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Numerical Classification Study of Species for Genus *Scorzonera* L. Asteraceae (Compositae) in Iraq

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ABSTRACT

Background: Most studies in taxonomy try to consider some characteristics or traits more important than others in classifying certain groups of organisms and then classification under these tests is more art than science and is influenced by the personal opinions of researchers.

Methods: The genus *Scorzonera* L. was treated mathematically and polygonal shapes were drawn based on the morphological and anatomical characteristics and pollen study.

Result: The similarity percentages between species were calculated and a dendrogram was drawn linking the species of the genus spread in Iraq. The results showed that the lowest similarity percentage was between the two species *S. latifolia* and *S. papposa* and reached 20.47%, while the highest similarity percentage was between the two varieties *S. cana* var. *jacquiniana* and *S. cana* var. *radicosa* and reached 80.95%. All species were linked as one unit at a similarity percentage of 36.90%.

Key words: Electronic computer, Numerical classification, *Scorzonera* L.

INTRODUCTION

The development in electronic computer science led to the possibility of using the principle referred to by (Stace, 1989) in determining the genetic homogeneity of organisms. Most researchers in taxonomy try to consider some characteristics or traits more important than others in classifying certain groups of organisms and then classification under these tests is more art than science and is influenced by the personal opinions of researchers. That is, all adjectives are given equal weight, that is, they have the same importance and weight, which is difficult to accept by many traditional classifiers (Stace, 1980). Using this principle, the classification is based on a mathematical method, which is currently called numerical classification or computer taxonomy, which was known by Sneath and Sokal (1973), Esma *et al*. (2020).

The genus comprises approximately 180-190 species in the world, most of which are perennial herbaceous plants. It originates in the Ancient Mediterranean. The *Scorzonera* species mainly inhibits temperate and arid regions of Central Europe Central Asia and Northern Africa, with the significant center of diversity in the arid and Irano-Turanian regions. It is the compilation of taxonomic units by using numerical methods in taxa classifications based on their characteristics. The initialization of numerical classification is by obtaining units that fit the type of traits studied and the way they are arranged. The term OTUS (Operational Taxonomic Units) was suggested by Jones and Sachin (1980) and Sivakumar *et al*. (2024) for the organisms to be classified numerically. Sneath (1995) has stated that numerical classification in the broad sense is the greatest advance in taxonomy since Darwin or perhaps since Linnaeus. It has stimulated many new fields of growth, including numerical phylogenetics, molecular taxonomy, morphometrics and numerical identification. The numerical classification uses binary variables, which are known as one of the two cases, the absence of the trait and the condition of the presence of the trait, or divided into several layers with one classification weight such as (3.2.1..... *etc*.) and numerical classification methods have been used In Iraq, in the study of many genus and from different families, such as Moter (2000); Sosa (2004); AL-Jowary *et al*. (2018) and Kumar *et al*. (2023). The current research dealt with 16 species belonging to the genus *Scorzonera* L. of the family Asteraceae (Compositae).

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MATERIALS AND METHODS

The 16 species of *Scorzonera* L. growing in Iraq, including two species, were treated as practical taxonomic units (OTUs) and 14 traits were collected for the order of Polygonal Graphs, as a number of morphological and anatomical traits were selected that characterize the species and the drawings were carried out according to Radford *et al*. (1974). As for the Dendrogram, 42 random traits were taken and treated with one weight and those

traits were compared between species according to Sneath and Sokal (1973) in order to obtain similarities between the species under study and the process was conducted accurately to obtain the best interrelationships between species only the following steps:-

1 - Choice of operational taxonomic units (OTUs).
2 - Choose attributes to organize the data.
3 - Coding traits, which is about giving a value to the trait within a certain range so that it occupies all kinds of traits and this is necessary to convert the raw information into a specific form of scales that fit the work of taxonomic calculations and that are used for the work of the classification system.
4 - Create a numerical classification matrix by distributing the characteristics according to the code given to them in Step (1) on the OTUs selected in Step (1).
5 - The similarity ratios between OTUs were extracted according to Eq:-

$$S\% = \frac{a}{n} \times 100$$

$$S\% = \frac{a}{a+b+c} \times 100$$

S = Similarity coefficient.
a = Both elements of practical taxonomic units exhibit the same trait.
b = The first element shows only the adjective.
c = The second element shows only the adjective.
n = Sum of all traits.

