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Some *Assyriella* Species in South East Anatolia in Turkey Differentiated by Multivariate Statistical Analysis (Gastropoda: Pulmonata, Helicidae)

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Abstract: This study was performed on 3 species of the genus *Assyriella* (*A. escheriana* , *A. guttata* and *A. thospitis*) collected from Diyarbakır province in Southeast Anatolia. Two derived and 6 shell variables of 50 specimens were examined for each species. Hierarchical clustering and discriminant analysis were used to evaluate the data in order to clarify and contribute to some systematic problems of these species.

It was shown that Ward's method with Euclidean distance is the most appropriate hierarchical clustering method to cluster these species. *A. escheriana* is clearly differentiated from *A. guttata* and *A. thospitis* by both Ward's method and discriminant analysis. The results of discriminant analysis and Ward's method reveal that *A. thospitis* and *A. guttata* may have a close evolutionary relationship. Also, the most important shell characters (variables) that differentiate these species from each other were determined by discriminant analysis and the success efficiency of these techniques in systematic problems was observed.

Consequently, the results of this study showed that more precise identification can be made in classification of *A. escheriana, A. guttata* and *A. thospitis* if classical criteria are used together with the group classification functions obtained from discriminant analysis.

Key Words: *Assyriella,* Biometry, Numeric Taxonomy

Türkiye, Güneydoğu Anadolu Bölgesi'nde Bulunan Bazı *Assyriella* Türlerinin (Gastropoda, Pulmonata, Helicidae), Çok Değişkenli İstatistik Metodlarla Ayırımının Yapılması

Özet: Bu çalışma, Güneydoğu Anadolu Bölgesi, Diyarbakır ili civarından toplanmış *Assyriella* genusunun üç türü *(A. escheriana , A. guttata* ve *A. thospitis*) üzerinde gerçekleştirilmiştir. Her bir tür için 50 örnek üzerinde, iki türetilmiş ve altı kabuk değişkeni incelendi. Bu üç türün bazı sistematik problemlerinin çüzümüne katkıda bulunmak amacıyla, veriler, hiyerarşik gruplama ve diskriminant analizi teknikleri ile değerlendirildi ve bu tekniklerin sistematikte ne derecede başarılı olarak kullanılabilecekleri gözlendi.

Öklit uzaklığı kullanılarak, Ward metodunun bu türleri gruplamada daha uygun bir hiyerarşik gruplama metodu olduğu görülmüştür. Hem Ward metodu hem de diskriminant analizi *A. escheriana'yı A. guttata* ve *A. thospitis*'ten belirgin bir şekilde ayırmaktadır. Diskriminant analizi ve Ward metodunun sonuçları, *A. guttata* ve *A. thospitis*'in evrimsel olarak daha yakın akraba olabilecekleri göstermektedir. Ayrıca, bu türleri biribirinden ayıran en önemli kabuk karakteristikleri (değişkenleri) diskriminant analizi ile belirlenmiş ve bu tekniklerin sistematikteki etkinlikleri gözlenmiştir.

Sonuç olarak, bu çalışmanın bulguları *A. escheriana, A. guttata* ve *A. thospitis*'in sınıflandırılmasında, geleneksel kriterler, diskriminant analizinden elde edilen grup sınıflandırma fonksiyonları ile birlikte kullanılırsa, daha doğru teşhislerin mümkün olabileceğini göstermektedir.

Anahtar Sözcükler: *Assyriella,* Biyometri, Numerik Taksonomi

Introduction

Schütt (1) stated that the species of the genus *Assyriella* spread in the Middle East, Near East and some islands such as Rhodes and Cyprus originally developed in Southeastern Anatolia. Their classification is mainly based on shell features and genital apparatus. Recently, a revision was made on the species of this genus. A total of 2 new and 15 known species have been described by Schütt and Subai (2).

Due to morphological and anatomical similarity, *Assyriella* species have many synonyms. For instance, *Assyriella thospitis* (Schütt and Subai, 1996) which was described as a new species in 1996 (2), was previously considered to be *Helix ergilensis* by Galland in 1885. *Assyriella guttata* (Olivier 1804) and *Assyriella escheriana* (Bourguignat, 1864) were considered to be *Helix guttata* by Olivier in 1804 and *Helix escheriana* by Bourguignat in 1864, respectively.

The shell features of *A.guttata* and *A.escheriana* and the comparative anatomy of their reproduction systems were studied by Agüloğlu and Balcı (3).

The present study was carried out on 3 species of the genus *Assyriella, A. escheriana, A. guttata* and *A. thospitis*, collected from Diyarbakır province in South-eastern Anatolia in order to clarify and contribute to the taxonomic status of these species by employing hierarchical clustering and discriminant analysis techniques and the efficiency of these techniques was observed. Some shell characters (variables) were used in the multivariate statistical techniques since these characters are the basis of the original species description.

Materials and Methods

Materials

This study was performed on the specimens of 3 species (*A. escheriana, A. guttata, A. thospitis*), collected from Diyarbakır province in Southeast Anatolia in Turkey between 1995 and 1999 and identified according to the traditional taxonomic characters used by Schütt and Subai (2). These specimens are kept at the Dicle University Science Faculty Museum (DUM). Fifty specimens were randomly drawn for each of the 3 species. The selected specimens of *A. escheriana A. guttata*, and *A. thospitis* were numbered [1-50], [51-100] and [101-150], respectively.

