

Morphological Diversity of Some *Tephrosia* Species (Fabaceae) in Saudi Arabia

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ABSTRACT

Morphological features of nine wild species belonging to the genus *Tephrosia* PERS growing in Saudi Arabia were extensively studied in order to support the diversity and simplify the identification of these species. The studied features included macro and micro morphological features of stem, leaves, flowers and pods. The most important features regarded for distinction of Saudi Arabia species of *Tephrosia* were pods shape, color, size, dehiscence and number of seeds per pod, inflorescences position, flower opening, shape of the upper 2 teeth of calyx, shape of sepals apex, shape of wings, length of hairs on ovary, direction of staminal tube tip, leaflets shape and surface and stem habit form and life spin. A key for the identification of the investigated species based on these morphological features is provided.

Keywords: Morphology; *Tephrosia*; Fabaceae; Saudi Arabia

1. Introduction

The genus *Tephrosia* PERS. (Fabaceae, Papilionoideae) comprises between 300 to 400 species of annual and perennial woody herb, distributed in tropical and subtropical regions of the world [1,2].

In Saudi Arabia, there are about 11 taxa of *Tephrosia*, which are mainly distributed in the northwestern, western, south and southwestern regions [3-7]. Plant morphology has served largely for systematics, using morphological characteristics to carve up diversity into its systematic sub-units [8].

Eight species of *Tephrosia* growing in Saudi Arabia were described by [7], namely *T. desertorum*, *T. heterophylla* (*T. schweinfurthii*), *T. nubica*, *T. pumila*, *T. purpurea*, *T. subtriflora*, *T. uniflora* and *T. villosa*. But specimens of *T. villosa* described as a species of Saudi Arabia flora [7], whereas plant specimen was collected from Ras al-Khaimah, United Arab of Emirates. Eleven species of *Tephrosia* were described briefly [5] including, *T. apollina*, *T. leptostachya* and *T. pubescens* which treated as subspecies or varieties of *T. purpurea*, in addition to *T. quartiniana* and other species recorded by [7] except *T. villosa*.

Tephrosia schweinfurthii and *T. subtriflora*, which are characterized by their 1-foliolate leaves, were recorded as rare and endangered species [5].

The aim of this work is to revise systematically most of the native taxa of *Tephrosia* in Saudi Arabia with reference to the earlier applied characters as well as macro

and micromorphological characters, which hope to be more reliable the diversity of these taxa.

2. Material and Methods

Morphological features of the studied species are based on the fresh plant samples collected from the sites which were reported by [4-7]; with field survey of the species throughout Saudi Arabia regions in addition to available herbarium specimens (**Table 1**). The plant specimens nomenclatured according to [5-7,9].

Field studies included growth characters, habit of stem, plant height, flower opening and corolla color. Microscopic characters were obtained by using binocular microscope (Zeiss Stemi 2000-Germany). Herbarium specimens of the studied species were prepared and deposited in the Herbarium of the Biology Department Faculty of Science, King Abdulaziz University Terminology used here follows [10].

3. Results and Discussion

The observed morphological characters are listed in **Tables 2-5**. The most important characters are discussed below.

3.1. Vegetative Characters

The stems of studied *Tephrosia* species are erect, ascending or prostrate. The perennial suffrutescent (herb woody at the base) are observed in *T. appolinea*, *T. pu-*

Table 1. List and sites of collection of the studied *Tephrosia* species with relevant information about their herbarium samples.