After extracting the similarity ratios between the studied species, the Similarity Matrix was obtained.

6 - The dendritic shape was drawn between the operational taxonomic units (OTUs) by using the Agglomerative Method where the clustering process begins by finding the pair of OTUs with the highest similarity that represent the nucleus of the cluster or group that appeared in step (5). Then the similarity between this group formed and any of the remaining (OTUs) is calculated by extracting the arithmetic average of the similarity values between them in step (5) and the process is repeated a second time to form new groups depending on the higher similarity coefficient and this may be between two (OTUs) or between (OTUs) and a group formed during the first aggregation cycle. Thus, the large cluster or dendritic shape that includes all species is obtained. OTUs can be linked in addition to the dendritic shape using other shapes such as regular circles or columns, depending on the similarity ratios.

RESULTS AND DISCUSSION

The results of the current study showed that the polygonal shapes of the species of the genus under study, shown in (Fig 1), show convergence between certain species and divergence and difference between other species. These shapes were drawn from selected and prominent characters (Table 1). A matrix was made for these characters (Table 2).

The two varieties *S. cana* var. *jacquiniana* and *S. cana* var. *radicosa* showed a great similarity, which is obvious since they belong to the same species. The two species *S. cinerea* and *S. incisa* also showed little similarity to them. *S. phaeopappa* and *S. semicana* showed similarity in their polygonal shapes. The species *S. cinerea, S. divisii* and *S. mollis* showed great similarity to it in polygonal shapes, *S. lanata* and *S. pseudolanata* also showed great similarity to each other. *S. latifolia, S. ramosissima* and *S. veratrifolia* also showed great similarity in their polygonal shapes. Also, 42 selected characteristics were used for the species under study to create a numerical classification matrix and to calculate the degree of similarity between them, (Table 3) and the tree diagram that connects them was drawn (Fig 2). Table 5a and the tree diagram show that the highest similarity percentage between the two varieties was 89.95%, followed by 78.57% and the two species *S. lanata* and *S. pseudolana* were similar in this way, as were the two species *S. phaeopappa* and *S. semicana*, as they showed the same similarity percentage.

The two species *S. mollis* and *S. schweinfurthii* were related by a similarity of 76.19%, while the species *S. mucida*, *S. phaeopappa* and *S. semicana* were related by a similarity of 73.80%. The species *S. ramosissima* met

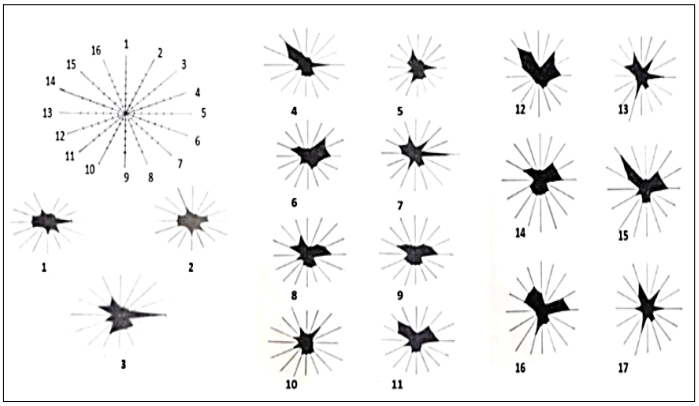


Fig 1: Polygonal figures to compare some species of the genus *Scorzonera* L. according to the selected characters. Details are in Tables (1) and (2).

with them with a similarity percentage of 69.04%. The species *S. papposa* met with the four previously mentioned species with a similarity percentage of 64.28% (Table 4). The similarity percentage of *S. latifolia* and *S. veratrifolia* was 61.90%. The two varieties *S. cana* and *S. incisa* met at the same percentage of similarity and *S. cinerea* was associated with them at a percentage of similarity of 57.14%. At 55.65% similarity, *S. mollis*, *S. mucida*, *S. papposa*, *S. phaeopappa*, *S. ramosissima*, *S. semicana* and *S. schweinfurthii* met, while *S. divisii* and *S. tortuosissima* met at 52.38% similarity. These two species met with the previous seven species with a similarity rate of 50.74%. All these species were associated with *S. latifolia* and *S. veratrifolia* with a similarity rate of 48.21%. These species were linked to the species *S. cinerea*, *S. incisa* and *S. pseudolanata* with a similarity percentage of 42.27% and these species in turn were linked as a single unit with the rest of the species at a similarity percentage of 36.90%.