Methods

Box plots

Box plots provide a simple graphical summary of a group (groups) of cases defined by a categorical (grouping) variable. Tukey (4) originally presented them as schematic plots. Vellman and Hoalgin (5) introduced them to non-technical users and demonstrated their power for a range of data. McGill et al. (6) implemented confidence intervals on the medians of several groups in box plots. If the intervals around 2 medians do not overlap, one can be about 95 % confident that the population medians are different and so the confidence intervals are useful for judging difference between groups. More information about constructing and interpreting box plots can be found in Hamilton (7).

Hierarchical clustering

There are many clustering methods and similarity coefficients. Many of them can be found in Sneath and Sokal (8), Hartigan (9); Abbot et al. (10) and Everit (11).

Discriminant Analysis

Discriminant functions were developed independently by Fisher (12), Mahaonobis (13) and Hotelling (14), whose primary interests were in different areas. The theoretical base of this analysis can be found in detail in Chatfield and Colins (15), Johnson and Wichern (16) and in the publications dealing with multivariate statistics. In summary, discriminant analysis is a technique for finding functions so as to discriminate several groups previously defined. It is therefore of considerable interest to those wishing to classify specimens, on each of which a number of measurements have been made and which are to be collected in previously defined groups. This analysis was employed for the same purpose in this study.

A large number of discriminant analysis studies and hierarchical clustering applications have been described such as in Akbayın et al. (17), Togan et al. (18), Özbay and Akbayın (19), Kristensen and Christensen (20), and Mukaratirva et al. (21).

Measurements

Two derived and 6 shell variables shown in Figure 1 and Table 1 were measured on the selected 150 specimens in millimeters by a calliper compass. In this way, we obtained a 150x8 data 3 with three categories. The data matrix with descriptive statistics by categories is given in Table 2. STATISTICA (22) vwas used for the statistical analysis.

Descriptive statistics, hierarchical clustering methods and discriminant analysis were used to evaluate the data matrix in order to clarify some systematic problems of these species.

Table 1. Measured variables of *Assyriella* species

Shell variable (Character)	Abbreviation
Shell Diameter (mm)	ShD
Shell Height (mm)	ShH
Ratio of shell diameter to shell height	ShD/ShH
Aperture Height (mm)	ApH
Aperture Width (mm)	ApW
Ratio of Aperture Height to aperture width	ApH/ApW
Spire Height (mm)	SpH
Truncation Width (mm)	TrW

Results

The multiple box plot given in Figure 2 was used to determine the classificatory values of the measured characteristics of *Assyriella* species in question. Therefore, the data matrix was categorised with respect to the species.

If Figure 2 is reviewed, the variables ShD/ShH, ApH/ApW and TrW have no classificatory value because of the approximately equal distribution of these variables. So these variables were removed when the cluster analysis was performed. On the other hand, the remaining variables have more or less classificatory value.

In the present study, the hierarchical methods with different similarity coefficients found in the STATISTICA (22) clustering module were applied to the data matrix given in Table 2 by removing the variables (ShD / ShH, ApH / ApW and TrW) that have no classificatory values. The results of these operations were observed. During the process, it was determined that Ward's (23) method with Euclidean distance is a more appropriate method than the others due to its producing clusters at high similarity level. The dendrogram obtained by Ward's method is given in Figure 3.,

The data matrix given in Table 2 was subjected to discriminant analysis taking species as grouping variables. Eigen values and discriminant functions associated with these eigen values were obtained. These functions were tested by chi-square statistics. The results of these operations are given in Table 3. The test statistics shown that the 2 discriminant functions were statistically significant ($p< 0.001$) in discrimination of the 3 species.

The scatter plot of the first canonical variate (CV1) by the second canonical variate (CV2) is presented in Figure 4.

The group classification functions are used to determine to which group (category) a new specimen most likely belongs. A specimen is classified into the group for which it has the largest classification function score. The group classification functions are given in Table 4.

Group classification functions were calculated for the data matrix (see Table 2) to see how our specimens are classified by these functions. Observed memberships against those predicted by these functions are given in Table 5.

Canonical loadings are correlations between variables and discriminant functions. These loadings are used to determine how much and in which direction a variable contributes to discrimination. The canonical loading produced during the application of discriminant analysis are given in Table 6 in decreasing order of importance.

