

## Numerical Investigation Within The Genus *Atriplex*

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**Abstract.** 70 morphological characters were used as Operational Taxonomic Units (OUT's) in a study of seventeen *Atriplex* species. The clustering analysis shows three groups: The first group contains both *A. patula* and *A. hastatea*, while the second gathered the species, *A. nummularia*, *A. inamoena* and *A. polycarpa*. The rest of the studied species have been clustered together in a third group. Three subgroups have been identified within this last group. The result has been discussed according to their morphological characters. A key for the studied species is also provided.

**Key Words:** Operational taxonomic unit, Clustering analysis, Morphological characters.

### Introduction

*Atriplex*, a large and widely distributed genus of the Chenopodiaceae, is regarded by most taxonomists as a natural group at the generic level (Taia and Sheha, 2001). The genus was, however, restored to its present state after several taxonomic revisions. For example, Hall and Clements (1923) found that the genera *Obione*, *Pterochiton* and *Edolopsis*, which have similar characters as those of *Atriplex*, is better to be regrouped together. Further, they divided the genus into two subgenera, *Euatriples* and *Obione*, according to the position of the embryo in the seeds; radicle inferior or lateral and monoecious versus radicle superior and either monoecious or dioecious. Eichler (1965) segregated the genera *Theleophyton*, *Senniella* and *Morrisiella* within the genus *Atriplex*. Most of the taxonomists, dealing with the *Atriplex* species, commented on the difficulty of selecting constant characters to classify various species. Parr-

Smith (1977) applied the ordination technique of principal components analysis in his treatment of the woody Australian *Atriplex*. Osmond *et al.* (1980) indicated the importance to seek a functional definition of the species by applying numerical or chemical methods. Bisalputra (1960) evaluated the vascularization pattern in the fruiting bracts as being an important character in the circumscription of the *Atriplex* species, but, Hall and Clements (1923) as well as Van der Meijden (1970) indicated that the use of this feature is undue. Kadman-Zahavy (1955) found a relation between bract-shape and seed, while Jones (1975) found that seed morphology and bracteole weight were correlated. Taschereau (1972) suggested that the relative abundance of two seed types (small, hard blackseed or large, soft brown seed) is a useful taxonomic character especially in the implications for reproductive processes with the consideration of the presence of seed dimorphism in the introduced species

such as *A.patula* and *A.hastatea* as mentioned by Hall and Clements (1923). For that, the genus is considered as one of the difficult genera, and depends to a large extent on the taxonomic scheme one follows. The leaf morphological characters are variable except the whitish mealiness surface, which considered a significant character within the *Atriplex* species (Frankton and Basett, 1968). The anatomy of the leaves is considered more important in the taxonomy of this genus, as some of its species possess two or more rows of cells around the vascular elements of the leaves termed Kranz syndrome (Black, 1954; Frankton and Basett, 1970; Taschereau, 1972). Teeri and Stowe (1976) indicated that the Kranz anatomy is correlated to a complex of environmental factors and noted to the presence of this feature in eight dicotyledonae families only, including Chenopodiaceae. These families are more abundant in arid habitats and suffer from environmental disorders.

It is known from the previous studies that, species within *Atriplex* display a wide range of morphological variation. The leaf size and thickness are related to nutrition, salinity, water availability, light intensity and temperature (Osmond *et al.* 1980). Even the trichomes, which cover both the stem and leaves of many *Atriplex* species are similar to those found on the epidermis of *Chenopodium album* and other Chenopods (Brian and Cattlin, 1968). Turki *et al.* (2000) have indicated the difficulty in segregating the species due to polymorphism in leaves and bracteoles. This paper describes a detailed numerical study designed to assess the extent of morphological variation within and between seventeen, mostly Egyptian, *Atriplex* species.

## Materials and Methods

Twenty specimens from each species from different locations were subjected to this study. A total of 70 characters were examined in all taxa (Table 1). These characters are used as operational taxonomic units (OUTs), and are of four types: binary, multistate quantitative (multistate ordered), multistate qualitative (multistate unordered) and continuous. Three computer programmes were used in this study; CHANDAT summarized the data obtained for each OUT. The distance matrix was then calculated by using the programme called DISIM. These two programmes are designed and written by the Department of Applied Statistics, Reading University, England. The programme TWINSPLAN was used to obtain a clustering tree.