Table 1: Selected characteristics of the polygons of the species for genus *Scorzonera* L.

Sequence	Adjective	Details	Code
1	Habit	- Herbal	1
		- Thorny shrub grass	2
2	Duration	- Perennial	1
3	Root shapes	- Tap root cylindrical not inflated	1
		- An enlarged tap root, cylindrical to spindle	2
		- Enlarged tap root ovate or cylindrical-ovate	3
		- Spherical enlarged tap root	4
4	The nature of the growth of the stems	- Erect, suberect, Ascending	1
		- Scapose	2
		- Scapose and subscapos	3
		- Intertwined with many branches	4
5	Basal leaf shapes	- Broadly linear, Elliptic and Ovate -Elliptic	1
		- Linear leaf-like grass, Elliptic and Ovate-Elliptic	2
		- Elliptic and Ovate-Elliptic	3
		- Linear leaf-like grass and Broadly linear	4
		- Linear- Filiform and Linear leaf-like grass	5
		- Absence of basal leaves	6
6	Presence of cauline leaves	- Present	1
		- Absence	2
7	The shape of pedunles directly below the inflorescence	- Not enlarged below the inflorescence	1
		- Enlarged at the top below the inflorescence	2
8	Presence of a horn-like and apical appendage in the outer rows of the bracts Indumentum	- Present	1
		- Absence	2
9	of ovary	- Hairy	1
		- Not hairy	2
10	The shape and position of the flower system	- Terminal inflorescences ending in stems or stems with a solitary head	1
		- Unlimited inflorescences arranged in a simple racrme and terminal inflorescence	2
		- Inflorescences arranged in a compound raceme or panicle	3
11	The presence of pith in the transverse sections of the stems	- Sold	1
		- Hollow	2
12	Type of vascular bundle in the transverse sections of the stem	- Collateral vascular bundle	1
		- Bicollateral vascular bundle	2
13	The shape of the cross section of the petiole	- Winged	1
		- Not winged	2
14	The venation type of leaves	- Acrodromous	1
		- Eucamptodromous	2
		- Paralleladromous	3

Thus, the study showed that the species of the genus Scorzonera converge at this ratio.

OTUs

Table 5a shows that the lowest similarity percentage was between *S. latifolia* and *S. papposa*, reaching 20.47%, while the highest similarity percentage was between the two varieties of the *S. cana* species, reaching 80.95%.

The polygonal shapes of the species of the genus *Scorzonera* showed great similarity between some species and divergence and difference between others. The two *S. cana* species showed a remarkable similarity in polygonal shapes, which is obvious since they belong to the same species. This was also confirmed by the similarity percentage between them shown by the dendrogram, which reached 89.95%, which is the highest percentage among species. These two species met with *S. incisa* species with a similarity percentage of 61.90% and their polygonal shapes were similar, which confirmed the similarity in most of the characteristics of these species. These species met with the species *S. cinerea* with a similarity rate of 57.14%, as they are species that show a fair similarity in many features, while the polygonal shapes showed a clear difference between them and this may be due to the selected features in drawing the shapes.

The species *S. phaeopappa* and *S. semicana* also showed great similarity in polygonal shapes and they are similar species in many characteristics. The similarity percentage was high, reaching 78.57%. They were placed by Boissier (1975) within one sector, Foliosae, which divided it into two groups. The first group included the two aforementioned species in addition to the species *S. incise,* which showed little similarity with them in the similarity percentage and in polygonal shapes, despite the fact that they belong to the same group. The second group in this sector, Lasiopra, included the species *S. ramosissima* and *S. veratrifolia*, which showed partial similarity in polygonal shapes and the similarity percentage was 48.21%. Although *S. lanata* and *S. pseudolanata* are very similar in most of the features, the polygonal shapes showed differences between them and the reason may be that the selected characters in drawing the polygonal shapes were limited and showed differences between the two species, while the percentage of similarity between them shown by the dendrogram is 78.57%, due to the use of the largest possible number of vegetative, reproductive and anatomical features regardless of their taxonomic importance. Although these two species were similar to *S. veratrifolia* in many features, the polygonal shapes were far from them. The percentage of similarity with them in the general percentage that all species met was 36.90% and the reason may be in the type of selected features for them. Thus, the process of clustering continued for the pairs of species with the highest similarity, as shown in (Table 5b) and according to the gradation of similarity percentages, until all species met as one unit at a similarity percentage of 36.90%. It is noted from the tree diagram that 87% of the species met at a similarity percentage of 39.58%, which confirms the connection of these species and supports the unity of each of them as an independent species. Although the results obtained in the current study through numerical classification are more objective and clear, they cannot completely replace the traditional classification followed in morphological and anatomical studies by diagnosing species and isolating them from each other.