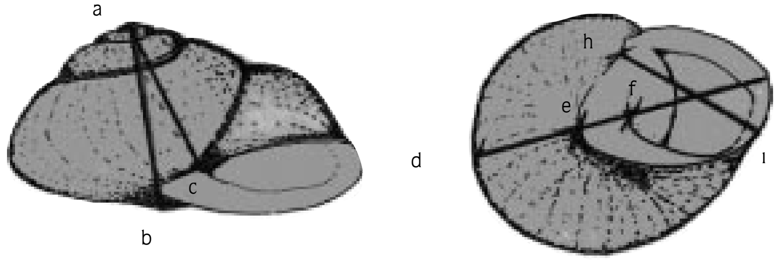

Figure 1. The location where measurements of shell variables were taken on each specimen of *Assyriella*.
ab: Shell Height (ShH)
ac: Spire Height (SpH)
dg: Shell Diameter ShD)
ef: Truncation Width (TrW)
eg: Aperture Width (ApW)
hı: Aperture Height (ApH)

Table 2. Data matrix obtained from the randomly selected specimens.*

A. escheriana

Sn	ShD	ShH	ShD/ShH	ApH	ApW	ApH/ApW	SpH	TrW
1	30.6	9.3	3.290	21.8	15.3	1.425	10.6	2.2
2	32.0	13.2	2.424	18.5	14.6	1.267	12.0	1.7
3	33.4	12.2	2.738	20.4	17.0	1.200	14.1	1.4
4	32.2	17.3	1.861	23.2	16.8	1.381	10.9	1.7
5	32.4	10.4	3.115	13.5	18.2	0.742	14.0	1.9
6	34.1	13.1	2.603	13.2	16.2	0.815	14.7	1.6
7	29.9	10.8	2.769	19.8	18.4	1.076	11.7	1.8
8	28.3	14.4	1.965	17.9	20.4	0.877	11.5	1.7
9	31.7	16.0	1.981	18.0	16.7	1.078	11.8	1.6
10	30.8	16.2	1.901	19.1	12.5	1.528	13.0	2.0
11	30.7	13.7	2.241	18.2	15.9	1.145	14.4	1.7
12	31.6	14.2	2.225	18.3	17.0	1.076	12.9	2.0
13	33.1	12.2	2.713	18.0	17.2	1.047	12.3	1.8
14	32.7	11.6	2.819	21.4	16.6	1.289	14.2	1.8
15	32.6	14.2	2.296	19.9	16.4	1.213	13.6	2.0
16	33.1	15.4	2.149	21.1	16.2	1.302	14.2	2.3
17	27.0	15.9	1.698	18.3	14.7	1.245	14.4	1.9
18	32.8	14.4	2.278	18.2	17.7	1.028	15.3	2.3
19	35.6	12.9	2.760	16.4	17.9	0.916	14.5	1.6
20	32.8	10.3	3.184	16.2	17.0	0.953	12.0	1.2
21	31.7	14.1	2.248	14.7	16.6	0.886	11.4	1.9
22	29.2	13.6	2.147	18.7	15.0	1.247	13.3	1.4
23	31.2	12.2	2.557	20.2	14.2	1.423	14.3	2.2
24	32.8	15.3	2.144	18.8	16.5	1.139	12.7	1.7
25	29.3	10.9	2.688	17.4	17.7	0.983	10.3	1.5
26	39.3	10.9	3.606	20.0	20.0	1.000	12.4	1.7
27	31.5	15.0	2.100	17.4	15.3	1.137	12.5	2.1
28	34.2	15.8	2.165	19.2	17.2	1.116	12.1	2.0
29	30.0	14.0	2.143	18.1	20.3	0.892	12.5	1.8
30	31.8	12.9	2.465	21.2	17.4	1.218	14.2	1.6
31	33.4	12.7	2.630	19.7	13.0	1.515	13.2	1.6
32	31.4	12.3	2.553	17.9	15.3	1.170	16.4	2.3
33	34.9	17.9	1.950	16.1	14.5	1.110	12.9	1.5
34	34.4	13.7	2.511	19.1	14.9	1.282	12.1	1.9
35	27.9	15.5	1.800	20.8	16.9	1.231	12.9	2.1
36	35.0	13.2	2.652	17.8	17.6	1.011	14.8	2.3
37	33.2	13.4	2.478	15.8	13.0	1.215	13.7	1.4
38	25.2	14.1	1.787	19.9	17.4	1.144	13.8	1.9
39	35.4	12.3	2.878	21.0	17.3	1.214	12.9	1.4
40	32.1	14.1	2.277	20.9	15.1	1.384	10.3	1.8
41	28.7	14.4	1.993	19.3	15.4	1.253	14.7	1.3
42	27.2	13.3	2.045	21.6	16.6	1.301	12.4	1.3
43	28.8	17.5	1.646	19.6	16.5	1.188	9.0	1.9
44	31.9	13.3	2.398	19.3	14.7	1.313	13.9	1.7
45	28.0	15.0	1.867	20.0	15.0	1.333	11.6	1.7
46	31.9	14.5	2.200	14.3	16.5	0.867	15.3	2.2
47	36.7	10.9	3.367	17.3	16.9	1.024	11.1	1.9
48	34.6	12.3	2.813	15.4	17.1	0.901	13.1	1.5
49	29.4	16.1	1.826	11.6	15.6	0.744	10.3	2.1
50	27.9	13.7	2.036	19.2	15.1	1.272	11.8	2.3
Mean	31.73	13.65	2.38	18.47	16.35	1.14	12.88	1.80
St. Dev.	2.718	1.922	0.455	2.373	1.665	0.191	1.537	0.296