## Results and Discussion

The results are summarised in tables 2 and Fig.1. A key for the studied species is provided. The clustering analysis (Fig.1), shows that the 17 *Atriplex* species were clustered into three main groups at dissimilarity distance of about 1.45. The first group comprises two species; *A. patula* and *A. hastatea*. These two species are C3 plants characterized by the angled stem. Bisalputra (1960) indicated that *A. patula* and *A. hastatea* can be easily identified by the free, leaf-like bracts and fused woody bracts respectively. Thus the separation of these two species according to their morphological characters coordinates with the previous observations.

Table 1: Characters employed for numerical investigation and their types.

Character	4 & 1	2 & 5	3 & 6	Type
1-Pl. form	1-herb	2-shrub	3-shrublet	<i>Multi.Qual.</i>
2-Pl. habit	1-annual	2-perennial		<i>Binary</i>
3-Pl.strength	1-herbaceous	2-woody		<i>Binary</i>
4-Pl.growth	1-prostrate 4-erect	2-decumbent	3-ascending	<i>Multi.Qual.</i>
5-Pl.height	(in cm.)			<i>Continuous</i>
6-Stem outline	1-angled	2-striped	3-rounded	<i>Multi.Quan.</i>
7-Stem colour	1-whitish 4-green	2-yellow	3-light green	<i>Multi.Quan.</i>
8-Internode L	(in cm.)			<i>Continuous</i>
9-Internode w	(in cm.)			<i>Continuous</i>
10-RatioL/w				<i>Continuous</i>
11-Branches d	1-dense bran.	2-spar.bran.		<i>Binary</i>
12-Stem hair	1-glabrous	2-hairy		<i>Binary</i>
13-Trichomes	1-absent 4-multiser.gl.	2-unicellular	3-uniser.multi.	<i>Multi.Quan.</i>
14-Petiole L	(in mm.)			<i>Continuous</i>
15-Pet. Hair	1-glabrous	2-spar.hairy	3-hairy	<i>Multi.Quan.</i>
16-Leaf col.	1-whit.green 4-dark green	2-light green	3-green	<i>Multi.Quan.</i>
17-Leaf meal.	mealy	not mealy		<i>Binary</i>
18-Midleaf L	(in cm.)			<i>Continuous</i>
19-Midleaf w	(in cm.)			<i>Continuous</i>
20-Ratio L/w				<i>Continuous</i>
21-Midleaf sh.	1-linear 4-ovate	2-lanceolate 5-obovate	Elliptic lanc. 6-orbicular	<i>Multi.Qual.</i>
22-Midleaf margin	1-entire 4-serrate	2-slight.dentate	3-dentate	<i>Multi.Qual.</i>
23-Midleaf ap	1-acute	2-apiculate	3-obtuse	<i>Multi.Qual.</i>
24-Midleaf b.	1-acute 4-cordate	2-attenuate	3-truncate	<i>Multi.Qual.</i>
25-Up.leaf L.	(in cm.)			<i>Continuous</i>
26-Up.leaf w.	(in cm.)			<i>Continuous</i>
27-Ratio L/w				<i>Continuous</i>
28-Upperleaf shape	1-linear 4-oblancoolate	2-elliptic	3-lanceolate	<i>Multi.Qual.</i>
29-Up.leaf margin	1-entire 1-acute	2-slight.dentate		<i>Binary</i>
30-Up.leaf apex	1-acute	2-apiculate	3-obtuse	<i>Multi.Qual.</i>
31-Up.leaf base	1-glabrous	2-attenuate		<i>Binary</i>
32-Leaf hair	1-absent	2-hairy		<i>Binary</i>
33-Trichomes	4-multi.gl. 1-absent	2-unicellular 2-present	3-uniser.multi.	<i>Multi.Quan.</i>
34Leaf crystal	1-cladodrom.	2-brochi.drom		<i>Binary</i>
35-Leaf ven.	1-spike	2-panicle		<i>Binary</i>

Table 1. contd.

