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BEETLE TAXONOMY—WHERE SUBJECTIVITY AND OBJECTIVITY MEET

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The data recorded on eight taxa of Bruchidae have been used to prove that the concepts of subjectivity and objectivity meet at a point where taxonomist uses his strong intutive power.

INTRODUCTION

For achieving objectivity, many coding and scaling methods for taxonomic characters have been described, yet none of these can be exclusively recommended as the Numerical Taxonomists lack good ways of checking phenetic resemblance on internal criteria (Sneath and Sokal, 1973). The present authors believe that if the end products of objectivity as well as subjectivity in taxonomy are compared, there may be a point "strong intutive power", where both the approaches meet. For this we started from an arbitrary coding to standardization and then using median values of the characters to delcniate the two states of '+' and '—'. It may be pointed out that the median values have not been reported earlier for this use. The results achieved have been depicted in the form of phenograms given in results and discussion.

This study envisages the six determined taxa (OTUs), namely *Caryedon opacus* Arora (I), *Caryedon prosopisus* Arora (II), *Caryedon accaciae* (Gyll.) (III), *Bruchidius angustifrons* Schilsky (IV), *Callosobruchus maculatus* (F.) (V), *Callosobruchus chinensis* (L.) (VI) and two unidentified taxa *Caryedon* sp., (VII), *Caryedon sp.* (*VIII*)

MATERIALS AND METHODS

Our OTU (Operational Taxonomic Unit) was a nominal species and each species was represented by five individuals of both sexes. Average of 5 specimens was considered a character state.

These adults were preserved in 70% alcohol and permanent mounts were prepared by the routine method of clearing, dehydrating, fixing and mounting. Measurements were made with an ocular micrometer. Seventy characters,

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Table 1. *Characters, morphometry and coding in different taxa of Bruchidae.*

Characters	Descriptions and measurements (in microns) of characters								
	I	II	III	IX	V	VI	VII	VIII	Coding for
Head:									
1. Length	1376	1247	1282	985	1113	1327	1317	1270	above 1150+
2. Width in front of eyes	423	472	386	362	?	467	?	?	above 400+
3. Width across eyes	1141	1129	1088	931	906	1025	?	?	discarded+
4. Interocular distance	271	282	285	196	209	392	268	309	above 250+
5. Head width[behind eyes at constriction]	655	540	639	589	564	644	?	?	above 600+
6. Head width behind constriction	741	725	694	655	643	760	711	725	above 700+
Antenna:									
7. Length of scape	393	327	301	177	206	258	336	332	above 300+
8. Length of pedicel	181	153	152	`89	113	137	161	161	above 150+
9. Length of terminal segment of flagellum	413	336	365	344	297	386	349	362	above 300+
Maxillary Palpus:									
10. Length of sub-terminal segment	153	129	112	59	79	83	121	121	above 100+
11. Length of terminal segment	282	263	216	150	174	193	228	255	above 250+

Prothorax:										
12.	Diameter of anterior foramen	668	654	544	564	595	721	612	612	above 600+
13.	Length of prosternal spine	235	188	201	208	329	339	?	?	above 250+
14.	Length of notum	932	885	794	761	690	575	1082	1035	above 700+
15.	Maximum width	1703	1581	1508	1203	1637	1623	1600	1459	above 1500+
16.	Length along left edge	969	922	843	728	783	781	?	?	discarded
Pterothorax:										
17.	Length of base of sternal apodeme	423	330	310	317	392	518	322	402	above 350+
18.	Length of arm of sternal apodeme	507	618	450	550	589	679	537	537	above 550+
19.	Angle between the two arms of sternal apodeme	obtuse	obtuse	right	acute	acute	acute	obtuse	obtuse	above right+
Scutellum:										
20.	Width at posterior	119	104	94	118	139	148	107	?	above 120+
21.	Width at anterior	547	524	483	376	453	379	?	?	discarded
22.	Shape of scutellum	squarish	quadrangular	rectangular	quadrangular	quadrangular	squarish	?	?	discarded
Forewing:										
23.	Length	3294	3369	3256	1938	2164	2465	3341	3341	above 3000+
24.	Width	1388	1252	1148	909	1139	1242	1223	1223	above 1200+