Taxa	Location/Collector
<i>T. purpurea</i> (L.) PERS. subsp. <i>apollinea</i> (DELILE) HOSNI & EL-KAREMY.	Wadi Assafraa, Bader, 100 km South of Almadinah, Al-Zahrani R. (R 1079).
<i>T. desertorum</i> SCHEELE.	East Jeddah, Al-Zahrani R. (R 1478).
<i>T. nubica</i> (BOISS.) BAKER.	Umm Hablain, Jeddah, Al-Zahrani R. (R 1980).
<i>T. purpurea</i> (L.) PERS. subsp. <i>leptostachya</i> (DC.) BRUMMITT var. <i>pubescens</i> BAKER.	Wadi Noaman, Makkah Taif (Al-Hada) Road, Al-Zahrani R. (R 1861).
<i>T. purpurea</i> (L.) PERS. subsp. <i>leptostachya</i> (DC.) BRUMMITT var. <i>leptostachya</i>	East Jeddah, Al-Zahrani R. (R 1183).
<i>T. pumila</i> (LAM.) PERS.	Jabal Fafa, Elkhashah, East of Jizan, Al-Zahrani R. (R 1982).
<i>T. purpurea</i> (L.) PERS.	Misk Lake, Jeddah
<i>T. quartiniana</i> CUFOD. Ex GREUTER & BURDET	East Jeddah, Al-Zahrani R. (R 1284).
<i>T. uniflora</i> PERS	Bulghazi, Jizan, Al-Zahrani R. (R 1105).

bescens, *T. pumila*, *T. purpurea*, *T. quartiniana* and *T. uniflora*, whereas annual suffrutescent in *T. desertorum* and *T. leptostachya*, and perennial shrubs in and *T. nubica*. The rough surface characterized stems of *T. pubescens* and *T. pumila*, while the surface of other studied species are smooth (Figure 1).

Reference [11] regarded the characters of leaf and flower grouping as the main features for the distinction of the Egyptian *Tephrosia* species. Leaves of the studied *Tephrosia* species are imparipinnate, petiolate, with narrowly triangular stipules. Leaflets are many 3 - 15 (number of leaflets per leaf are not stable for the same species), petiolate with petiole length range from 0.75 to 1.75 mm. The leaflets arrangement is opposite without stipels. Leaflets are obovate, oblanceolate, or elliptic to oblanceolate, with entire margin. Leaflets apex was apiculate, emarginate or obcordate with acuminate tip (Table 2).

3.2. Flower Characters

Floral characters are the most important features that used in systematic of Papilionoideae [12]. Inflorescences of the studied *Tephrosia* species are Pseudoracemes, bracteolate (triangular 0.35 - 1 × 1.25 - 3 - 5 mm size), flowers with triangular bracteale. According to Pseudoracemes characters, studied *Tephrosia* species can be classified into three groups: the first includes *T. apollinea*, *T. desertorum*, *T. leptostachya*, *T. nubica*, *T. pubescens*, and *T. pumila* which characterized by inflorescences borne terminal (opposite the leaf). The second

includes *T. quartiniana* and *T. uniflora* characterized by axillary inflorescences. Whereas *T. purpurea* was recognized in the third group by the inflorescences borne terminal (opposite to a leaf) or axillary. Based on the peduncle length, the first and third groups are padunculate ranged from 0 to 7 cm long, while the second group shows reduced peduncle. Others floral characters showed significant importance in distinction between the studied *Tephrosia* species are, Flower opening (day or evening opening), the shapes the 2 upper teeth of calyx (cleft or dentate), shape of sepals apex (acute or caedate), shape of wings (club, boat or kidney) length of hairs on ovary and direction of staminal tube tip (Figures 2-4).

3.3. Fruits Characters

Pods shapes and characters (color, size, dehiscence and number of seeds) are valuable for species identification [13]. With the exception of *T. nubica*, the other species of *Tephrosia* have linear, yellow to brown, many seeded (5 - 13) pods. Pods size range 0.25 - 0.4 × 2.75 - 5.3 cm, covered with short to medium white hairs, dehiscing at maturity. In *T. nubica* Pods are ovoid, one seeded, with

