RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
55 (2) 442-452, 2023
http://doi.org/10.54910/sabrao2023.55.2.16
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

NUMERICAL TAXONOMY OF THE GENUS *ROSA* L. (ROSACEAE) GROWN IN THE KURDISTAN REGION OF IRAQ

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SUMMARY

The presented research aimed to study the numerical taxonomy of the genus *Rosa* L. and to identify and differentiate its various species grown in different regions in Kurdistan, Iraq. This study proceeded in the 2021–2022 season at the College of Education of Pure Science, University of Mosul, Mosul, Iraq. Forty morphological quantitative and qualitative characteristics, including vegetative and reproductive traits (leaves, flowers, fruits, seeds, and pollen grains), gained taxonomic analysis. From there, selection of 12 morphological features finally drew polygonal shapes for the concerned species. The analysis of the polygonal shapes revealed the species owned significant variations in these forms. The similarity among these species ranged between 0.5% to 91.0%, and the highest level of similarity (91.0%) occurred between the two species *Rosa canina* var. 'canina,' and *Rosa canina* var. 'verticillacantha,' and the lowest (0.05%) emerged from the species. *R. elyamaitica* and *R. dumalis* subsp. *boissieri*. From the cluster analysis, the UPGMA dendrogram separated the 13 species into three main groups and subgroups. The first main groups, divided into two subgroups, included the species *R. canina* var. 'canina,' *R. canina* var. 'verticillacantha,' *R. canina* var. 'dumetorum,' *R. canina* var. 'deseglisei,' and *R. dumas* subsp. *boissieri*. The second main groups included the species *R. eiyamaitica* and *R. heckeliana* subsp. *orientalis*. The second subgroup included the species *R. gallica*, *R. centifolia,* and *R. damascena*. Moreover, the third main group included the species *R. foetida*, *R. foetida* var. *bicolor,* and *R*. *hemisphareaca*.

Keywords: *Rosa* L. (Rosaceae), numerical taxonomy, species, genetic variations, quantitative and qualitative traits, cultivars, UPGMA, cluster analysis

Key findings: Using numerical taxonomy helped identify and differentiate the 13 taxa of the genus *Rosa* L. (Rosaceae), grown in the Kurdistan region of Iraq, based on quantitative and qualitative parameters, comprising vegetative morphological and reproductive traits.

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: February 1, 2023; Accepted: April 9, 2023.

Citation: Al-Mathidy A, Al-Doskey ZAS, Shehab MOM (2023). Numerical taxonomy of the genus *Rosa* L. (Rosaceae) grown in the Kurdistan Region of Iraq. *SABRAO J. Breed. Genet.* 55(2): 442-452. http://doi.org/10.54910/sabrao2023.55.2.16.

INTRODUCTION

The modern classification of crop plants mainly depends on numerical taxonomy. It hinges on transforming information from other taxonomic aspects (phenotypic, anatomical, phytochemical, and reproductive). Numerical taxonomy uniquely deals with the grouping by the numerical method of taxonomic units into taxa based on the state of the various traits (Sneath and Sokal, 1973).

Numerical taxonomy is not a new system of classification, nor does ever a new set of principles underlying one; however, it's a new method considered for organizing data obtained from the categorization (Stace, 1980). In a taxonomy method, the classification basis is on a multivariate analysis of observable differences and similarities between taxonomy groups. The numerical taxonomy program implementation applies various approaches to resolve classification problems (Aziz *et al*., 2016; Pavlinov, 2020; Mohsin *et al*., 2023).

The Rosaceae family, often the rose family, consists of 100 genera and about 3,500 taxa, including many essential and economic species. Apomixis is the most common reproduction in the family of Rosaceae. A commonly adopted classification of the family Rosaceae comprises four subfamilies based on fruit type (Amygdaloideae, Maloideae, Rosoideae, and Spiraeoideae) (Schultze-Menz, 1964; Xiang *et al*., 2017). However, based on the molecular indication, three subfamilies are proposed, i.e., Dryadoideae, Rosoideae, and Spiroeoideae (Potter *et al*., 2007).

The family Rosaceae includes herbs, shrubs, and trees. Most species are deciduous, with some evergreen. Various economically important and edible fruits belong to the family Rosaceae, such as, apples, pears, quinces, apricot, plums, cherries, peaches, raspberries, and almonds. The family also includes some popular ornamental trees and shrubs, such as, roses (Pandey, 2009). *Rosa* L. is one of the largest and most central genera of the subfamily Rosoideae and family Rosaceae (Zielinski, 1982). The genus *Rosa* and its members are native to temperate regions of the Northern Hemisphere, including North America, Europe, Asia, and the Middle East.