36-Inflores.T.	1-axillary	2-terminal		<i>Binary</i>
37-Inflores.P.	1-absent	2-present		<i>Binary</i>
38-Involucre	1-monoecious	2-polygamous		<i>Binary</i>
39-Plant	1-whit. Green	2-light green	3-green	<i>Multi.Quant</i>
40Fl.colour	(in mm.)			<i>Continuous</i>
41-Tepal L	(in mm.)			<i>Continuous</i>
42-Tepal w				<i>Continuous</i>
43-Ratio L/w	1-lanceolate	2-elliptic	3-orbicular	<i>Multi.qual.</i>
44-Tepal sh.	1-acute	2-obtuse		<i>Binary</i>
45-Tepal ap.	1-membranous	2-leafy		<i>Binary</i>
46-Tepal T.	free	2-base united		<i>Binary</i>
47-Tepal stat.				<i>Continuous</i>
48-Stamens	1-equal	2-half		<i>Binary</i>
49-Ant./filam.	1-filamentous	2-ribbon		<i>Binary</i>
50-filam.sh.	free	united styles		<i>Binary</i>
51-Style &St.				<i>Continuous</i>
52-No.stigma	1-dull	2-shiny		<i>Binary</i>
53-Seed app.	1-acute	2-rounded		<i>Binary</i>
54-Seed marg.	1-light green	2-light brown	3-brown	<i>Multi.Qual.</i>
55-Seed col.	4-black			<i>Continuous</i>
	(inmm.)			<i>Continuous</i>
56-Seed L.	(in mm.)			<i>Continuous</i>
57-Seed w.				<i>Continuous</i>
58-Ratio L/w	1-terrete	2-discoid	3-oblong	<i>Multi.Qual.</i>
59-Seed sh.	1-reticulate	2-wrinkeled	3-smooth	<i>Multi.Qual.</i>
60-Seed surf.	1-lateral	2-apical		<i>Binary</i>
61-Microp.po.	1-triangular	2-reniform	3-square	<i>Multi.Qual.</i>
62-Fruit sh.	1-soft	2-hard		<i>Binary</i>
63-Pericarp strength	1-toothed	2-trilobed	3-dentate	<i>Multi.Qual.</i>
64-Peri.marg.	4-entire			<i>Binary</i>
	1-absent	2-present		<i>Continuous</i>
65-Fruit stalk	(in mm.)			<i>Continuous</i>
66-F.st.L.	(in mm.)			<i>Continuous</i>
67-F.perian.L	(in mm.)			<i>Binary</i>
68-F.perian.w	1-absent	2-present		<i>Binary.</i>
69-F.per.ner.	1-glabrous	2-hairy.		
70-F.per.hair				

## Taxa employed in the clustering analysis

- |                                     |                                |                                       |
|-------------------------------------|--------------------------------|---------------------------------------|
| 1- <i>A.canescens</i> (Pursh.)Nutt. | 2- <i>A.semibaccata</i> R.Br.  | 3- <i>A.portulacoides</i> L.          |
| 4- <i>A.farinosea</i> Forssk.       | 5- <i>A.halimus</i> L.         | 6- <i>A.lentiformis</i> (Torr)S.Wats. |
| 7- <i>A.serenana</i> A.Nelson       | 8- <i>A.littoralis</i> L.      | 9- <i>A.stylosa</i> Viv               |
| 10- <i>A.rosea</i> F.Muell.         | 11- <i>A.coriacea</i> Forssk.  | 12- <i>A.hymenelytra</i> (Torr)S.Wats |
| 13- <i>A.hastatea</i> L.            | 14- <i>A.patula</i> L.         | 15- <i>A.polycarpa</i> S.Wats         |
| 16- <i>A.inamoena</i> Aellen        | 17- <i>A.nummularia</i> Lindl. |                                       |