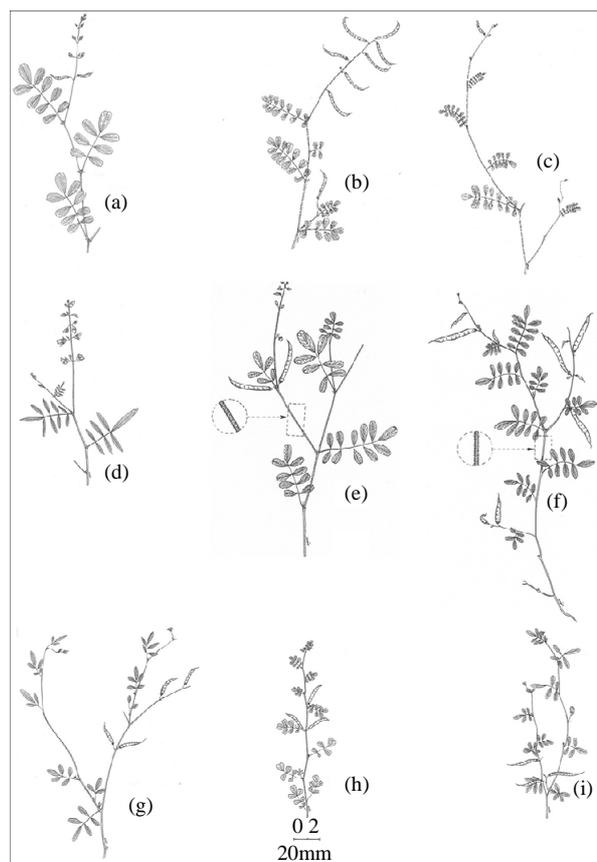


Figure 1. Schematic diagram showing arial parts of different *Tephrosia* species: (a) *T. apollinea*; (b) *T. desertorum*; (c) *T. leptostachya*; (d) *T. nubica*; (e) *T. pubescens*; (f) *T. pumila*; (g) *T. purpurea*; (h) *T. quartiniana*; (i) *T. uniflora*.

Table 2. Vegetative characters of the studied *Tephrosia* species.

Taxa	Stem			Plant length (M)	shape	Size cm	Leaflets					Stipule size mm
	Habit	Life form	Surface				numbers	apex	Tip length	Petiole length Mm	Surface	
<i>T. apollinea</i>	Perennial suffruticose	Erect	smooth	0.4	Obovate	1.3 - 0.5 × 3 - 1	9 - 5 - (3)	Emarginate	0.25 mm	1.7	pannose	1 × 8
<i>T. desertorum</i>	Annual suffruticose	Ascending	smooth	0.4	Obovate	1.3 - 0.6 × 2.2 - 0.9	13 - 9 - (7) - (15)	Obcordate	0.4	1.5	pannose	1 × 5
<i>T. leptostachya</i>	Annual herb	prostrate	smooth	0.5	Obovate	0.8 - 0.4 × 1.5 - 0.4	17 - 9 - (7)	Obcordate	0.25	1	pannose	1 × 4
<i>T. nubica</i>	Perennial shrub	Erect	smooth	1.5	Oblanceolate	0.7 - 0.3 × 4 - 1	(9) - 7 - 5	Apiculate	0.5	1.5	pannose	1.5 × 3
<i>T. pubescens</i>	Perennial suffruticose	Ascending	rough	0.4	Oblanceolate	0.7 - 0.3 × 2.2 - 0.6	9 - (7 - 5) - 13	Emarginate	0.35	1.7	pubescent	1 × 4
<i>T. pumila</i>	Perennial suffruticose	prostrate	rough	0.3	Oblanceolate	0.5 - 0.25 × 1.2 - 0.4	9 - 7 - (5)	Apiculate	0.5	0.75	pubescent	0.75 × 2
<i>T. purpurea</i>	Perennial shrub or suffruticose	Erect/Ascending	smooth	0.7	Elliptic/Oblanceolate	0.7 - 0.3 × 2.6 - 0.9	5 - 3	Apiculate	0.5	1	pannose	1 × 6
<i>T. quartiniana</i>	Perennial suffruticose	prostrate	smooth	0.7	Obovate	1.1 - 0.3 × 1.3 - 0.5	(9) - 7 - 5	Emarginate	0.25	1	Pannose down	1 × 3
<i>T. uniflora</i>	Perennial suffruticose	Erect	smooth	0.6	Oblanceolate	0.4 - 2 × 0.03 - 0.7	7 - 5 - (3)	Apiculate	0.25	1	pannose	0.75 × 2.75

All measures are given as a mean.