Wissemann (2003) divided the genus *Rosa* into four subgenera. The subgenus *Rosa* includes *R. hemisphareaca* Herrman, *R. fetida* Herrman, and *R. spinosissima* L. species. The Flora of Pakistan has a few accounts relating to the presence of specific *Rosa* species (Nasir, 1972). Davis (1985) published the Flora of Turkey, Khatamsaz (1992) compiled the Flora of Iran, and the Flora of Iraq was mostly updated by Townsend and Guest (1985).

Several scientists have utilized numerical taxonomy to assess the degree of similarity and the strength of the relationship among the species. Employing number-based taxonomy has reorganized the classification of various species of angiosperms (El-Gazzar, 2008). Several related studies have advanced in Iraq but not focused on the genus *Rosa* (Al-Mashhadani, 1992; Al-Maa'thidy *et al.,* 2007; Al-Joboury, 2017; Al-Juwary *et al*., 2018; Al-Maa'thidy and Shehab, 2021). Based on the above discussion, the presented study aimed to determine the classification of 13 taxa of the genus *Rosa* L. based on vegetative, morphological, and reproductive characteristics, applying numerical taxonomic methods.

MATERIALS AND METHODS

The contemporary study happened in the 2021–2022 season at the College of Education of Pure Science, University of Mosul, Mosul, Iraq. Fresh material of the species came from the different sites in the Kurdistan region of Iraq. Selecting 12 traits of qualitative nature, i.e., vegetative, morphological, and reproductive, helped draw the polygonal diagrams (Tables 1 and 2). The 40 traits, selected for 13 taxonomic units numerically used in Operation Taxonomic Unit (OTUs), followed methods as reported by Sneath (1957) and Sneath and Sokal (1987).

The data arrangement continued for the characteristics of various species under study after encoding them with the former number, as shown in Tables 3 and 4. After discovering the similarity and differences matrix among the species under research, processing the encoded data using the SPSS-20 software program yielded a dendrogram that indicates a similarity relationship (kinship) and a divergence among the studied species within a cluster, with such a study carried out for the first time in Iraq.

Table 1. The morphological characteristics selected for drawing polygonal shapes of the studied species of the genus *Rosa* L.

No.	Traits	Character state	Code
1	Growth habit	Non-spreading plants	1
		Spreading plants	2
2	Prickles shape	Hooked	1
		Straight	2
		Slightly curved	3
3	Leaf shape	Ovate	1
		Obovate	2
		Elliptical	3
4	Leaflet margins shape	Crenate	1
		Serrate to doubly serrate	2
		Serrate	3
5	Bracts	Absent	1
		Present	2
6	Hypanthium shape	Ovoid or ellipsoid	1
		Globose or subglobose	2
		Urceolate	3
7	Calyx fruiting stage	Persistence	1
		Caducous	2
8	Anther shape	Hastate	1
		Oblong	2
9	Fruit shape	Globose	1
		Oblate	2
		Ovoid or ellipsoid	3
		Obovoid	4
10	Fruit pubescence	Glabrous	1
		Moderately densely	2
		Densely	3
11	Achene shape	Pyramidal	1
		Ovoid or broadly ovoid	2
		Globose or subglobose	3
		Irregular	4
12	Pollen grain shape	Subprolate	1
		Prolate	2

Table 2. Traits for drawing the polygonal among the species of genus *Rosa* L.

Species	Traits											
	1	2	3	4	5	6	7	8	9	10	11	12
1- *Rosa canina* var. *canina*	2	1	1	3	2	2	2	2	3	1	1	1
2- *R. canina* var. *dumetorum*	2	1	3	3	2	2	2	2	3	1	1	2
3- *R. canina* var. *deseglisei*	2	1	1	3	2	2	2	2	3	1	1	2
4- *R. canina* var. *verticillacantha*	2	1	2	2	2	2	2	2	3	1	1	1
5- *R. foetida*	2	2	1	3	1	1	1	1	2	1	1	1
6- *R. foetida* var. *bicolor*	2	2	3	3	1	1	1	1	2	1	1	1
7- *R. hemisphareaca*	2	1	3	3	1	2	2	1	3	1	4	1
8- *R. gallica*	1	2	1	1	2	1	2	2	1	1	3	2
9- *R.* x *centifolia*	1	2	1	1	2	1	2	1	1	1	3	2
10- *R.* x *damascena*	2	3	2	3	2	2	2	2	4	1	3	2
11- *R. elyamaitica*	2	2	1	3	2	1	1	2	1	2	2	2
12- *R. heckeliana* subsp. *orientalis*	2	2	3	3	2	1	1	2	3	3	2	2
13- *R. dumalis* subsp. *boissieri*	2	3	1	3	2	2	1	2	3	1	2	2