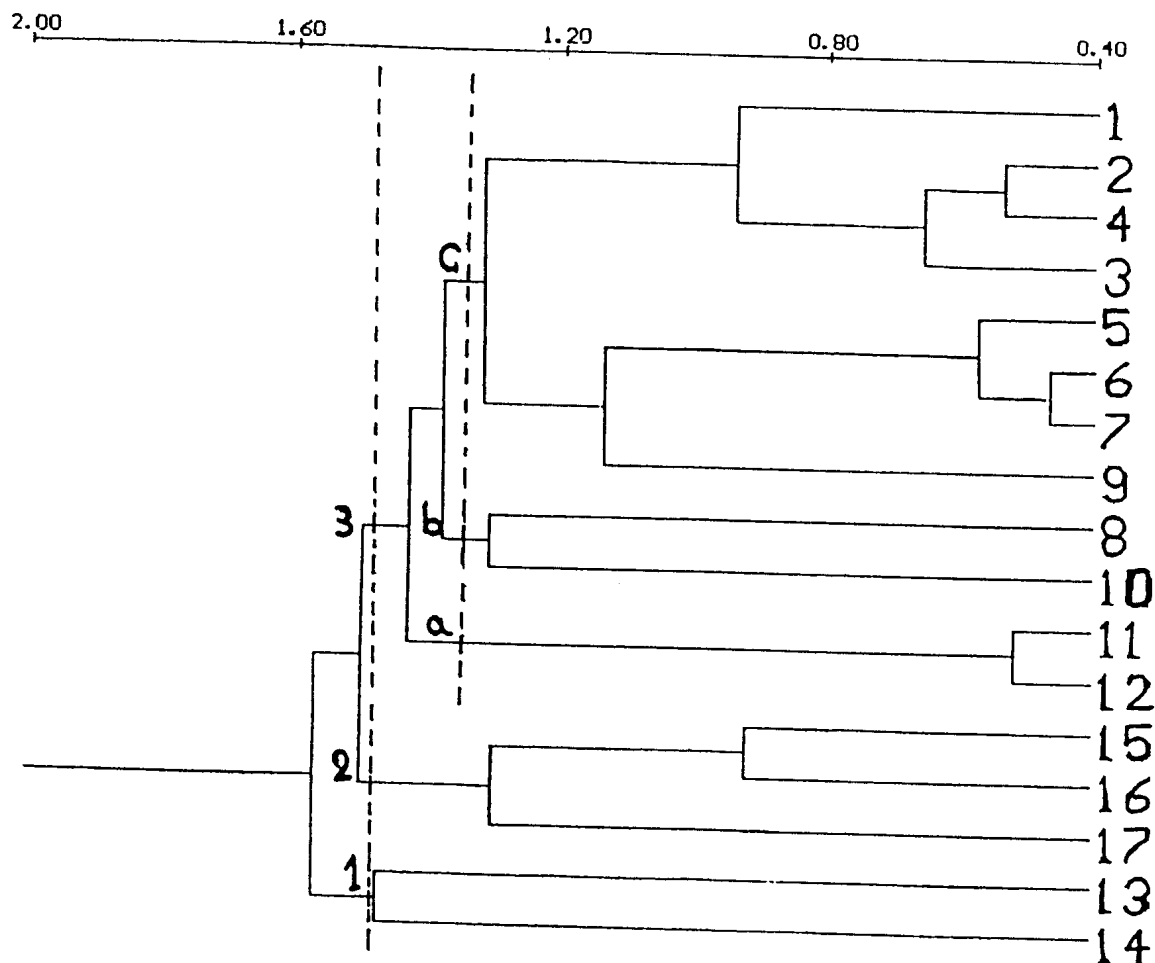


Fig 1. Results of the clustering analysis.

to their morphological characters coordinates with the previous observations.

The second group has three species; *A. polycarpa*, *A. inamoena* & *A. nummularia*, they are C4 plants. This group has striped stem. *A. nummularia* is well separated from the other two species by orbicular mealy leaves with serrate margins as well as their discoid seed with a smooth surface. The other two species in this group have orbicular, mealy or nonmealy leaves with entire margins and triangular, smooth surfaced seed. The morphological character of the leaf, to be mealy or not mealy, is considered significant within the

*Atriplex* species by Frankton and Basett (1968). In contrast to the other leaf morphological characters which might respond to the environmental stress (Osmond *et al.*, 1980).

The third group has the rest of the studied species with round stems. This group is further divided into three subgroups at a dissimilarity distance of 1.3. Subgroup (a) gathered *A. coriacea* and *A. hymenelytra*, both are C4 plants and can be separated by their leaf shapes. Subgroup (b) comprises *A. littoralis* and *A. rosea* which are different plants, as the first is C3 plant while the later is C4. They also differ in their leaf surfaces. Subgroup

