2011; Sherry *et al.*, 2011), where species of clusters one and two were located in two different sections; Algarobia and *Prosopis*, respectively. In addition to, *Prosopis strombulifera* was located in separate cluster (Figure 3 and Table 3). This was due to the dissimilarities in some morphological characters (Table 1). These finding of dissimilarities were confirmed by (Burkart, 1976; Catalano, *et al.*, 2008; Llanes *et al.*, 2011), where the species is located in separate section; *Strombocarpa*. Moreover, this study showed the importance of morphological tools for taxonomic evaluation among the studied taxa.

Conclusion

The current taxonomic study based on morphological characters revealed that, the position of following studied species: (*Prosopis glandulosa* and *Prosopis juliflora*), (*Prosopis farcta* and *Prosopis cineraria*) and (*Prosopis strombulifera*) in different three clusters respectively, confirmed its closed relationship. This work recoded the invasive alien *Prosopis juliflora* to the Flora of Egypt. However, there seems to be a certain disagreement regarding the naturalized *Prosopis juliflora* which calls for further study to settle the point.

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