Table 3. Codes of the selected traits for the numerical taxonomy of the various species of genus *Rosa* L.

No.	Traits	Character state	Code
1	Plant nature	Dwarf shrubs	1
		Small shrubs	2
		Medium-large shrubs	3
2	Number of branches stem	Erect unbranched	1
		Few branched (2-5)	2
		Many branched more than 5	3
3	Growth habit	Non-spreading plants	1
		Spreading plants	2
4	Twig color	Reddish	1
		Reddish-brown	2
		Greenish	3
5	Prickles shape	Hooked	1
		Straight	2
		Slightly curved	3
6	Prickles color	Brown reddish	1
		White milky	2
		Bright brown	3
7	Leaf shape	Ovate	1
		Obovate	2
		Elliptical	3
8	Terminal leaflet blade shape	Ovate or elliptical	1
		Orbicular or broadly ovate	2
		Obovate or oblong	3
9	Petiole length	Short less than 20 mm	1
		Medium 20-30 mm	2
		Long more than 30 mm	3
10	Leaflet margins shape	Crenate	1
		Serrate to doubly serrate	2
11	Leaflet base shape	Acute	1
		Acuminate	2
12	Leaflet pubescence	Glabrous	1
		Pilose	2
		Villous	3
		Tomentose	4
13	Leaf color	Bright green	1
		Gray green	2
		Green	3
14	Stipules length	Short narrow	1
		Long large	2
15	Bracts	Absent	1
		Present	2
16	Bracts length	Short less than 13 mm	1
		Long more than 13 mm	2
17	Bracts Apex	Acuminate	1
		Acute	2
18	Upper surface of stipule pubescence	Glabrous	1
		Moderately hairs	2
19	Lower surface of stipule pubescence	Glabrous	1
		Densely hair	2
20	Flower gland Flower pedicle gland	Eglandular	1
		Glandular	2
21	Pedicel pubescence	Glabrous	1
		Pubescence	2
22	Hypanthium shape	Ovoid or ellipsoid	1
		Globose or subglobose	2
		Urceolate	3
23	Hypanthium length	Short	1
		Long	2

Table 3. (cont'd.)

No.	Traits	Character state	Code
24	Calyx at fruiting stage	Persistence	1
		Caducous	2
25	Upper surface of sepal pubescence	Moderately densely	1
		Densely	2
		Densely to tomentose	3
26	Lower surface of sepal pubescence	Moderately	1
		Moderately to densely	2
		Densely	3
		Densely to tomentose	4
27	Number of petals per flower	5	1
		20	2
		45	3
		60-105	4
		220-330	5
28	Petals color	White	1
		Yellow	2
		pink to crimson	3
29	Petal apex shape	rounded or irregular	1
		Emarginate	2
30	Anther shape	Hastate	1
		Oblong	2
31	Stigma color	Green-yellowish	1
		Yellow	2
		Purple	3
32	Fruit stalk color	Red	1
		Green	2
33	Fruit base shape	Rounded	1
		Obtuse-rounded	2
		Obtuse	3
		Acute	4
34	Fruit shape	Globose	1
		Oblate	2
		Ovoid or ellipsoid	3
		Obovoid	4
35	Fruit color	Dark red	1
		Bright red	2
		Orange	3
		Green	4
36	Fruit pubescence	Glabrous	1
		Moderately	2
		Densely	3
37	Number of achenes per flower	Without achenes	1
		Less than 10	2
		More than 10	3
38	Achene shape	Pyramid	1
		Ovoid or broadly ovoid	2
		Globose or subglobose	3
		Irregular	4
39	Pollen grain shape	Subprolate	1
		Prolate	2
40	Pollen grain size	Small	1
		Medium	2

Table 4. A matrix shows the selected traits in the numerical taxonomy of the genus *Rosa* L.

