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Numerical Taxonomic Study within the Egyptian Caryophyllaceae

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Abstract. Forty-three characters in 72 species representing the Egyptian Caryophyllaceae are used for numerical investigation. The three clustering methods used produced different results of the groupings. The group average dendrogram produced five groupings, which are not in accordance with the three recognized subfamilies. Only the Paronychioideae (with the exception of *Herniaria glabra, Cometes abyssinica* and *C. surattensis* which intermingled with the other subfamilies) stands as a distinct subfamily. The Alsinoideae and Silenoideae are not clearly distinguished from each other in this study.

Introduction

Generic delimitation within the family Caryophyllaceae have been confused since the early days of its taxonomic study [1-4]. Pax and Harms [5] divided the family into three subfamilies: the Alsinoideae, the Silenoideae and the Paronychioideae. The position of genera within these subfamilies has been altered according to many opinions [6-8].

In Egypt, there are twenty-eight genera, distributed mainly over the Mediterranean Coastal strips and Sinai [9]. They include a few cosmopolitan species. In order to investigate the phenetic relationships between the different species by numerical methods all the genera including most of their species representation are included in this work.

Materials and Methods

Five attributes from each species were used as operational taxonomic units (OTU). A total of 47 characters were examined in each OTU relating to gross morphology, seed, pollen and floral morphology. The characters employed are of four types: binary, multistate qualitative, multistate quantitative and continuous. Description of the characters and their states are given in Appendix I.

The computer programme used in this study is the SPSS/PC* [10] were rescaled dissimilarity distances can be calculated using the Euclidean distances [11], and further to calculate the group average (average-linkage), nearest neighbour (single-linkage) and furthest neighbour (complete-linkage).

Results and Discussion

The three dendrograms obtained from the clustering methods are illustrated in Figs 1-3.

The dendrogram using average linkage between species (Fig. 1) has produced five groupings of OTU's (a,b,c,d & e) in a straight phenon line at relatively high rescaled dissimilarity distance [7]. Group (a) is further subdivided into two subgroups (1&2) which can be separated at 5 rescaled dissimilarity distances. The first subgroup includes all the species of subfamily Paronychioideae and as well, the genera *Bufonia* and *Arenaria*. It also incorporates the species *Minuartia geniculata* and *M. procumbens* which belong to subfamily Alsinoideae, and *Gypsophila capillaris* which belongs to the Silenoideae. The second subgroup includes three species, each one belonging to a different subfamily (see Table 1).

Group (b) is subdivided into three subgroups (3,4 & 5) at the same phenon line at the same dissimilarity level (5). Subgroup (1) represents the genus *Cometes* alone, while subgroup (4) lumps *Vaccaria oxyodonta* with two *Silene* species *i.e. S. tridentata* and *S. longipetala*. Subgroup (5) lumps a number of taxa of both the Silenoideae and Alsinoideae. The three last groups (c,d & e) include species belonging to subfamily Silenoideae.

In the furthest neighbour dendrogram (Fig. 2), the same groupings were produced but with somewhat different results: Group (c) was separated at (5) rescaled dissimilarity distance, Group (e) was separated below this level and the two sub-

*The genera *Herniaria* and *Cometes* are now recognized as members of the family Illecebraceae.