Proleg:										
25.	Length of coxa	506	424	393	392	590	594	429	416	above 400+
26.	Length of femur	1170	1050	1007	660	983	1090	993	993	above 1050+
27.	Length of tibia	1153	1046	964	682	953	996	939	780	above 1000+
28.	Length of tarsus	753	700	725	574	668	700	738	725	above 700+
Mesoleg:										
29.	Length of coxa	513	448	442	352	495	510	470	470	above 450+
30.	Length of femur	1242	1114	1013	738	1154	1060	1007	1141	above 1100+
31.	Length of tibia	1167	1020	936	768	1059	1125	1074	1047	above 1000+
32.	Tibial spine towards distal end	present	present	present	absent	present	absent	present	present	presence+
33.	Length of first tarsal segment	334	275	266	312	413	406	268	268	above 350+
34.	Length of second tarsal segment	182	171	153	138	201	195	175	174	discarded
Metaleg:										
35.	Length of femur	2089	1816	1727	1010	1430	1477	1882	1835	above 1500+
36.	Width of femur	1039	907	827	303	528	555	926	889	above 600+
37.	Presence of femoral spine	present	present	present	absent	present	present	present	present	presence+
38.	Length of tibia	1069	1383	1364	819	1170	1176	1459	1317	above 1200+
39.	Length of tibial distal spine	204	204	215	121	347	325	228	228	above 250+
40.	Width of tibia at proximal end	174	153	146	64	136	137	148	161	above 100+
41.	Width of tibia at distal end	178	172	160	172	330	336	161	228	above 200+

42.	Length of first tarsal segment	537	359	451	448	841	869	470	510	above 600 +
43.	Shape of first tarsal segment	straight	straight	straight	curved	curved	curved	straight	straight	non-curved +
Abdomen:										
44.	Length of first segment	?	?	471	644	756	766	?	?	discarded
45.	Length of base of fork	414	339	392	309	397	432	332	?	above 350+
46.	Breadth at diverging point	141	151	150	164	260	330	?	?	above 200+
47.	Length of arm of fork	1233	1092	974	682	872	942	1007	?	above 1000+
48.	Length of pygidium	1157	1063	1028	1073	1297	1440	993	1074	above 1100 +
Miscellaneous:										
50.	Length of phallus	1250	1430	1490	1116	1570	1730	?	?	above 1450 +
51.	Chromosome number (2n)	18	20	18	20–22	19–20	19–20	?	?	above 18 +
52.	Colour of head	dark brown	dark brown	dark brown	black	black	both	dark brown	dark brown	discarded
53.	Antennal colour	dark brown	testaceous	reddish brown	testaceous	variable	dark brown	dark brown	dark brown	non-testaceous +
54.	Colour of setae on pronotum	pale	pale yellow	pale	pale yellow	pale	light brown	light brown	light brown	non-pale +
55.	Tip of scutellum	curved	curved	curved	bifid	curved	curved	curved	curved	without cut +
56.	Colour of setae on scutellum	pale	?	pale	pale	white	white	?	?	non-white +
57.	Abdominal fork : shape with ventral portion of the first segment	circular	circular	circular	angular	angular	angular	circular	circular	non-angular +