Traits / Species	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	35	36	37	38	39	40
1-*Rosa canina* var. *canina*	3	3	2	1	1	1	1	1	2	3	2	3	1	2	2	1	1	1	1	1	1	2	1	2	1	1	1	1	2	2	1	2	3	3	2	1	3	1	1	1
2-*R. canina* var. *dumetorum*	3	3	2	1	1	1	3	1	2	3	2	3	2	2	2	1	1	1	1	1	1	2	1	2	2	1	1	1	2	2	1	2	3	3	2	1	3	1	2	2
3- *R. canina* var. *deseglisei*	3	3	2	1	1	1	1	1	2	3	2	3	3	2	2	1	1	1	1	2	1	2	1	2	2	2	1	1	2	2	1	2	3	3	2	1	3	1	2	2
4- *R. canina* var. *verticillacantha*	3	3	2	1	1	1	2	1	2	2	2	3	1	2	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	2	1	2	3	3	2	1	3	1	1	2
5-*R. foetida*	3	3	2	2	2	2	1	3	1	3	1	1	2	1	1	2	2	1	1	1	1	1	2	1	1	1	1	2	2	1	2	1	1	2	1	1	1	1	1	2
6- *R. foetida* var. *bicolor*	3	3	2	2	2	2	3	3	1	3	1	1	2	1	1	2	2	1	1	1	1	1	2	1	1	1	1	2	2	1	3	1	1	2	1	1	1	1	1	2
7-*R. hemisphareaca*	3	3	2	2	1	3	3	3	1	3	1	2	3	1	1	2	2	1	1	1	1	2	3	2	2	2	4	2	1	1	2	1	2	3	4	1	2	4	1	1
8-*R. gallica*	2	2	1	3	2	3	1	2	3	1	2	1	3	2	2	1	1	1	1	2	1	1	2	2	2	3	2	3	1	2	1	2	2	1	4	1	2	3	2	2
9-*R.* x *centifolia*	1	1	1	3	2	3	1	2	2	1	2	1	2	2	2	1	1	1	1	2	1	1	2	2	2	3	3	3	1	1	1	2	2	1	4	1	2	3	2	2
10-*R.* x *damascena*	3	2	2	3	3	3	2	3	3	3	2	3	3	2	2	1	1	1	1	2	1	2	1	2	2	2	2	3	1	2	1	2	4	4	3	1	2	3	2	2
11-*R. elymaitica*	2	3	2	1	2	2	1	3	1	3	1	2	4	1	2	2	2	2	2	2	2	1	2	1	3	4	1	1	2	2	1	1	1	1	3	2	2	2	2	1
12- *R. heckeliana* subsp. *orientalis*	2	3	2	1	2	2	3	3	1	3	2	2	4	2	2	2	2	2	2	2	2	1	2	1	3	3	1	1	2	2	1	1	2	3	1	3	3	2	2	1
13-*R. dumalis* subsp. *boissieri*	2	3	2	1	3	3	1	1	2	3	2	2	1	2	2	1	1	1	1	2	1	2	1	1	1	2	1	1	2	2	1	2	3	3	1	1	3	2	2	2

RESULTS

Twelve chosen main traits of taxonomic importance for the studied species drew the polygonal diagrams, depending mainly on the qualitative features compared with the quantitative, to avoid the wide variations, especially in the individuals of the same species. The variations observed in the shapes of species, i.e., *R. hemisphareaca*, *R.* x *damascena,* and *R. elyamaitica,* were unique in their appearances in diagrams because of their differences in some morphological traits, such as fruit shapes, i.e., obovoid, achene, globose, and subglobose (Table 1, Figure 1).

Externally, the *Rosa* L. species *R. canina* var. 'dumetorum' and *R. canina* var. 'deseglisei' appeared very similar due to their respective diagrams. However, the two species did differ in leaf shape, with the former having an elliptical leaf and the latter an ovate one. The *Rosa* L. species *R. heckeliana* subsp. *orientalis* and *R. dumalis* subsp. *boissieri* showed superficially similar, though their prickles, leaves, hypanthiums, and fruits were notably different. The species' illustrations and features confirmed that all these unique species were members of the genus *Rosa* L.