A. guttata

Sn	ShD	ShH	ShD/ShH	ApH	ApW	ApH/ApW	SpH	TrW
51	36.2	17.6	2.057	20.4	19.5	1.046	15.6	2.4
52	34.7	17.9	1.939	20.4	17.2	1.186	15.7	2.6
53	34.7	16.6	2.090	20.0	16.4	1.220	16.0	2.0
54	34.8	17.4	2.000	17.7	17.5	1.011	16.4	2.0
55	34.0	18.1	1.878	21.0	19.0	1.105	16.4	2.1
56	35.4	17.3	2.046	20.9	17.4	1.201	16.7	2.3
57	35.8	17.2	2.081	18.8	18.6	1.011	16.6	2.4
58	34.9	16.8	2.077	20.1	17.3	1.162	15.4	2.3
59	33.5	16.9	1.982	20.7	19.7	1.051	15.9	2.6
60	34.5	17.4	1.983	22.1	18.5	1.195	16.2	2.2
61	35.3	17.3	2.040	20.1	17.9	1.123	16.3	2.6
62	34.7	16.8	2.065	20.6	16.1	1.280	16.0	2.2
63	34.3	17.6	1.949	19.4	19.1	1.016	17.2	2.4
64	34.3	16.8	2.042	20.6	18.3	1.126	15.6	2.5
65	35.3	16.4	2.152	19.8	16.9	1.172	16.3	2.4
66	33.1	17.4	1.902	20.2	15.9	1.270	15.9	2.4
67	34.0	17.2	1.977	19.7	18.0	1.094	14.6	2.1
68	37.3	16.2	2.302	21.2	18.7	1.134	16.1	2.1
69	35.7	18.6	1.919	20.3	17.8	1.140	16.5	2.5
70	34.6	17.7	1.955	18.9	18.2	1.038	16.4	2.4
71	34.5	16.8	2.054	20.1	17.1	1.175	16.6	2.1
72	35.9	18.0	1.994	20.2	19.1	1.058	15.5	2.1
73	36.2	17.4	2.080	21.4	16.8	1.274	16.0	2.3
74	35.9	16.1	2.230	20.3	18.2	1.115	16.4	2.3
75	33.4	17.1	1.953	21.4	18.8	1.138	15.9	2.2
76	36.2	17.1	2.117	21.9	16.6	1.319	16.5	2.5
77	35.5	16.7	2.126	18.9	17.3	1.092	16.4	1.9
78	36.0	16.9	2.130	20.7	17.1	1.211	16.3	2.0
79	35.6	17.5	2.034	20.2	17.8	1.135	16.5	2.3
80	34.4	16.5	2.085	21.5	16.2	1.327	16.0	2.3
81	34.5	17.5	1.971	21.0	19.0	1.105	16.6	2.6
82	34.6	17.8	1.944	19.1	16.8	1.137	16.6	2.3
83	35.3	17.9	1.972	19.8	20.3	0.975	16.1	2.1
84	35.7	16.7	2.138	20.2	17.4	1.161	15.9	2.2
85	34.2	18.2	1.879	19.4	19.7	0.985	16.1	2.0
86	34.3	16.3	2.104	19.2	17.0	1.129	16.5	2.6
87	34.2	16.3	2.098	20.4	18.6	1.097	17.0	2.6
88	34.3	16.4	2.091	19.8	18.0	1.100	16.6	2.2
89	35.2	17.6	2.000	20.8	18.1	1.149	16.6	2.1
90	34.7	16.9	2.053	19.7	19.9	0.990	15.8	2.1
91	35.2	17.5	2.011	21.1	16.1	1.311	15.1	2.2
92	34.9	16.8	2.077	21.3	18.5	1.151	16.8	2.2
93	34.5	16.1	2.143	20.0	18.1	1.105	15.9	2.5
94	35.5	16.7	2.126	19.8	16.6	1.193	17.2	2.6
95	35.0	17.3	2.023	20.7	17.9	1.156	15.9	2.1
96	35.6	16.7	2.132	20.4	18.1	1.127	16.7	2.4
97	34.5	18.0	1.917	21.2	20.0	1.060	16.6	2.6
98	35.1	16.6	2.114	19.2	18.5	1.038	15.8	2.6
99	35.1	17.0	2.065	20.2	17.7	1.141	15.8	2.1
100	35.5	17.8	1.994	21.6	16.1	1.342	16.3	2.3
Mean	34.97	17.15	2.04	20.29	17.91	1.14	16.20	2.30
St. Dev.	0.806	0.597	0.087	0.873	1.126	0.091	0.501	0.204