Table 2: Selected trait matrix for drawing the polygons of the genus *Scorzonera* L.

No.	Types	Trials															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	*S.cana* var. *jacquiniana*	1	1	1	1	3	1	2	1	2	1	1	2	2	2	1	2
2	*S. cana* var. *radicosa*	1	1	1	2	2	1	2	1	2	1	1	2	2	2	1	2
3	*S. cinerea*	1	1	1	1	6	1	2	2	2	3	1	2	1	3	2	3
4	*S. divisii*	1	1	1	1	4	1	2	2	2	2	1	2	1	3	5	2
5	*S. incisa*	1	1	1	1	3	1	2	2	2	3	1	2	1	2	2	3
6	*S. lanata*	1	1	4	3	4	2	2	2	1	1	2	1	1	3	2	1
7	*S. latifolia*	1	1	3	1	6	1	2	2	1	3	1	1	2	3	2	3
8	*S. mollis*	1	1	2	3	4	1	2	2	2	2	2	1	1	3	2	3
9	*S. mucida*	1	1	2	3	4	1	2	2	2	2	2	2	1	3	2	1
10	*S. papposa*	1	1	3	1	1	1	2	2	2	2	1	2	1	2	1	2
11	*S. phaeopappa*	1	1	3	3	4	1	1	2	2	2	1	2	1	3	4	2
12	*S. pseudolanata*	1	1	4	3	4	2	2	2	1	1	1	1	1	3	5	3
13	*S. ramosissima*	1	1	3	1	4	1	2	2	1	3	1	1	1	3	2	3
14	*S. schweinfurthii*	1	1	3	3	4	1	2	2	2	2	2	2	1	3	2	1
15	*S. semicana*	1	1	3	3	4	1	1	2	2	2	1	2	1	3	6	1
16	*S. tortuosissima*	2	1	1	4	5	1	2	2	2	3	1	1	1	3	3	3
17	*S. veratrifolia*	1	1	3	1	3	1	2	2	1	3	1	1	2	1	2	1

Table 3: Details of the selected traits in the numerical classification of the species of the genus *Scorzonera* L.

Sequence	Adjective	Details	Code
1	Habit	- Herbal	1
		- Thorny shrub grass	2
2	Duration	- Perennial	1
		- Tap root cylindrical not inflated	1
3	Root shapes	- An enlarged tap root, cylindrical to spindle	2
		- Enlarged tap root ovate or cylindrical-ovate	3
		- Spherical enlarged tap root	4
4	The nature of the growth of the stems	- Erect, suberect, Ascending	1
		- Scapose	2
		- Scapose and subscapose	3
		- Intertwined with many branches	4
5	Stem colors	- Earthy or dusty white	1
		- Light to dark brown	2
		- Green	3
6	Basal leaf shapes	- Broadly linear, Elliptic and Ovate-Elliptic	1
		- Linear leaf-like grass, Elliptic and Ovate-Elliptic	2
		- Elliptic and Ovate-Elliptic	3
		- Linear leaf-like grass and Broadly linear	4
		- Linear- Filiform and Linear leaf-like grass	5
		- Absence of basal leaves	6
7	Basal leaf length/width ratio	- More than 50	1
		- More than 20 and less than 50	2
		- Less than 20	3
		- There are no basal leaves	4
8	Shape of the cauline leaves	- Lanceolate, Lanceolate-Ellipitic	1
		- Other shapes	2
		- There are no cauline leaves	3
9	The ratio of stem length/width	- More than 30	1
		- Less than 30	2
		- There are no cauline leaves	3
10	The shape and position of the flower system	- Terminal inflorescences ending in stems or stems with a solitary head	1
		- Unlimited inflorescences arranged in a simple racrme and terminal inflorescence	2
		- Inflorescences arranged in a compound raceme or panicle	3
11	The shape of pedunles directly below the inflorescence	- Not enlarged below the inflorescence	1
		- Enlarged at the top below the inflorescence	2
12	Indumentum of pedunles for the inflorescence	- Dense, composed of normal, multicellular non-glandular hairs	1
		- There are no such hairs	2
13	Capitular receptacle shape	- Convex	1
		- Convex flat	2
		- Concave	3
		- Concave flat	4
		- Flate	5
14	The number of rows of involucral bracts	- 2	1
		- 3	2
		- 4	3
		- (2-3)	4
		- (3-4)	5
		- (5-7)	6

Table 3: Continue....