Table 3. Inflorescence and floral (calyx) characters of the studied *Tephrosia* species.

Taxa	Inflorescence					Flower												
	Position	Axis length	Peduncle length cm	Bracts size mm	Bracteoles size mm	Number/whorls	Pedicel length mm	Opening	Length mm	Calyx								
										Sepal apex shape	Length mm	Tube size mm	Upper two teeth		Lower teeth			
<i>T. apollinea</i>	Opposite to leaf	20 - 10	6.5 - 0	0.5 × 2.75	0.25 × 1.2	2 - 4	2.75	Day	11.5	Acute	3.5	2.25 - 1.25	Cleft	1.25 × 3.25	1	1 × 3.255	1 × 3.5	2.25
<i>T. desertorum</i>	Opposite to leaf	4 - 16	5.8 - 0	0.5 × 2.5	0.25 × 1.75	2 - 3	2	Day	9.5	Acute	3.75	2 - 1.5	Cleft	1.5 × 3	1.5	1.5 × 3.25	1.5 × 3.75	2.5
<i>T. leptostachya</i>	Opposite to leaf	13 - 5	6.5 - 0	0.5 × 2	0.25 × 0.5	1 - 2	2	Day	8	Acute	2.5	1.5 - 1	Cleft	1.25 × 2.25	1	1 × 2.5	1 × 2.75	1.75
<i>T. nubica</i>	Opposite to leaf	30 - 20	7 - 0	1 × 3.5	0.5 × 2	1 - 4	5.5	Evening	13	Acute	7.5	2 - 2.25	Dentate	2 × 5	3	2 × 6.5	1.5 × 7.5	5
<i>T. pubescens</i>	Opposite to leaf	14 - 5	6.5 - 0	0.5 × 2.5	0.2 × 0.8	1 - 3	2.5	Day	10.25	Acute	3.5	2.25 - 1.25	Cleft	1.25 × 3.25	1	1 × 3.255	1 × 3.5	2.25
<i>T. pumila</i>	Opposite to leaf	10 - 2	1.5 - 0	0.35 × 1.25	0.2 × 0.75	1 - 2	2	Evening	7	Caedate	2.75	1.25 - 1	Cleft	1 × 2	1	1 × 2.25	1 × 2.75	1.75
<i>T. purpurea</i>	Axillary or opposite to leaf	15 - 0	5 - 0	2 × 0.5	0.25 × 1	2 - 5	3	Evening	10.5	Mucronate	3.25	2 - 1.5	Cleft	1.25 × 3	1	1.25 × 3	1.25 × 3.25	1.75
<i>T. quartiniana</i>	Axillary	-	-	0.5 × 2.75	0.25 × 1	1 - 3	2	Evening	7	Acute	2.5	1.5 - 1	Cleft	1 × 1	0.75	1 × 2.5	1 × 2.5	1.5
<i>T. uniflora</i>	Axillary	-	-	2 × 0.5	0.2 × 1.25	1 - 2	2.5	Evening	8.25	Acute	4.25	2.25 - 1.25	Cleft	1 × 4	1.75	1.25 × 4	1 × 4.25	3

All measures are given as a mean.

Table 4. Corolla and Androecium characters of the studied *Tephrosia* species.