In the studied *Rosa* L. species, the similarity ranged from 0.5% to 91% (Table 5), with the highest level of similarity at 91% (between *R. canina* var. 'verticillacantha' and *R. canina* var. 'canina'*)*. The mentioned species showed the most analogous for most morphological and reproductive (pollen grains) traits; however, they differed in leaf shapes (ovate in the first species and obovate in the second). The two species, *R. foetida* var. *bicolor* and *R. foetida,* at 88% indicated similarities in most morphological traits; but showed a difference in leaf shape (elliptical in the first species and ovate in the second). At the level of similarity of 88%, the species *R. centifolia* and *R. gallica* revealed alike in all the characteristics except plant nature, branches per stem, petiole length, leaf color, petals per flower, and anther shape.

The two species, *R. canina* var. 'verticillacantha' and *R. canina* var. 'dumetorum,' met at an 87% similarity, similar in most morphological characteristics (Table 5). However, these two species differed in leaf shape, leaflet margins shape, leaf color, flower gland, flower pedicle gland, the upper and lower surfaces of sepal pubescence, and the pollen grain shape. At the level of an 84%

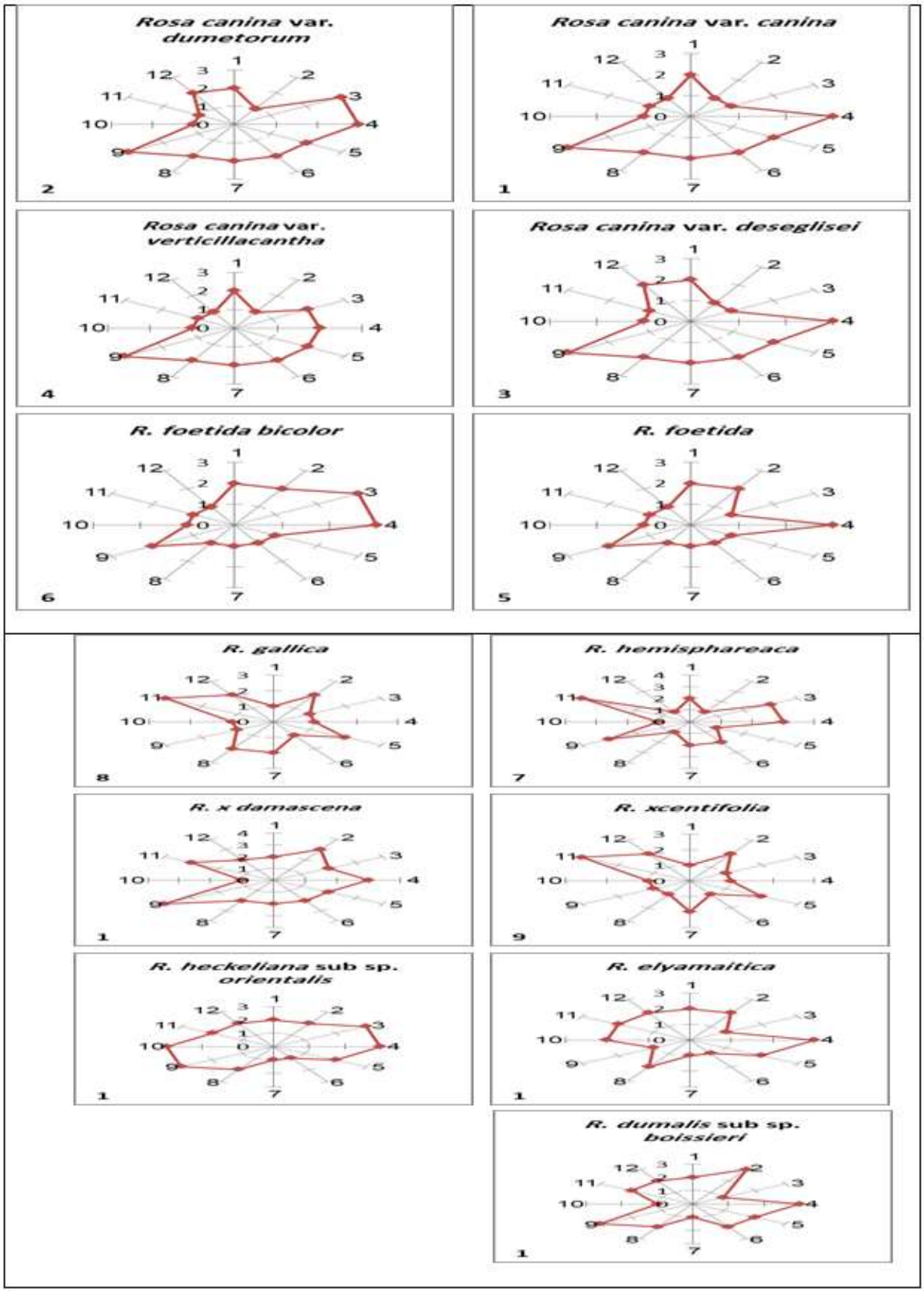

Figure 1. Polygonal diagrams to compare some species of *Rosa* L.