Table 3: Continue....

15	The appearance of the bracts	- Dense of the Indumentum	1
		- Leathery look	2
		- Grassy look	3
16	The shapes of the inner rows of the bracts	- Deltoid ovate and ovate-lanceolate	1
		- Ovate-lanceolate	2
		- Lanceolate - linear	3
17	The shapes of the bract tops in the inner rows	- Obtuse	1
		- Aristate	2
		- Acute	3
		- Attenuate-Mucronate-	4
18	The Indumentum of the bract tops	- Papillae only	1
		- Glandular and non-glandular hairs	2
		- Multicellular non-glandular hairs	3
19	Presence of a horn-like and apical appendage in the outer rows of the bracts	- Present	1
		- Absence	2
20	The shapes of the ligule	- Oblong-Ellipticlal	1
		- Oblong	2
21	Indumentum of the tip of the tapering towards the apex tubular part and the bottom of the ligament of the corolla	- Uniseriate multicellular non-glandular hairs	1
		- Free of these appendages	2
		- T- shape hairs and papillae only	3
22	Indumentum of ovary	- Hairy	1
		-Not hairy	2
23	Inner pappus shape	-Plumose pappus	1
		- Non plumose pappus	2
24	Fruit shape similar	- Similar or Homomorphic	1
		- Dimorphic	2
25	Fruit Shapes	- Narrow Lanceolate	1
		- Oviod-oblong	2
		- Cylindrical	3
		- The outer fruits are Oviod-oblong and the inner fruits are cylindrical	4
26	Fruit base shape	- Acute	1
		- Swollen	2
		- Trancate	3
		- 4-angular	4
27	Fruit colors	- White and straw dark or light	1
		- Dark or light straw	2
		- White	3
		- White and the outer fruits arebrown	4
		- Bright yellow	5
		- Brouwn-	6
28	Stomata guide for upper surface in leaves	- Less than 15	1
		- Greater than 15	2
29	The presence of pith in the transverse sections of the stems	- Sold	1
		- Hollow	2
30	Arrangement of collenchyma and places of its distribution in the cross-sections of the stems	- Continuous	1
		- Dissected in blocks of spaced segments corresponding to vascular bundles	2
			3
31	Bundle cup is present in transverse sections of the stem	- Present	1
		- Absence	2

Table 3: Continue....

Table 3: Continue....

32	Medullary vascular Bundle is present in transverse sections of the stem	- Present	1
		- Absence	2
33	Type of vascular bundle in the transverse sections of the stem	- Collateral vascular bundle	1
		- Bicollateral vascular bundle	2
34	The shape of the vascular bundle in the stem sections	- Wide conical and semi-circular	1
		- Obovoid-oblong	2
		- Obovoid-subcircular	3
		- Ovoid and circular	4
		- Obovoid-deltoid	5
35	The shape of the cross-section of the petiole	- Winged	1
		- Not winged	2
36	Tissue type in the cortex layer of the sections of the petiole	- Parenchyma tissue only	1
		- Lamella collenchyma and parenchyma tissue	2
37	The number of rows of the palisade layer on both the upper and lower surfaces	- One-layer fixed number	1
		- Two-layer fixed number	2
		- Variable number consisting of (2-3) rows	3
		- Variable number consisting of (3-5) rows	4
		- Variable number consisting of (1-2) rows	4
38	The venation type of leaves	- Acrodromous	1
		- Eucamptodromous	2
		- Paralleladromous	3
39	Flower colors	- Yellow with purple or reddish streaks	1
		- Yellow with dark streaks dorsally	2
		- Dark yellow or yellow-orange	3
		- Lilac or crimson	4
40	Presence of druses crystals in the corolla's epidermis	- Present	1
		- Absence	2
41	T-shape hairs	- Present	1
		- Absence	2
42	Color of the outer pappus bristles	- Dark brown	1
		- White	2
		- Straminous or light brown	3