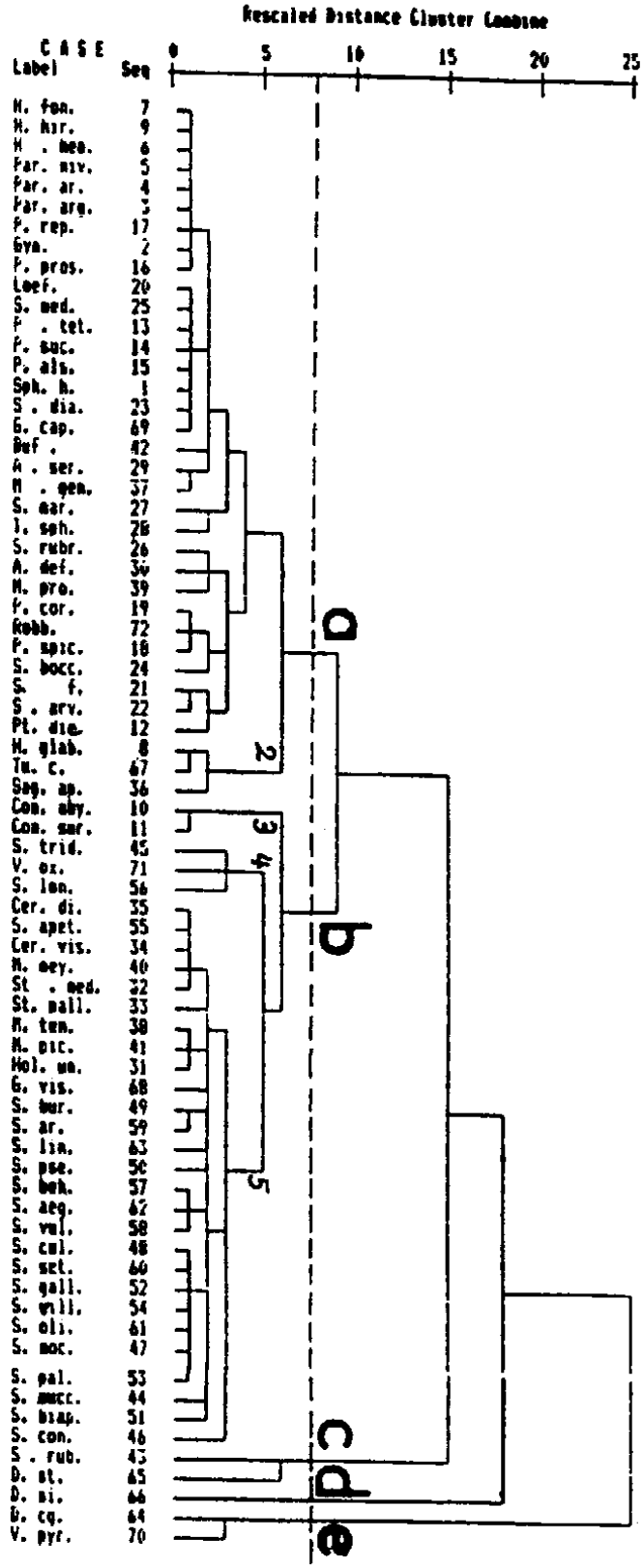

Fig. 1. Dendrogram using average linkage (between groups)