Table 5. The matrix of similarity and differences among the species of the genus *Rosa* L.

Proximity Matrix													
Case	Absolute Correlation between Vectors of Value												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000												
2	0.847	1.000											
3	0.830	0.846	1.000										
4	0.913	0.873	0.807	1.000									
5	0.140	0.085	0.110	0.043	1.000								
6	0.045	0.153	0.009	0.038	0.883	1.000							
7	0.103	0.139	0.070	0.037	0.354	0.394	1.000						
8	0.120	0.132	0.043	0.117	0.066	0.174	0.304	1.000					
9	0.264	0.293	0.161	0.260	0.202	0.284	0.334	0.887	1.000				
10	0.417	0.419	0.457	0.386	0.194	0.114	0.411	0.495	0.402	1.000			
11	0.076	0.046	0.206	0.198	0.258	0.126	0.260	0.212	0.073	0.005	1.000		
12	0.102	0.271	0.317	0.061	0.220	0.242	0.174	0.164	0.283	0.072	0.655	1.000	
13	0.636	0.529	0.592	0.603	0.165	0.046	0.036	0.033	0.054	0.481	0.010	0.191	1.000

1-*Rosa canina* var. *canina*, 2-*R. canina* var. *dumetorum,* 3- *R. canina* var. *deseglisei,* 4- *R. canina* var. *verticillacantha*, 5-*R. foetida,* 6- *R. foetida* var. *bicolor,* 7-*R. hemisphareaca*, 8-*R. gallica,* 9-*R.* x *centifolia,* 10-*R.* x *damascena,* 11-*R. elymaitica,* 12- *R. heckeliana* subsp. *orientalis,*13-*R. dumalis* subsp. *boissieri*

similarity, the species *R. canina* var. 'dumetorum' met with *R. canina* var. 'canina,' with similarities in various characteristics while showing differences in leaf shape, leaf color, the upper surface of sepal pubescence, and pollen grain shape and size.

The two species *R. canina* var. 'deseglisei' and *R. canina* var. '*dumetorum,*' displayed a similarity level of 84%. Both species were identical in most morphological traits except for leaf shape and color, flower gland, flower pedicle gland, and lower surface of sepal pubescence. The two *Rosa* species, *R. canina* var. 'deseglisei' and *R. canina* var. 'canina,' met at an 83% similarity level, resembling in most morphological traits, yet, differed in leaf color, the upper and lower surface of sepal pubescence, pollen grain shape, and size. Two more species, *R. canina* var. 'verticillacantha' and *R. canina* var. 'deseglisei,' indicated a resemblance at 80%. They are similar in various morphological characteristics, though differing in leaf shape and color, leaflet margins shape, the upper and lower surface of sepal pubescence, and the pollen grain size.

At the similarity level of 63%, the two species, i.e., *R. dumas* subsp. *boissieri* and *R. canina* var. 'canina' showed similarities in several morphological and pollen grain traits, yet differing in plant nature, prickles color, leaflet pubescence, flower gland, flower pedicle gland, calyx at fruiting, the lower surface of sepal pubescence, fruit color, achene shape, and pollen grain shape and size. The two species, *R. dumas* subsp. *boissieri* and *R. canina* var. 'verticillacantha' exhibited a 60% similarity, indicating that these species share some morphological characteristics.

The species *R. dumas* subsp. *boissieri* showed a 52% similarity with *R. canina* var. 'dumetorum,' sharing resemblance in many morphological traits but differing in some. The two species *R. damascena* and *R. gallica* showed a level of 49% similarity, similar in the number of branches per stem, twig color, prickles color, petiole length, leaflet base shape, leaf color, stipules length, bracts, and some other morphological traits.