A. thospitis

Sn	ShD	ShH	ShD/ShD	ApH	ApW	ApH/ApW	SpH	TrW
101	35.4	17.7	2.000	21.4	16.8	1.274	16.0	2.3
102	36.3	17.7	2.051	20.9	20.5	1.020	17.2	2.3
103	36.6	16.4	2.232	20.5	21.2	0.967	15.7	2.6
104	36.4	18.2	2.000	20.6	18.1	1.138	15.3	2.4
105	37.0	17.1	2.164	19.7	20.2	0.975	16.9	2.3
106	36.5	17.5	2.086	21.8	19.1	1.141	17.0	2.0
107	36.4	18.1	2.011	20.4	19.7	1.036	17.3	2.1
108	37.7	18.4	2.049	19.5	20.0	0.975	16.7	2.4
109	38.2	18.0	2.122	21.6	18.0	1.200	15.4	2.4
110	35.6	17.5	2.034	20.4	20.5	0.995	16.3	2.4
111	36.0	17.8	2.022	20.5	18.5	1.108	14.9	2.1
112	36.2	17.4	2.080	20.1	21.1	0.953	16.6	2.2
113	36.6	17.9	2.045	20.2	17.3	1.168	16.2	2.6
114	36.1	17.5	2.063	20.5	19.2	1.068	15.4	2.6
115	36.3	17.3	2.098	21.8	21.1	1.033	17.1	2.0
116	37.6	19.0	1.979	21.1	21.8	0.968	16.3	2.2
117	33.0	17.3	1.908	20.9	18.9	1.106	14.9	2.4
118	37.3	18.1	2.061	20.7	18.0	1.150	16.6	2.2
119	35.6	17.8	2.000	20.4	19.3	1.057	17.3	2.3
120	36.5	17.7	2.062	22.0	17.9	1.229	14.9	2.2
121	35.5	17.1	2.076	21.3	19.4	1.098	16.0	2.3
122	36.7	17.6	2.085	20.7	19.2	1.078	16.1	1.8
123	36.1	17.8	2.028	21.0	20.3	1.034	17.5	2.3
124	37.5	18.7	2.005	20.0	20.7	0.966	14.7	2.3
125	36.9	18.2	2.027	21.3	18.1	1.177	16.5	2.4
126	34.9	18.4	1.897	20.7	17.3	1.197	15.8	2.2
127	34.8	16.6	2.096	19.4	17.5	1.109	18.1	2.1
128	36.0	17.6	2.045	20.5	20.4	1.005	17.4	2.3
129	35.0	18.6	1.882	21.2	19.3	1.098	17.2	2.3
130	36.8	16.9	2.178	20.0	19.3	1.036	15.6	2.1
131	34.6	17.8	1.944	21.3	19.2	1.109	16.4	2.1
132	37.8	17.5	2.160	20.2	18.9	1.069	16.2	2.3
133	34.9	17.7	1.972	20.9	19.7	1.061	16.9	2.6
134	35.8	17.5	2.046	21.8	18.1	1.204	16.0	2.5
135	36.7	17.7	2.073	20.0	20.2	0.990	16.0	2.2
136	36.2	18.9	1.915	19.9	18.7	1.064	15.1	2.1
137	34.8	17.7	1.966	19.8	19.5	1.015	15.8	2.4
138	36.5	16.6	2.199	20.5	19.5	1.051	16.5	2.2
139	37.9	18.3	2.071	20.6	19.9	1.035	16.4	2.1
140	35.1	17.2	2.041	20.5	19.0	1.079	16.5	2.1
141	37.0	17.7	2.090	19.2	19.4	0.990	17.0	2.4
142	39.2	18.2	2.154	20.4	20.6	0.990	15.7	2.1
143	37.1	17.8	2.084	21.8	18.9	1.153	15.6	2.5
144	36.3	18.2	1.995	21.0	18.9	1.111	16.3	2.4
145	35.7	16.5	2.164	19.7	19.3	1.021	16.9	2.0
146	35.2	17.4	2.023	20.1	17.9	1.123	16.2	2.4
147	36.5	19.1	1.911	19.6	18.7	1.048	17.4	2.0
148	35.4	17.3	2.046	20.8	19.2	1.083	16.1	2.3
149	34.7	17.7	1.960	23.2	20.7	1.121	16.4	2.4
150	36.1	17.8	2.028	20.1	19.3	1.041	16.2	2.3
Mean	36.22	17.73	2.04	20.65	19.29	1.07	16.29	2.27
St. Dev.	1.095	0.602	0.078	0.775	1.118	0.076	0.770	0.178

*For abbreviation see Table 1 and Figure 1.