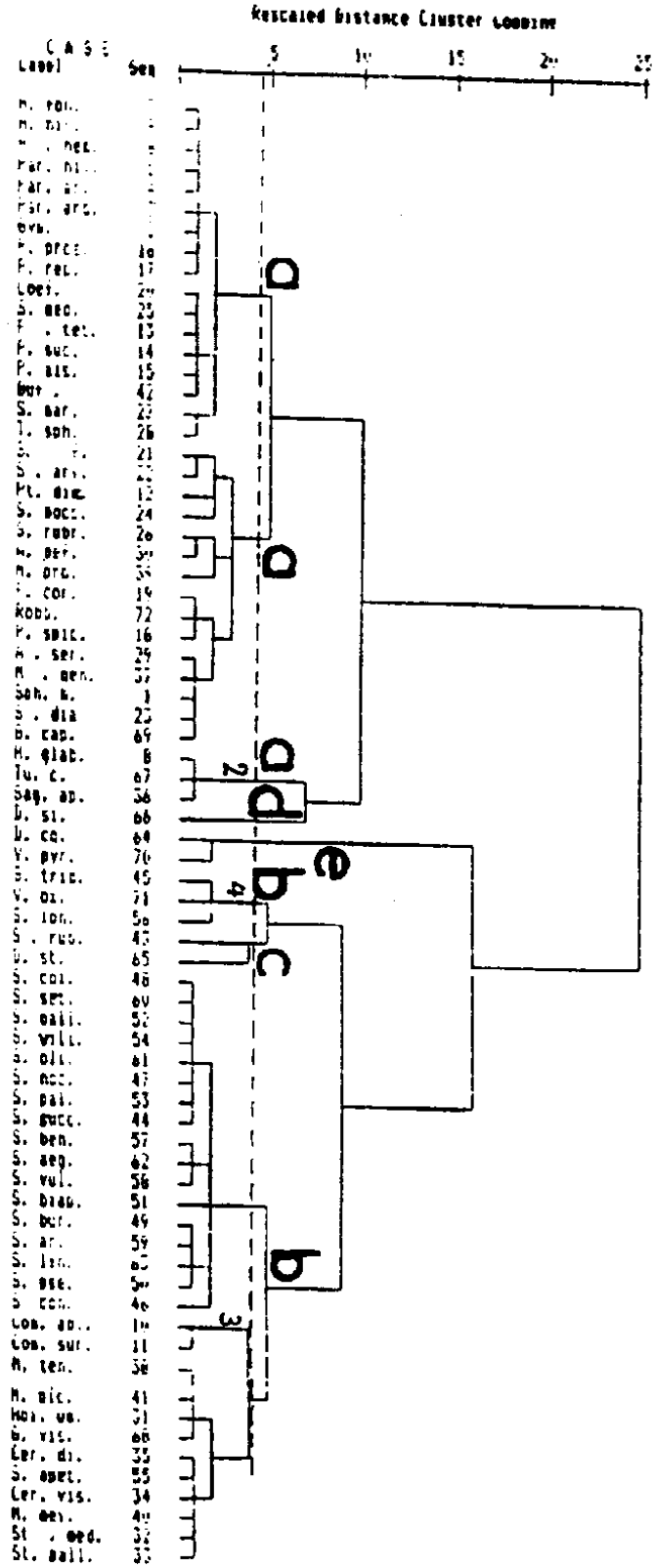

Fig. 2. Dendrogram using complete linkage

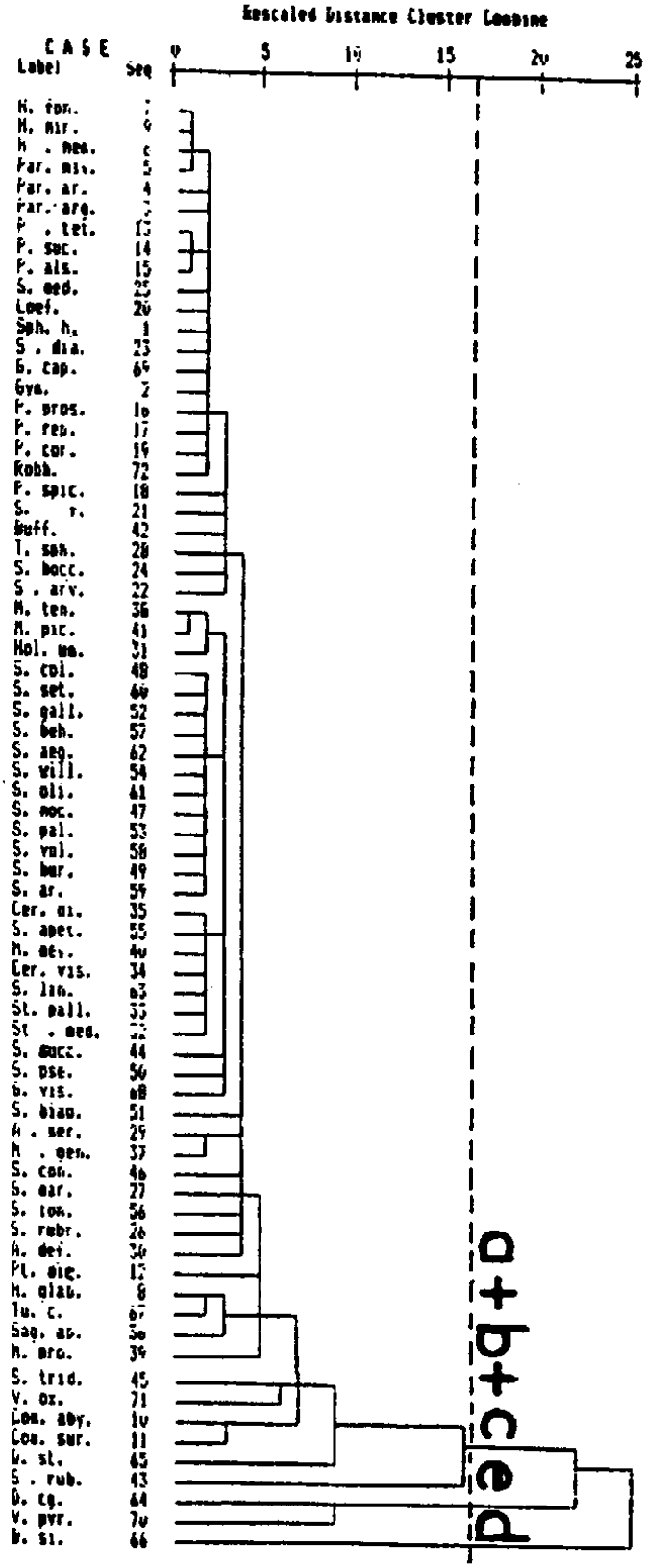

Fig. 3. Dendrogram using single linkage

Table 1. Taxa included in the different groups and subgroups

Group number	Subgroup number	Species	Subfamily
(a)	1	1-*Herniaria fontanesii* J. Gay	Paronychioideae
		2-*H. hirsuta* L.v.*cinerea* L.(herm.)	"
		3-*H. hemistemon* J. Gay	"
		4-*Paronychia nivea* DC.	"
		5-*P. arobica* (L.) DC.	"
		6-*P. argentea* Lam.	"
		7-*Polycarpaea repens* (Forssk.) Asch. & Schiweinf.	"
		8-*Gymnocarpos decandrum* Forssk.	"
		9-*Polycarpon prostratum* (Forssk.) Aschers.& Schweinf.	"
		10-*Loeflingia hispanica* L.	"
		11-*Spergularia media* (L.) C.Presl ex Griseb.	"
		12-*Polycarpon tetraphyllum* (L.)L.	"
		13-*P. succulentum* (Del.) J. Gay	"
		14-*P. alsinifolium* (Biv.) DC.	"
		15-*Sphaerocoma hookeri* T. Anders.	"
		16-*Spergularia diandra* (Guss.) Boiss.	"