The species *R. elyamaitica* and *R.* x *damascena* showed a 0.5% level of similarity, although they differed in general appearance. However, they showed similarities in prickles shape, leaf shape, bracts, flower gland, flower pedicle gland, hypanthium shape, hypanthium length, anther shape and stigma color, fruit stalk color, fruit pubescence, achenes per flower, achene shape, and pollen grain shape and size.

By examining the dendrogram shown in Figure 2, the studied species gained division into three main groups. The first main group included two subgroups comprising the species, i.e., *R. canina* vars. 'canina,' 'verticillacantha,' 'dumetorum,' and 'deseglisei,' and *R.* dumas subsp. *boissieri*. The mentioned group went further, dividing into the first cluster between the two species, *R. canina* var. 'canina' and *R. canina* var. 'verticillacantha,' with a similarity level of 91%. The results showed that the second cluster included the two species *R. canina* var. 'canina' and *R. canina* var. 'dumetorum,' with a similarity level of 84%. However, the third cluster included the two species, i.e., *R. canina* var.

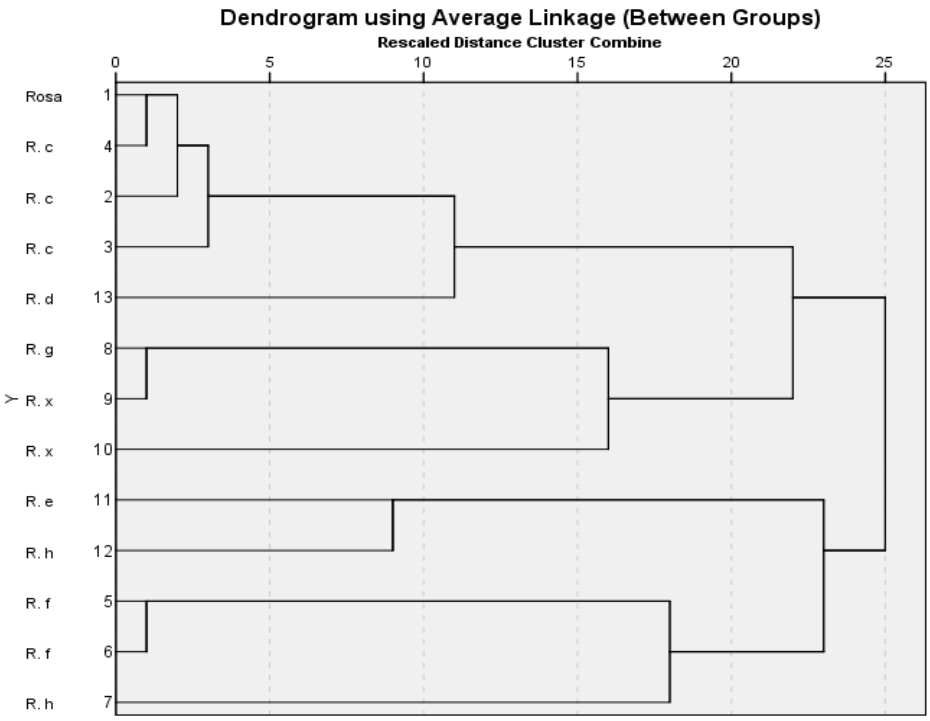

Figure 2. Dendrogram shows the degrees of similarity and difference between species of the genus *Rosa* L., according to their sequence in Table 5.
1-*Rosa canina* var. *canina*, 2-*R*. *canina* var. *dumetorum,* 3- *R*. *canina* var. *deseglisei,* 4- *R*. *canina* var. *verticillacantha*, 5-*R*. *foetida,* 6- *R*. *foetida* var. *bicolor,* 7-*R*. *hemisphareaca*, 8-*R*. *gallica,* 9-*R*. x *centifolia,* 10-*R*. x *damascena,* 11-*R*. *elymaitica,* 12- *R*. *heckeliana* subsp. *orientalis,*13-*R*. *dumalis* subsp. *boissieri*

'verticillacantha' and *R. canina* var. 'deseglisei,' with a similarity level of 80%. The three clusters came together in one cluster when *R. canina* var. 'dumetorum' and *R. dumas* subsp. *boissieri* participated with 52% of the traits analyzed by this process. The second subgroup included the species *R. gallica*, *R.* x *centifolia,* and *R.* x *damascena*, divided into the first cluster containing the two species *R. gallica* and *R.* x *centifolia,* with a similarity of 88%. Meanwhile, the two species *R. gallica* and *R. damascena* participated with a similarity level of 40%.