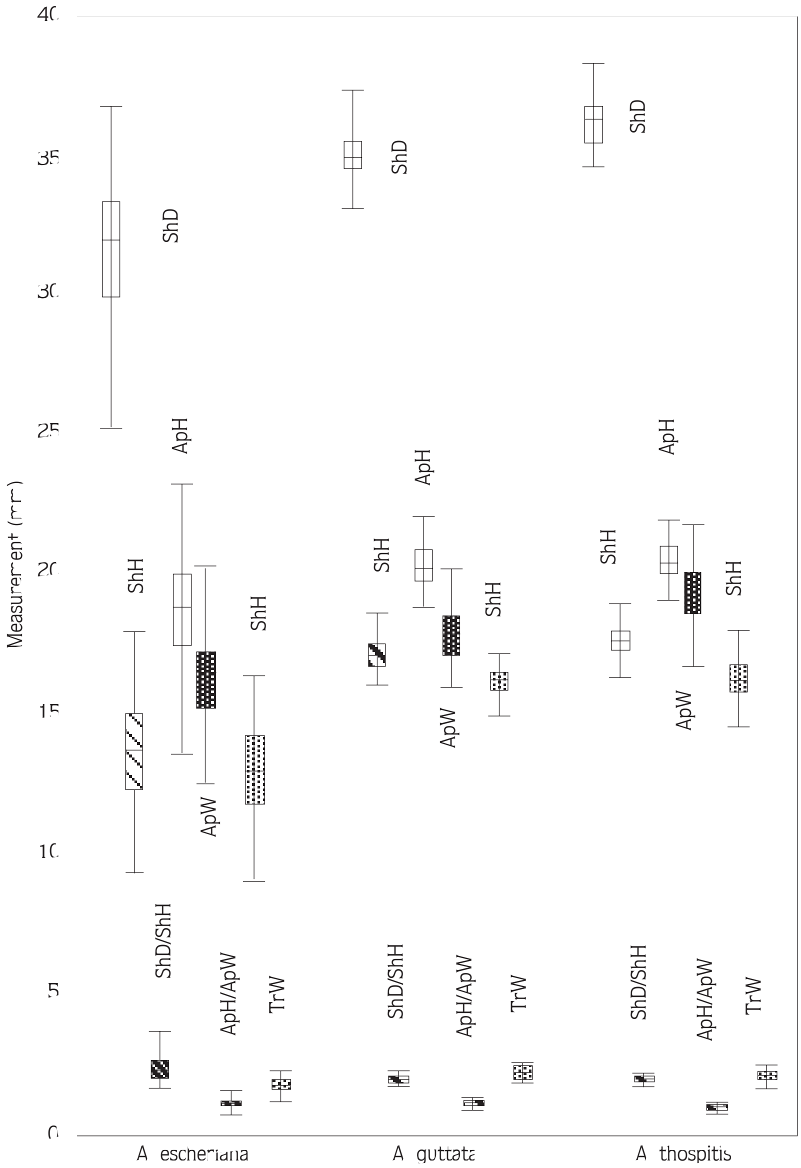

Figure 2. Multiple box plot of the measured variables by *Assyriella* species.

*For abbreviation see Table 1 and Figure 1.

Discussion

Ward's method with Euclidean distance based on these variables is the most appropriate hierarchical clustering method for these species (*A. escheriana, A. guttata, A. thospitis*) because it produces clusters at high similarity level and the obtained clusters are in accord with the classification determined by the traditional method (See Figure 2 and Table 2).

Clusters I, II and III were constituated at an 87.5 % similarity level by Ward's method. Cluster I, which includes specimens of *A. escheriana,* is clearly differentiated from Clusters II and III, which include *A. thospitis* and *A. guttata* respectively. However, some specimens, which were originally described as *A. thospitis* or *A. guttata,* fall into the same clusters. So there may be an evolutionarily close relationship between *A. guttata* and *A. thospitis* rather than *A. escheriana* (See Figure 3).

In the case of a similarity level greater than 87.5 %, Cluster I is segregrated into 2 sub- clusters. This result is interpreted as *A. escheriana* possibly comprising 2 varieties. The impression of 2 varieties may be considered a subject for new research (Figure 3).

Table 3. Raw coefficients and constants for Canonical Variables.*

Variable	CV1	CV2		
ShD	0.0693	0.3505		
ShH	-1.2464	-0.3207		
ShD/ShH	-4.2137	-2.4573		
ApH	-0.5160	-1.4631		
ApW	0.1105	2.1397		
ApH/ApW	5.2743	24.8986		
SpH	-0.5799	-0.4077		
TrW	-1.1122	-1.5015		
Constant	40.3478	-29.2369		
	Explained variance (Eigen value)	Cumulative percent of explained variance	Chi-squre Statistics	P-level
	9.7390	0.9792	367.69125	0.00000
	0.2073	1.0000	27.03905	0.00033

*For abbreviation see Table 1 and Figure 1.
CV1: The first canonical variable, CV2: The second canonical variable

Table 4. Group classification functions and constants.*

Variable	*A. escheriana*	*A. guttata*	*A. thospitis*
ShD	-69.87	-70.52	-70.21
ShH	201.60	209.26	210.21
ShD/ShH	1080.85	1107.68	1109.38
ApH	-251.28	-247.20	-248.27
ApW	290.38	288.27	290.50
ApH/ApW	4344.68	4296.30	4318.04
SpH	27.85	31.59	31.74
TrW	25.53	33.19	32.70
Constant	-4291.02	-4504.24	-4580.43

*For abbreviation see Table 1 and Figure 1.

The discriminant analysis as illustrated by the point of CV1 to CV2 mainly shows 2 clusters; 1 consists of specimens originally classified as *A. escheriana* and the other includes specimens which were classified as *A. thospitis* and *A. guttata*. The latter cluster seems to consist of 2 subclusters: 1 mainly consists of *A. guttata* and the other subcluster mainly includes *A. thospitis* (See Figure 4).

Table 5. Observed classification (rows) against predicted (columns).

Species	Percent of Correct Classification	*A. escheriana*	*A. guttata*	*A. thospitis*
A. escheriana	98	49	1	0
A. guttata	84	0	42	8
A. thospitis	84	0	8	42
Total	88.66	49	51	50

Table 6. Canonical loadings in decreasing importance.*

Variable	CV1	Variable	CV2
SpH	-0.493313	ApW	0.686959
ShH	-0.480596	TrW	-0.407456
ShD	-0.346135	ApH/ApW	-0.396973
TrW	-0.311651	SpH	-0.386501
ApW	-0.275063	ShD	0.320868
ApH	-0.201802	ShD/ShH	0.187056
ShD/ShH	0.187102	ApH	0.024679
ApH/ApW	0.051266	ShH	-0.018809

*For abbreviation see Table 1 and Figure 1.