		17-*S. marina* (L.) Griseb.	"
		18-*Telephium sphaerospermum* Boiss.	"
		19-*Spergularia rubra*-(L.) J.&C. Presl.	"
		20-*Polycarpaea corymbosa* (L.) Lam.	"
		21-*Robbairea delileana* Milne Redh.v.*major* (schweinf) Tackh.	"
		22-*Polycarpaea spicata* Wight ex Arn.	"
		23-*Spergularia bocconii* (Sol. ex Scheele) A.& G.	"
		24-*Spergula fallax* (Lowe) E.H. Krause	"
		25-*S. Arvensis* L.	"
		26-*Pteranthus dichotomus* Forssk.	"
		27-*Bufonia multiceps* Decne.	Alsinoideae
		28-*Arenaria serpyllifolia* L.	"
		29-*A. deflexa* Decne.	"
		30-*Minuartia geniculata* (Poiret) Thell.	"
		31-*M. procumbens* Graebn.	"
		32-*Gypsophila capillaris* (Forssk.) C. Chr.	Silenoideae
	2	33-*Tunica compressa* Fisch. & Mey.	"
		34-*Sagina apetala* Ard.	Alsinoideae
		35-*Herniaria glabra* L.	Paronychioideae
(b)	3	36-*Cometes abyssinica* R.Br.ex Wall.	"
		37-*C. surattensis* L.	"

Table 1. (Cont).