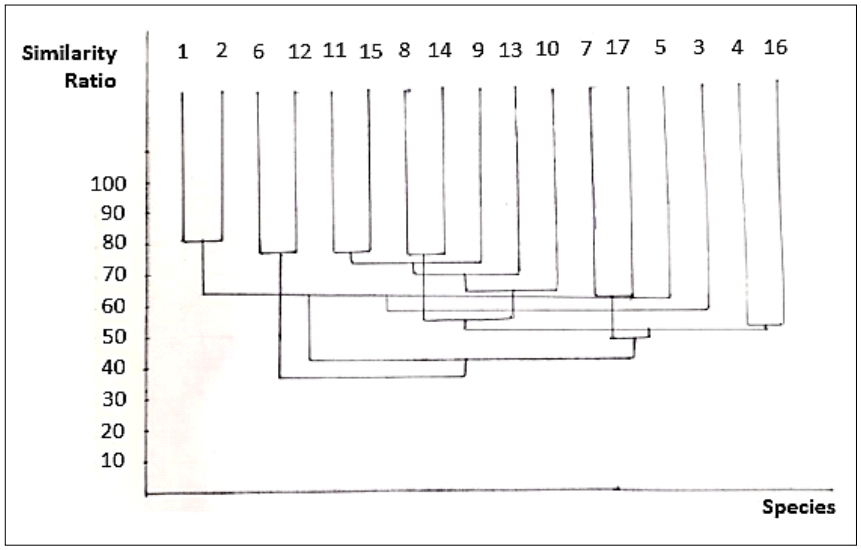


Fig 2: The dendrogram showing the degrees of similarity between the species of the genus *Scorzonera* L.

Table 4: A matrix of selected traits in the numerical classification of species of genus *Scorzonera* L.

No.	Types	Trails																																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	34	36	37	38	39	40	41	42
1	*S.cana* var. jacquiniana	1	1	1	1	2	3	3	2	2	1	2	2	5	5	3	3	1	1	1	2	1	2	1	1	3	3	1	2	1	2	2	1	2	1	2	1	1	2	1	2	1	2
2	*S.cana* var. radicosa	1	1	1	2	2	2	3	2	1	1	2	2	5	3	3	3	1	2	1	2	1	2	2	1	*3	3	1	2	1	2	2	2	2	1	2	1	5	2	1	2	1	2
3	*S. cinerea*	1	1	1	1	2	6	4	1	2	3	2	2	5	1	3	2	2	1	2	2	1	2	2	1	1	3	2	2	1	1	2	1	2	1	1	2	2	3	2	2	1	3
4	*S. divisii*	1	1	1	1	3	4	1	2	1	2	2	2	2	6	2	2	3	3	2	2	2	2	1	1	3	3	5	2	1	2	2	1	1	2	1	2	3	3	2	1	2	2
5	*S. incisa*	1	1	1	1	2	3	3	2	2	3	2	2	5	5	3	1	1	3	2	2	1	2	2	2	3	*3	2	1	1	2	1	1	2	3	1	2	1	2	3	2	2	3
6	*S. lanata*	1	1	4	3	2	4	3	3	3	1	2	1	5	1	1	3	1	3	2	1	2	1	2	1	2	1	2	2	2	2	2	2	1	3	1	2	1	3	2	2	1	1
7	*S. latifolia*	1	1	3	1	3	6	4	1	2	3	2	2	4	4	2	3	1	1	2	2	2	1	1	2	4	3	2	1	1	2	1	2	1	4	2	2	3	3	1	1	1	3
8	*S. mollis*	1	1	2	3	2	4	2	2	2	2	2	2	3	2	1	2	1	3	2	2	1	2	1	2	3	2	2	2	1	1	2	1	2	4	1	2	5	3	1	2	2	3
9	*S. mucida*	1	1	2	3	2	4	3	2	2	2	2	2	1	2	3	3	1	3	2	2	2	2	1	1	3	2	2	1	2	2	2	1	2	5	1	2	2	3	1	2	2	1
10	*S. papposa*	1	1	3	1	2	1	3	2	2	2	2	2	3	2	3	2	1	3	2	1	1	2	2	1	3	4	1	1	1	2	2	1	2	5	1	2	2	2	4	2	2	2
11	*S. phaeopappa*	1	1	3	3	2	4	3	2	2	2	1	2	1	4	3	3	1	3	2	2	1	2	1	2	3	2	4	2	1	2	2	1	2	5	1	2	5	3	1	2	2	2
12	*S. pseudolanata*	1	1	4	3	2	4	2	3	3	1	2	1	5	1	1	3	1	3	2	1	2	1	2	1	2	1	5	1	2	1	2	2	1	3	1	2	1	3	1	1	2	3
13	*S. ramosissima*	1	1	3	1	2	4	3	2	2	3	2	2	5	3	2	3	4	3	2	1	2	1	2	2	4	3	2	1	1	2	2	2	1	3	1	2	4	3	2	2	1	3
14	*S. schweinfurthii*	1	1	3	3	2	4	2	2	1	2	2	2	5	2	1	2	1	3	2	2	2	2	2	2	3	3	2	2	2	1	2	1	2	5	1	2	1	3	1	2	2	1
15	*S. semicana*	1	1	3	3	2	4	2	2	2	2	1	2	1	4	3	2	1	3	2	2	2	2	1	2	3	2	6	1	1	2	2	1	2	5	1	2	5	3	2	1	1	1
16	*S. tortuosissima*	2	1	1	4	3	5	1	2	2	3	2	2	2	2	2	3	3	2	2	2	3	2	2	1	3	3	3	1	1	2	1	2	1	3	1	2	4	3	1	2	1	3
17	*S. veratrifolia*	1	1	3	1	1	3	3	2	2	3	2	1	4	2	1	3	3	1	2	2	2	1	2	1	3	3	2	2	1	2	1	2	1	4	2	2	2	1	1	1	2	3