**Table 2:** The status of the characters investigated

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Ch.																	
1	1	1	3	1	2	2	2	1	3	1	2	2	1	1	3	2	2
2	1	1	2	1	2	2	2	1	2	1	2	2	1	1	2	2	2
3	1	1	2	1	2	2	2	2	2	2	2	2	1	1	2	2	2
4	1	3	3	4	4	4	4	4	4	4	2	2	4	4	4	4	4
5	38	30	49	46	7.0	23	32	45	29	26	30	14	52	40	13	42	50
6	3	3	3	3	3	3	3	3	3	3	3	3	1	1	2	2	2
7	2	2	2	3	1	1	1	2	2	3	1	1	4	4	4	4	4
8	21	18	12	18	28	32	19	23	9	10	12	18	28	36	6	14	16
9	1.0	2.0	1.5	1.0	3.0	3.0	2.0	2.0	1.0	1.0	2.0	2.5	2.5	2.0	1.0	3.0	2.0
10	21	9.0	8.0	18	9.0	11	9.5	11	9.0	10	6.0	7.0	12	18	6.0	4.7	8.0
11	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1	1
12	2	1	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1
13	3	3	3	1	1	1	1	3	2	4	2	2	1	1	1	1	1
14	1.0	1.0	2.0	1.0	4.0	2.5	2.0	3.0	2.0	2.5	2.0	2.0	19	3.0	1.0	2.0	4.0
15	2	2	2	1	2	2	2	1	1	2	1	1	1	1	2	1	1
16	2	3	2	2	1	1	1	4	1	2	2	2	4	1	3	1	1
17	1	1	1	1	1	1	1	2	1	1	2	2	2	2	2	1	1
18	12	17	22	13	10	25	18	30	14	12	21	12	50	35	7	15	19
19	4.0	5.0	5.0	5.0	8.0	18	14	6.0	7.0	4.0	14	5.0	30	5.0	3.0	13	15
20	3.0	3.4	4.4	2.6	1.3	1.4	1.3	5.0	2.0	3.0	1.5	2.4	1.7	7.0	2.3	1.2	1.3
21	3	3	3	2	5	5	5	1	5	3	4	4	5	2	6	6	6
22	3	2	3	3	3	3	3	2	2	3	1	1	3	1	1	1	4
23	2	1	1	1	2	2	2	2	1	1	3	3	1	1	3	3	2
24	2	1	1	1	2	2	2	2	3	2	2	2	4	1	1	1	2
25	5.0	5.0	6.0	5.0	5.0	8.0	8.0	7.0	12	8.0	4.0	4.0	12	8.0	4.0	9.0	9.0
26	2.5	2.0	2.5	3.0	3.0	4.0	3.0	2.0	4.0	3.0	2.0	3.0	6.0	1.0	2.0	5.0	5.5
27	2.0	2.5	2.4	1.7	1.7	2.0	2.7	3.5	3.0	2.7	2.0	1.3	3.5	8.0	2.0	1.8	1.6
28	2	2	1	2	2	2	2	1	1	1	3	4	3	1	4	4	3
29	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	2	1	1	1	3	1	1	3	3	1
31	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1
32	2	2	2	1	2	2	2	2	2	2	2	2	2	1	1	1	1
33	3	3	3	1	2	2	2	3	4	2	4	4	1	1	1	1	1
34	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
35	1	1	1	1	1	1	1	2	1	2	2	2	1	1	2	2	2

Table 2 contd.

36	2	2	2	2	1	1	1	1	1	1	2	2	1	2	1	1	2
37	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
38	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2
39	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2
40	2	2	2	2	1	1	1	2	2	2	3	3	2	2	2	2	3
41	0.5	0.9	0.9	0.7	1.0	1.0	1.5	1.0	1.1	0.6	0.9	1.6	1.0	0.7	1.5	1.1	1.0
42	0.5	0.6	0.5	0.4	0.5	0.6	1.0	0.7	0.8	0.4	0.5	1.6	0.5	0.5	0.9	0.5	1.0
43	1.0	1.5	1.8	1.8	2.0	1.7	1.5	1.4	1.4	1.5	1.8	1.0	2.0	1.4	1.7	2.2	1.0
44	2	1	1	2	1	1	1	3	2	2	2	2	1	2	3	3	3
45	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	2
46	1	1	1	1	2	2	2	1	1	2	2	2	2	2	2	2	1
47	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	2
48	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
49	2	2	1	1	2	2	2	2	1	2	2	2	2	1	2	2	2
50	2	2	2	2	2	2	2	2	1	2	1	1	1	1	1	1	2
51	1	1	1	1	1	1	1	1	2	2	1	1	1	1	2	2	2
52	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
53	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1
54	1	1	1	1	1	1	1	2	1	2	1	1	1	1	2	2	1
55	1	3	3	2	3	3	3	3	4	3	2	2	3	2	2	2	2
56	1.5	1.7	1.6	1.2	2.0	1.0	1.0	1.0	0.5	1.2	0.7	1.5	1.0	0.9	1.2	1.1	1.0
57	1.5	1.3	1.4	1.0	2.0	0.9	1.0	1.0	0.5	1.0	0.7	1.5	1.0	0.9	1.0	1.0	1.0
58	1.0	1.3	1.1	1.2	1.0	1.1	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.0	1.2	0.9	1.0
59	2	2	2	3	2	2	2	2	2	3	2	2	2	2	1	1	2
60	1	1	1	1	2	2	3	2	2	2	2	2	2	2	3	3	3
61	1	1	2	1	2	2	2	2	1	1	2	2	1	1	1	1	1
62	1	1	1	1	2	2	2	1	1	3	3	3	1	1	1	1	1
63	1	1	2	1	2	1	1	1	1	2	2	2	1	1	1	1	1
64	1	1	1	1	3	3	3	1	2	1	2	2	1	2	2	2	2
65	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
66	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	3.0	3.1	4.0	3.2	10	4.0	3.5	1.0	2.0	2.0	3.5	3.0	3.0	2.2	2.8	12	6.0
68	2.5	3.1	3.0	2.5	4.0	3.2	3.0	1.0	1.0	1.0	3.0	3.0	3.0	2.2	2.8	6.0	4.0
69	2	2	2	2	2	1	1	2	1	1	1	1	1	2	1	1	1
70	1	2	2	1	2	2	2	2	1	1	1	1	1	1	1	1	1