Figure 4 reveals that CV1 essentially serves to distinguish *A. escheriana* from *A. guttata* and *A. thospitis*, while *A. guttata* and *A. thospitis* are differentiated by CV2.

In the present study based on shell morphology, *A. escheriana* can be clearly differentiated from *A. thospitis* and *A. guttata* although the variability of the canonical scores of *A. escheriana* was greater than that of *A. thospitis* and *A. guttata*. On the other hand, the convergence of the canonical scores of *A. thospitis* and *A. guttata* support the idea that these two species may have a close evolutionary relationship (See Figure 4).

Group classification functions are used to determine to which group a new specimen most likely belongs. One

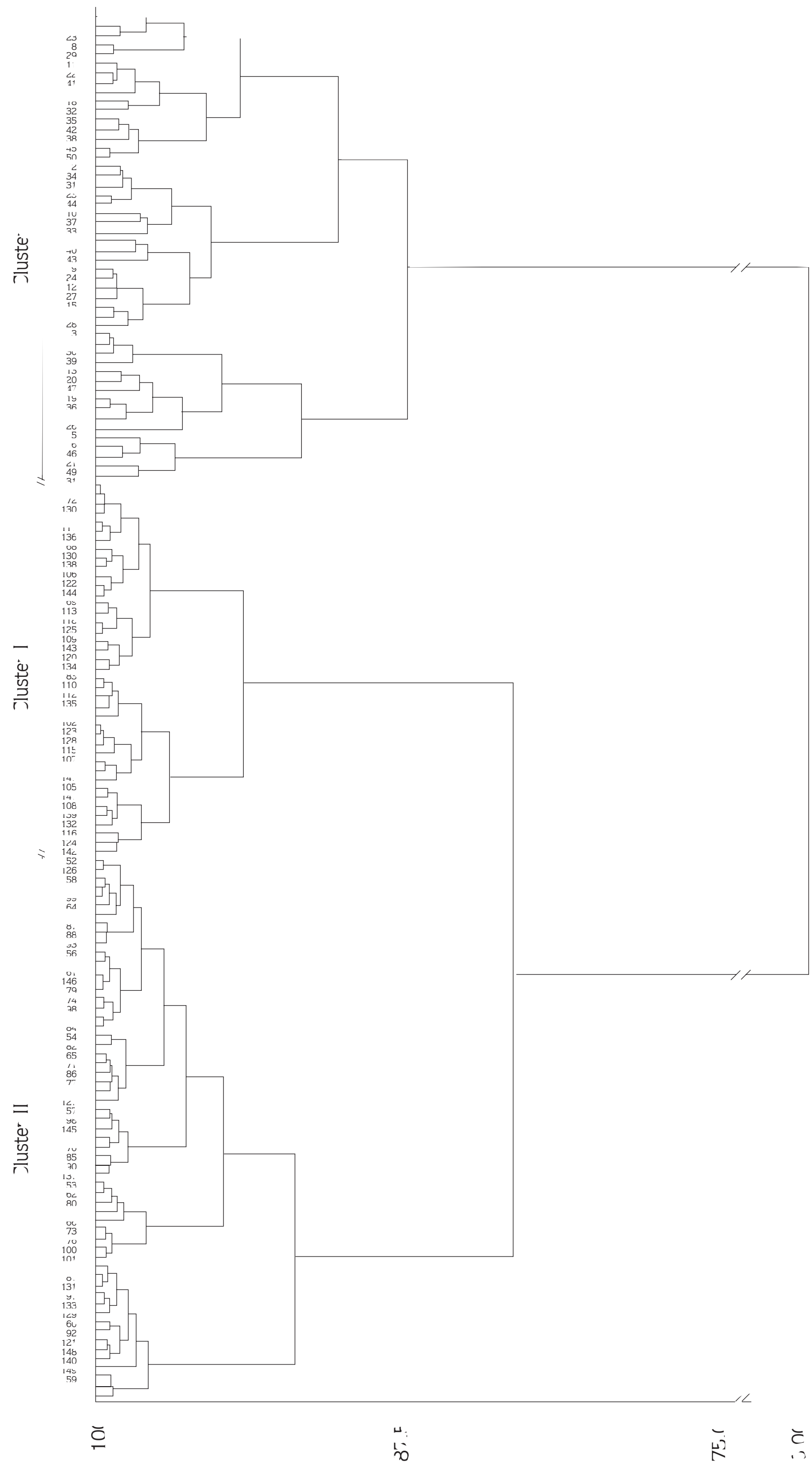

Figure 3. Dendrogram obtained by Ward's method

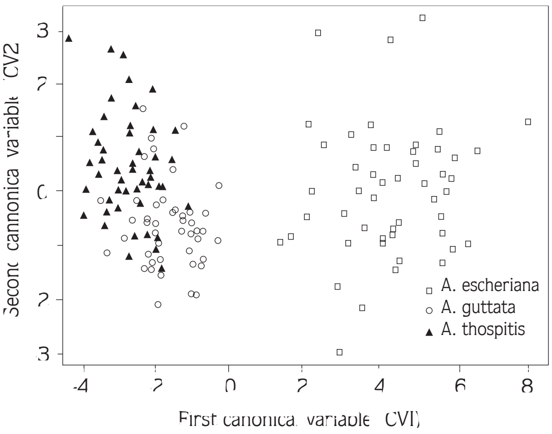

Figure 4. The scatter plot of CV1 by CV2

can apply these functions to new data and assign each case to the group with the largest function value for that case. These functions given in Table 4 were applied to the data matrix (Table 2) to see how these assignments work for our specimens. The results of this operation are given in Table 5. The largest percentage of specimens used in the present study were predicted correctly by group classification functions. We hope that the methods tried here on a limited number of individuals will be equally successful when further material is examined.