Group number	Subgroup number	Species	Subfamily
	4	38-*Silene tridentata* Desf.	Silenoideae
		39-*S. longipetala* Vent.	"
		40-*Vaccaria oxyodonta* Boiss.	"
	5	41-*Cerastium dichotomum* L.	Alsinoideae
		42-*C. viscosum* L.	"
		43-*Minuartia meyeri* Bornm.	"
		44-*M. tenuifolia* (L.) Hiern.	"
		45-*M. picta* (Sibth. & Sm.) Borm.	"
		46-*Stellaria media* (L.) Vill.	"
		47-*S. pallida* (Dumortier) Piré	"
		48-*Holosteum umbellatum* L.	"
		49-*Gypsophila viscosa* Murr.	Silenoideae
		50-*Silene apetala* Willd.	"
		51-*S. burchelii* Otth. ex Dc.	"
		52-*S. arabica* Boiss.	"
		53-*S. linearis* Decne.	"
		54-*S. pseudatocion* Desf.	"
		55-*S. behen* L.	"
		56-*S. aegyptiaca* (L.) L.G.	"
		57-*S. vulgaris* (Moench) Garcke	"
		58-*S. colorata* Poiret	"
		59-*S. setacea* Viv.	"
		60-*S. gallica* L.	"
		61-*S. villosa* Forssk.	"
		62-*S. oliveriana* Otth. in Dc.	"
		63-*S. nocturna* L.	"
		64-*S. palaestina* Boiss.	"
		65-*S. succulenta* Forssk.	"
		66-*S. biappendiculata* Rohrb.	"
		67-*S. conoidea* L.	"
(c)		68-*S. rubella* L.	"
		69-*Dianthus strictus* Banks et Sol.	"
(d)		70-*D. sinaicus* Boiss.	"
(e)		71-*D. cyri* Fisch. & Mey.	"
		72-*Vaccaria pyramidata* Medicus	"

groups (3&5) linked together at (3) rescaled dissimilarity distance. Subgroup (4) showed great similarity with a new subgroup (6), and subgroup (2) showed the same similarity with group (d).

In the third "nearest neighbour" dendrogram two of the group (d&e) were singletons, whereas the remaining three groups (a,b & c) lumped together in a series of chaining.

The results obtained from the three clustering methods are inconsistent. This may be attributed to the different properties of the methods used *e.g.* chaining or space contraction in nearest neighbour and space dilation in furthest neighbour [11;12]. Pielou [13] points out that the nearest neighbour clustering is not often used in practice because it is prone to chaining. McNeill [14, pp. 281-296] points out that the single linkage method tends to chain the OTU's. Thus, if several programming options were applied and produced somewhat different results, the practice is to select that method which best matches the traditional taxonomic treatment [14]. In our study the group average dendrogram method is accordingly adopted here for clustering. It portrays the Paronychioideae as a well distinguished subfamily in spite of the fact that *Herniaria glabra, Cometes abyssinica* and *C. surattensis* intermingle with the other subfamilies*. The Alsinoi deae and Silenoideae were not clearly distinguished from each other and their relationship with the Paronychioideae become obscure.

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Appendix I

The attributes and their states arranged in groups according to organs. (The attributes and states are symbolized for computation)

Organ	Attribute		State recognized	Character
1-whole plant	colour	(1)	1-brown/2-light brown/3-dark brown 4-olive/5-green/6-light green/7-yellow 8-yellowish brown/9-orange/10-greyish white.	multistate unordered
	internode	(2)	Average length in mm.	numerical
		(3)	Average width in mm.	numerical
	texture	(4)	1-glabrous/2-sparsely villous/3-villous 4-hairy.	multistate ordered
	type of hairs	(5)	1-absent/2-pointed unicellular/3-pointed multicellular/4-glandular/5-tabular	multistate ordered
2-leaf morphology	stomata	(6)	1-diacytic/2-anomocytic/3-anisocytic 4-diacytic & anisocytic	multistate unordered
	texture	(7)	1-glabrous/2-sparsely villous/3-villous 4-hairy.	multistate ordered
	type of hairs	(8)	1-absent/2-pointeduncellular/3-pointed multicellular/4-glandular multicellular 5-tabular.	multistate ordered
	crystals	(9)	1-absent/2-present	binary
	stipules	(10)	1-absent/2-present	binary
	venation	(11)	1-parallelodromous/2-reticuloparallelo dromous/3-reticulodromous/4-eucamptodro-mous/5-brochidodromous.	multistate unordered
	dimentions	(12)	average length in mm.	numerical
		(13)	average width in mm.	numerical
	margin	(14)	1-entire/2-crenate/3-dentate	multistate ordered
	apex	(15)	1-acuminate/2-apiculate/3-cuspidate 4-acute/5-rounded/6-mucronate.	multistate ordered

Appendix I (Cont.)