shape. *A.halimus*, *A.lentiformis* and *A.serrenana* are closely resembled in their morphological characters can be identified by more internal investigations, as *A.halimus* belongs to subgenus *Euatriplex* is characterized by inferior or lateral radicles and monoecious. Both *A.lentiformis* and *A.serrenana* belong to subgenus *Obione* is characterized by a superior radicle and is either monoecious or dioecious. Taia and Sheha (2001) have identified these two species according to their pollen grains as *A.lentiformis* has small pollen grains never exceed 12.5 Um with few sexine ornamentation while *A.serrenana* has bigger pollen grains with moderate sexine ornamentation.

**Key for the studied *Atriplex* species according to their morphological characters**

I- Stem outline angled	<b>Group 1</b>
a-leaf-shape lanceolate	<i>A.patula</i>
b-leaf-shape ovate-triangular	<i>A.hastata</i>
II-Stem outline stripped	<b>Group 2</b>
A-leaf surface not meally	<i>A.polycarpa</i>
B-leaf surface meally	
i-leaf margin serrate	<i>A.nummularia</i>
ii-leaf margin entire	<i>A.inamoena</i>
III-Stem outline rounded	<b>Group 3</b>
A-leaf surface not meally	
1-plant erect	<i>A.littoralis</i>
2-plant decumbent	
a-leaf lanceolate with acute apex	<i>A.coriacea</i>
b-leaf oblanceolate with obtuse apex	<i>A.hymenelytra</i>
B-leaf surface meally	
1-plant prostrate	<i>A.canescens</i>
2-plant ascending	
*leaf glabrous	<i>A.portulacoides</i>
**leaf hairy	<i>A.semibaccata</i>

3-plant erect, herbaceous	
*leaf glabrous	<i>A.farinose</i>
**leaf hairy	<i>A.rosea</i>
4- plant erect, shrub or shrublet	
a-leaf ovate-triangular with acute apex and truncate base	<i>A.stylosa</i>
b-leaf ovate-triangular with apiculate apex and attenuate base	<i>A.halimus</i> , <i>A.lentiformis</i> , <i>A.serrenana</i>
5- Radicle inferior (subgenus <i>Euatriplex</i> )	<i>A.halimus</i>
6- Radicle superior (subgenus <i>Obione</i> )	
a-pollen grains small in size never exceed 12.5 Um	<i>A.lentiformis</i>
b-pollen grains exceed 12.5 Um	<i>A.serrenana</i>

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## تنقيبات عديدة في جنس الأترييلكس

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**الملخص:** لقد تم دراسة ٧٠ صفة تصنيفية تابعة للشكل الخارجي في ١٧ نوع من أنواع جنس الأترييلكس . ومن الشكل العنقودي المتحصل عليه حصلنا على ثلاثة مجاميع . المجموعة الأولى تحتوي على نوعين فقط بينما المجموعة الثانية تحتوي على ثلاثة أنواع أما باقي الأنواع فقد تجمعوا في مجموعة ثالثة . هذه المجموعة الأخيرة قد أعطت بدورها ثلاثة مجاميع . هذه النتائج قد تم مناقشتها على أساس الصفات الخارجية وقد تم عمل مفتاح تصنيفي لهذه الأنواع .