The order of importance of the characteristics (variables) for discriminating these species is shown in Table 6 in decreasing importance. SpH, ShH, ShD and TrW are most differentiating characters for *A. escheriana* from *A. thospitis* and *A. guttata*. The 4 most differentiating characters between *A. guttata* and *A. thospitis* are ApW, TrW, ApH / ApW and SpH in decreasing importance.

Consequently, the results of this study show that more precise identification can be made in the classification of *A. escheriana, A. thospitis* and *A. guttata* if the classical criteria are used together with the group classification functions.

References

1. Schütt, H., Landschnecken der Türkei. *Acta Biologica Benrodis Suppl.* 4, 482p., 1996.
2. Schütt, H. and Subai P., Revision der Gattung *Assyriella* P. HESSE 1908 (Gastropoda: Pulmonata: Helicidae: Helicinae. *Arch. Molluskenkunde*, 125: (1/2), 117-161, 1996.
3. Agüloğlu, B., Balcı K., The shell features of *Assyriella guttata* and *Asyyriela escheriana* and comparative anatomy of their reproduction systems. *Proceedings of XII. National Biology Congress*, 6-8 July, 40-46, Edirne / Turkey, 1994.
4. Tukey, J. W., *Expletory Data Analysis*, Reading Mass Addison-Wesley, 1977.
5. Velleman, P.F. and Hoalgin, D.C., *Applications Basics and Computing of Expletory Data Analysis*, Boston: Duxbury Press.,1981.
6. McGill, R., Tukey, J.W., and Larsen, W.A., Variations of Box Plots, *The American Statistician*, 32: 12-16, 1978.
7. Hamilton, L.C., *Modern Data Analysis*: A first course in applied statistics, Brooks / Cole Publishing Comp., California, 1990.
8. Sneath, P.H.A. and Sokal, R.R., *Numerical Taxonomy*, W.H. Freeman and Company, San Francisco, 1973.
9. Hartigan, J.A., *Clustering Algorithms*, New York, Wiley and Sons Inc., 1975.
10. Abbot, L.A., Bisby, A.F. and Rogers, D.J., *Taxonomic Analysis in Biology*, Colombia Univ. Press, New York, 1985.
11. Everith,B., *Cluster Analysis*, Reineman Educational Book Ltd., London, 1974.
12. Fisher, R.A., The use of multiple measurements in taxonomic problems, *Ann. Eugenics*, 7: 179-188, 1936.
13. Mahalanobis, P.C., On the generalised distance in statistics, *Proceedings of the Natural Institute of Science of India*, 12: 49-55, 1936.
14. Hotelling, H., The generalisation of Student's ratio, *Ann. Math. Statist.* 2: 360-378, 1931.
15. Chatfield, C. and Colins, A.J., *Introduction to the Multivariate analyses*, Chapman and Hall, London, New York, 1980.
16. Johnson, R.A. and Wichern, D.W., *Applied Multivariate Statistical Analysis*, Third Edition, Prentice-Hall, Inc., A Simon and Schuster Company, Englewood Cliffs, NJ 07632, 1992.
17. Akbayın, H., Demir, R., and Ertekin, A.S., Solution of some taxonomic problems in *Medicago rigudula* (L.) All. Varieties by using discriminant analysis technique, *Tr. J. Of Botany* 18: 481-488, 1994.
18. Togan, I., Aydem, N. and Kence, A., A Numerical Taxonomic Study on *Carthamus* L. Taxa in Turkey, NATO ASI series, GI, 1983.
19. Özbay, C. and Akbayın, H., A Numerical taxonomic Study of Vespidae (Hymenoptera) Species from South-East Anatolia in Turkey., *Tr. J. Of Biology*, 21: 189-196, 1997.

20. Kristensen, T.K., Christensen, A.G., *Bulinus africanus*- Group species in West Africa Differentiated by Morphometric Analysis (Gastropada, Planorbidae). J. *Moll. Stud*. 55: 103 – 110, 1989.

21. Mukaratirwa, S, Kristensen T.K., Siegismund, H.R., Chandiwana, S.K., Genetic and morphological variation of populations belonging to the *Bulinus truncatus* Tropicus complex (Gastropoda: Planorbidae) in southwestern Zimbabwe. *J. Moll. Stud.* 64: 435-446, 1998.

22. Statistica, Statistica for Windows Computer Program manual, Tulsa OK: StatSoft Inc., 1995.

23. Ward, J.H., Hierarchical grouping to optimize an objective function., *J. Am. Statist. Ass*, 58: 236-244, 1936.