Table 5a: Similarity ratios between species of the genus *Scorzonera* L.

1	100															
2	80.95	100														
3	57.14	47.61	100													
4	42.85	40.47	47.61	100												
5	61.90	52.38	59.52	45.23	100											
6	35.71	52.38	42.85	38.09	40.47	100										
7	40-47	33.33	47.61	45.23	45.23	31.47	100									
8	47.61	40.47	54.76	50.00	54.76	40.47	40.47	100								
9	52.38	45.23	47.61	52.38	57.14	52.38	40.47	69.14	100							
10	54.76	52-38	52.38	50.00	56.52	30.09	28.57	59.52	64.28	100						
11	57.17	52.38	45.23	50.00	50.00	40.47	40.47	71.42	76.19	64.28	100					
12	38.09	30.95	33.33	38.09	38.09	78.57	38.09	69.04	47.61	35.71	35.71	100				
13	40.47	40.85	50.00	50.00	59.52	61.90	61.90	69.04	50.00	50.00	47.61	52.38	100			
14	42.85	45.23	52.38	54.76	57.14	52.38	35.71	76.19	71.42	57.14	64.28	52.38	50.00	100		
15	40.47	38.09	45.23	54.76	47.61	40.47	45.23	66.66	71.42	54.76	78.57	35.71	47.61	64.28	100	
16	38.09	45.23	45.23	52.38	52.38	33.33	52.38	40.47	45.23	38.09	38.09	35.71	54.76	38.09	35.71	100
17	45.23	40.47	38.09	42.85	50.00	42.85	61.90	42.85	42.85	40.47	35.71	42.85	50.00	40.47	30.95	52.38
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 5b: Similarity ratios between species of the genus *Scorzonera* L.

Species numbers according to Table 2	Similarity ratio
1, 2	80.95
6, 12	78.57
11, 15	78.57
8, 14	776.19
9, 11, 15	73.80
9, 11, 15, 13	69.04
9, 11, 15, 13,10	64.28
7, 17	61.90
1, 2, 5	61.90
1, 2, 5, 3	57.14
8, 14, 9, 11, 15, 13, 10	55.65
4, 16	52.38
4, 16, 8, 14, 9, 11, 15, 13, 10	50.74
4, 16, 8, 14, 9, 11, 15, 13, 10, 7, 17	48.21
4, 16, 8, 14, 9, 11, 15, 13, 10, 7, 17, 1, 2, 5, 3	42.27
4, 16, 8, 14, 9, 11, 15, 13, 10, 7, 17, 1, 2, 5, 3, 6, 12	36.90

CONCLUSION

The study concludes that the two *S. cana* species showed a remarkable similarity in polygonal shapes, which is obvious since they belong to the same species. This was also confirmed by the similarity percentage between them shown by the dendrogram, which reached 89.95%, which is the highest percentage among species. These two species met with *S. incisa* species with a similarity percentage of 61.90%.

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Disclaimers

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Conflict of interest

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