The second main group included the two species, i.e., *R. elyamaitica* and *R. heckeliana* subsp. *orientalis*, participating in the cluster formation, with a similarity level of 65%. The third major group included the species, viz., *R. foetida*, *R. foetida* var. *bicolor*, and *R. hemisphareaca*, with the indicated group dividing into the first cluster having the species *R. foetida* and *R. foetida* var. *bicolor*, with a similarity level of 88%. The results further revealed that the species *R. hemisphareaca* could be similar to the other species *R. foetida*; therefore, it clusters with a similarity level of 35% of the traits analyzed by this process.

DISCUSSION

Taxonomy usually relies on morphological traits to define the species. In classification, problems arise when the taxa display a large amount of variability due to phenotypic variability (Van-den-Berg and Groendijk-Wilders, 1994). Several authors have studied the genus *Rosa* taxonomically with few morphological traits (Al-Maa'thidy, 2003; Fatemi, 2009; Ullah *et al.*, 2021). However, the presented study used many vegetative and morphological traits for scoring and for numerical analysis used the UPGMA method to study the relationships among the species to approximate the level of variation. UPGMA is a simple agglomerative hierarchical clustering method that gives insight into the degree of similarity and predicts whether these species are from group clusters and the level of variation among the species.

Using several taxonomy methods have classified various species of the genera belonging to the family Rosaceae and interpreting the results of studies (Al-Duski, 2001; AL-Maa'thidy *et al.,* 2007; Fatemi *et al*., 2012a, b; AL-Maa'thidy and Shehab, 2021). In the recent study, during the fieldwork, the numerical methods employed analyzed the data recorded on morphological traits of vegetative and reproductive features of the plant (prickles shape, leaf shape, bracts, hypanthium, fruit, and achene shape) in understanding the relationships among the 13 species of the genus *Rosa* L. belonging to the family Rosaceae grown in Kurdistan region of Iraq.

The supposed technique proved very effective and has never been used and reported earlier in the numerical analysis of the genus *Rosa* (Al-Duski, 2001; Zhou *et al.,* 2021). It seemed that the selected traits reflect the taxonomic relationships, as well as, the pollen grain's shape and size variations among the *Rosa* species, subspecies, and varieties. Therefore, it is imperative to taxonomically distinguish the various species of the genus *Rosa* (Erdtman, 1971; Hebda and Chinnappa, 1990; Jacob and Pierret, 2000; Fatemi *et al*., 2012a, b; Ullah *et al.,* 2022).

The polygonal diagram showed contrast among the species of the genus in degrees of similarity through the selected characteristics and the dendrogram (Figure 1). Figure 2, obtained by UPGMA, showed countless similarity among the studied species. The dendrogram resulting from the cluster analysis of the traits data obtained from the specimen of *Rosa* species gave three main clusters. The first cluster representative consisted of *R. canina* vars. 'canina,' 'verticillacantha,' 'dumetorum,' and 'deseglisei,' and *R. dumalis* subsp. *boissieri.* The second cluster comprised species *R. gallica*, *R. centifolia, R. damascena,* and the third cluster, species *R. foetida* var. *bicolor* and *R. hemisphareaca*. The presented study showed the usefulness of the numerical method in resolving the obscured literature about the various species of the genus *Rosa* grown in Iraq. *Rosa* is a taxonomically complicated genus with remarkably variable species (Zielinski, 1982; Hebeda and Chin, 1990; Potter *et al.*, 2007). Based on the morphology and pollen grains of *Rosa* L., the dendrogram in UPGMA clustering between *Rosa* species defined three main clusters, the similarity of the first cluster at 63.6% and the second cluster at 49.5%, with the third main cluster was 35.4%. Moreover, this study added new findings to the literature limited to the known species, subspecies, and various cultivars of the genus *Rosa*.

CONCLUSIONS

The numerical taxonomic analysis can benefit further studies on the morphology of vegetative and reproductive characteristics, similarities, and variations among the species of the genus *Rosa* L. grown in the Kurdistan region of Iraq. A comprehensive study covering all *Rosa* L. species would be necessary to make a detailed classification that could serve useful for more studies using molecular data and comparing the same with morphological results.

ACKNOWLEDGEMENTS

The researchers thanked the College of Education for Pure Sciences and the Laboratory Unit, University of Mosul, Mosul, Iraq, for their cooperation in this research work.

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