Organ	Attribute		State recognized	Character
	base	(16)	1-angustatus/2-cuneate/3-auriculate.	multistate ordered
3-floral characters	bract	(17)	1-absent/2-present	binary
	sepal dimentions	(18)	average length in mm.	numerical
		(19)	average width in mm.	numerical
	sepal colour	(20)	1-green/2-brown/3-light brown/4-papery white/5-yellow or membranous/6-light green.	multistaste unordered
	type of calyx hairs	(21)	1-absent/2-pointed unicellular/3-pointed multicellular/4-glandylar multicellular 5-tabular	multistate ordered
	texture	(22)	1-glabrous/2-sparsely villous/3-villous 4-hairy.	multistate ordered
	sepal shape	(23)	1-lanceolate/2-oblanceolate/3-elliptic 4-linear/5-acuminate/6-piliferus/7-ovate 8-tridentate.	multistate ordered
	sepal venation	(24)	1-parallelodromous/2-reticulodromous 3-campylodromous/4-eucamptodromous/5-3 parallel nerves/6-acrodromous.	multistate unordered
	sepal number	(25)		numerical
	ratio bet. cal.& sta.	(26)	1-stamen shorter/2-equal/3-longer	multistate ordered
	petals	(27)	1-absent/2-present	binary
	petal colour	(28)	1-absent/2-white/3-pink/4-yellow membranous/5-light green/6-green/7-white membranous/8-rose/9-yellow/10-orange.	multistate unordered
	petal dimensions	(29)	average length in mm.	numerical
		(30)	average width in mm.	numerical
	petal number	(31)		numerical
	petal shape	(32)	1-absent/2-entire-lanceolate/3-dentate or slightly bifed/4-filiform/5-deeply bifed 6-elongated fimbriated.	multistaste unordered
	colour of pedicel	(33)	1-orange/2-yellow/3-brown/4-light brown 5-green/6-light green/7-dark brown/8-grey	multistate unordered
	pedicel shape	(34)	1-cylindrical/2-flattened.	binary
	pedicel length	(35)	average length in mm.	numerical
4-seed characters	shape	(36)	1-reniform/2-subglobular/3-globular	multistate unordered
	colour	(37)	1-yellow/2-black/3-brown/4-light brown 5-dark brown/6-straw.	multistate unordered
	dimentions	(38)	average length in mm.	numerical
		(39)	average width in mm.	numerical

Appendix I (Cont.)

Organ	Attribute		State recognized	Character
	surface	(40)	1-smooth/2-tuberculated/3-rugose 4-striate/5-aculeate/6-punctate 7-undulate/8-reticulate.	multistate unordered
5-pollen characters	type	(41)	1-pantoporate/2-trizonocolpate/3-polycolpate.	multistate unordered
	size	(42)	mean length in μm. in polar view.	numerical
		(43)	mean length in μ. in equatorial view.	numerical
	number of aper.	(44)	number of pores or colpi.	numerical
	length of aper.	(45)	the mean in μm.	numerical
	exine thick.	(46)	the mean thickness in μm.	numerical
	sexine pattern	(47)	1-papillate/2-granulate/3-baculate/4-pilate 5-reticulate/6-punctate/7-faintly reticulate.	multistate unordered

دراسة تصنيفية عدديّة في الفصيلة القرنفليّة المصريّة

وفاء كمال طايع وسامية رشاد إسماعيل

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(سُلِّمَ في ١٤١٣/١٢/١٨هـ، وقُبل للنشر في ١٤١٥/٥/٤هـ).

ملخص البحث. تمّ دراسة ٤٣ صفة مورفولوجية في ٧٢ جنسًا تابعين للفصيلة القرنفليّة الموجودة بالفلورا المصرية. ومن الثلاث تجمعات الناتجة من التحليل العددي، وجد أنّ المجموعات الناتجة من المجاميع المتوسطة غير متفقة مع التقسيم التصنيفي للفصيلة القرنفليّة ولكن تحت الفصيلة البارونخييّة، تميّزت بصفاتها وانفصلت في تجمع خاص بها، أما تحت الفصيلة السيلنيّة والألسينيّة فقد اندمجت وأصبحت علاقتها ببعضا البعض غير محدّدة كما أصبحت علاقتها بتحت الفصيلة البارونخييّة غامضة.