Species	Color	Corolla					Androecium					
		Corolla length mm	Standard size mm	Wings size mm	Keel size mm	Wings shape	Length of stamen tube mm	Height of stamen tube mm	Length of cohesion distance mm	Length of free stamen mm	Tip shape	Tip direction
<i>T. apollinea</i>	Pink	11.5	10.5 × 11.5	5 × 11	3 × 7	Club	7	1.5	5	6.25	Quardrate	Vertical on tube
<i>T. desertorum</i>	Deep pink	9.5	10 × 9.5	4.5 × 9.5	3.25 × 6.75	Club	7.5	2	5	5.75	Quardrate	Toward anther
<i>T. leptostachya</i>	Pink	8	8 × 8	2.5 × 7	2.25 × 5.75	Club	5.5	1.25	4	5	Quardrate	Vertical on tube
<i>T. nubica</i>	Pale pink	13	13 × 14	6 × 14.5	4.5 × 11.5	Boat	11	3	6.75	10	Triangle	Vertical on tube
<i>T. pubescens</i>	Pink	10.25	8 × 10.5	4 × 9.75	3 × 7.25	Club	6.5	1.5	4	5.5	Quardrate	Toward anther
<i>T. pumila</i>	Pale pink	7.5	5 × 7.5	2 × 7	2.75 × 7	Kidney	7	1	5	5.5	Triangle	Vertical on tube
<i>T. purpurea</i>	Pale pink	10.5	9 × 10.5	4 × 10.5	3.25 × 6	Boat	8.75	1.5	6	8	Triangle	Vertical on tube
<i>T. quartiniana</i>	Pale pink	7	7.5 × 7	3 × 8	2.75 × 7	Boat	7.25	1.75	4.5	6	Triangle	Vertical on tube
<i>T. uniflora</i>	Pale pink	8.25	8 × 8.25	3 × 7.5	3 × 7.5	Boat	8	1.25	5.5	6.5	Triangle	Vertical on tube

All measures are given as a mean.

Table 5. Gynoecium and fruits characters of the studied *Tephrosia* species.

Species	Gynoecium				Fruits						
	Carpel length mm	Ovary size Mm	Hairs on ovary	Color	Shape	Dehiscence	Numbers of seeds	Size mm	Trace of seed	Presence of membrane	
<i>T. apollinea</i>	8	0.75 × 4	Short	Yellowish brown	Linear	Dehiscent	7 - 5	0.35 × 4.3	Present	Present	
<i>T. desertorum</i>	8.25	0.75 × 4.5	Short	Brown	Linear	Dehiscent	8 - 6	0.3 × 4	Present	Present	
<i>T. leptostachya</i>	6.5	0.5 × 3.25	Short	Yellow	Linear	Dehiscent	8 - 7	0.25 × 2.8	Present	Present	
<i>T. nubica</i>	12	1.75 × 6	Long	Cream	Ovoid	Not dehiscent	1	0.6 × 1.2	Absent	Absent	
<i>T. pubescens</i>	8.5	0.75 × 4.5	Short	Yellowish brown	Linear	Dehiscent	8 - 7	0.3 × 3.8	Present	Present	
<i>T. pumila</i>	7.75	1 × 4.25	Medium	Dark brown	Linear	Dehiscent	13 - 9	0.3 × 3.8	Absent	Absent	
<i>T. purpurea</i>	10.25	0.75 × 5.25	Medium	Dark brown	Linear	Dehiscent	7 - 5	0.35 × 3.25	Absent	Absent	
<i>T. quartiniana</i>	7.75	0.75 × 4	Medium	Yellow	Linear	Dehiscent	10 - 7	0.4 × 2.75	Absent	Present	
<i>T. uniflora</i>	9.25	0.75 × 4.75	Short	Yellow	Linear	Dehiscent	11 - 10	0.3 × 5.3	Absent	Absent	

All measures are given as a mean.

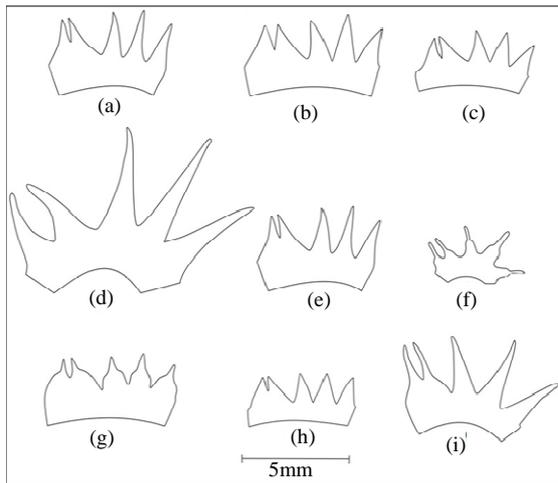


Figure 2. Schematic diagram showing sepals shape of studied *Tephrosia* species: (a) *T. apollinea*; (b) *T. desertorum*; (c) *T. leptostachya*; (d) *T. nubica*; (e) *T. pubescens*; (f) *T. pumila*; (g) *T. purpurea*; (h) *T. quartiniana*; (i) *T. uniflora*.

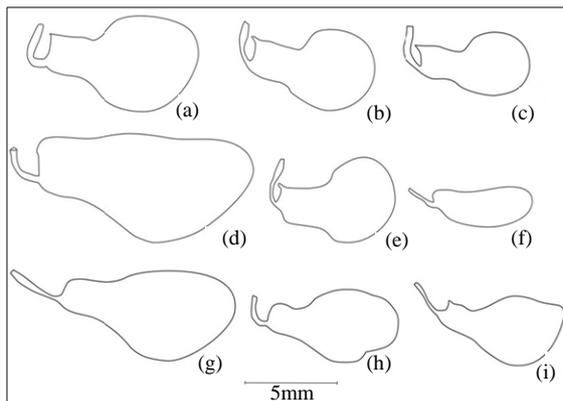


Figure 3. Schematic diagram showing wings shape of corolla of the studied *Tephrosia* species: (a) *T. apollinea*; (b) *T. desertorum*; (c) *T. leptostachya*; (d) *T. nubica*; (e) *T. pubescens*; (f) *T. pumila*; (g) *T. purpurea*; (h) *T. quartiniana*; (i) *T. uniflora*.

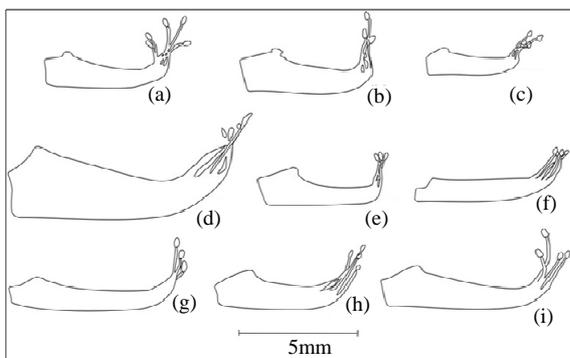


Figure 4. Schematic diagram showing side view of stemal tube shape of androecium of the studied *Tephrosia* species: (a) *T. apollinea*; (b) *T. desertorum*; (c) *T. leptostachya*; (d) *T. nubica*; (e) *T. pubescens*; (f) *T. pumila*; (g) *T. purpurea*; (h) *T. quartiniana*; (i) *T. uniflora*.

size 0.6×1.2 cm, covered with creamy long hairs, not dehiscent at maturity.

3.4. Systematic Treatment

1. Pod ovoid, one seeded, covered with creamy long hairs, not dehiscent at maturity, upper 2 teeth of calyx cleft *T. nubica*
 +Pod linear, many seeded, covered with short to medium white hairs, dehiscent at maturity, upper 2 teeth of calyx dentate 2
2. Inflorescence axillary..... 3
 +Inflorescence pseudoracemes borne terminal (opposite a leaf).....4
 ++Inflorescence pseudoracemes borne terminal (opposite a leaf) and/or axillary..... *T. purpurea*
3. Leaflets obovate pubescent on both surfaces..... *T. quartiniana*
 +Leaflets oblanceolates glabrous on the upper surface *T. uniflora*
4. Day flowering with kidney wings of corolla..... *T. pumila*
 +Flowering evening with club wings of corolla5
5. Perennial, leaflets obovate or oblanceolates, with emarginate or apiculate apex.....6
 +Annual, leaflets obovate with obcordate apex7
6. Stem erect, leaflets obovate, with emarginate apex, long pinnose hairs, tip of staminal tube vertical to the tube..... *T. apollinea*
 +Stem ascending, leaflets oblanceolate, with apiculate apex. Pubescent hairs, staminal tube toward stamen *T. pubescens*
7. Stem ascending, pubescent hairs, staminal tube toward anther *T. desertorum*
 +Stem prostrate, tip of staminal tube vertical to the tube..... *T. leptostachya*

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