58.	Parameres	fused	fused	fused	fused	free	free	?	?	free+
59.	Exophalic valve	acuminate	triangular	triangular	triangular	conical	acuminate	?	?	non-conical+
60.	Spermathecal lobes	different	?	different	equal	subequal	different	?	?	different+
61.	Host range	polyphagous	monophagous	monophagous	monophagous	polyphagous	polyphagous	monophagous	monophagous	polyphagous+
62.	Number of generations	multivoltine	multivoltine	multivoltine	univoltine	multivoltine	multivoltine	multivoltine	multivoltine	multivoltine+
63.	Place of attack on seeds	field	field	field	field	store	store	field	field	store+
64.	Frequency of mating of males to virgin females	polygamous	polygamous	polygamous	monogamous	polygamous	polygamous	polygamous	polygamous	polygamy+
Larva:										
65.	Sensory satae on clypeus	present	present	present	present	absent	present	present	present	presence+
66.	Number of ocelli	3 pairs	3 pairs	3 pairs	1 pair	1 pair	1 pair	3 pairs	3 pairs	above 1 pair+
67.	Shape of labrum	oval	rectangular	rectangular	spindle shape	oval	subconical	?	?	non oval+
68.	Number of truncated processes on distal end of mala	5	5	5	5	5	6	5	5	above 5+
69.	Thoracic annuli	1,2,2	1,2,2	1,2,2	1,2,2	3,2,2	3,2,3	1,2,2	1,2,2	above 1,2,2+
70.	Annulus on eighth abdominal segment	absent	absent	absent	present	absent	absent	absent	absent	presence+

both qualitative and quantitative were recorded of all the OTUs under study (Table 1). A few of these were discarded on account of their ambiguous nature and only sixty were left out. These characters were coded dichotomously as under:

(i) In each row, wherever there was a wider gap between two individual measurements, a point was fixed arbitrarily and individuals having measurements above this point were termed '+', and the remaining ones '—'.

(ii) Characters were standardized using the relation $x-\bar{x}/S.D.$ where x is the character's value, $\bar{x}$ is mean and S.D. standard deviation of the row (Sokal and Sneath, 1963). All scores above 0 were called '+' and all values '0' or below '0' were coded as '—'.

(iii) The eight values in a row were arranged in an ascending or decending order, and the average of the two values in the centre of row was considered the limit between '+' and '—' states. Values above median were coded as '+' and the remaining ones as '—'. In rows where the observations were in odd number, central value was used as a limit.

The qualitative characters in all the three methods were coded as dichotomous.

Similarity matrices (Tables 2—4) for the above three coding methods were prepared using the coefficient of Simple Matching (Sokal and Michner, 1958). The relation for this association measure is:

$$S_{SM} = m/n$$

Where m are the positively + negatively matched pairs and n the total number of characters used.

To represent results, three phenograms (Figs. 1—3) were generated by the method provided by Hashmi and employed by Chaudhry (1974, unpublished) and Khokhar (1976, unpublished). This method is reproduced as under:

Similarity Matrix of 5 species

OTUs	A	B	C	D	E
A	x				
B	16	x			
C	83	29	x		
D	66	19	52	x	
E	44	37	52	76	x

(a) Assume a hypothetical similarity matrix of 5 species of a genus as depicted above.

(b) To construct the phenogram proceed as under:

(i) link the pair of taxa with the highest phenetic similarity (i.e. 'A', 'C', 83%).

(ii) determine the second highest similarity. This could be a single taxon on the 'A—C' pair or between 2 single taxon. To calculate the similarity between a single taxon and a linked pair, determine the average. For example, the average similarity of 'B' to the pair 'A—C' is 22.5%. For the similarity matrix above, the second highest correlation is between 'D' and 'E' (76%).

(iii) determine the third highest linkage. You will have to consider the similarity between pairs, i.e. 'A—C' and 'D—E' and between the single taxon 'B' and the linked pair.

To compute the similarity between pairs, average all four pertinent values. For example the 'A—C' to 'D—E' similarity is the average of 66%, 52%, 44% and 52% which is equal to 53.5%. This is the third linkage for the matrix illustrated.

(iv) determine at what level 'B' is linked to the 'A—C—D—E' group by averaging the remaining values '16%, 29%, 19% and 37%=25.25%).

For the similarity matrix illustrated, the phenogram given below would be generated.

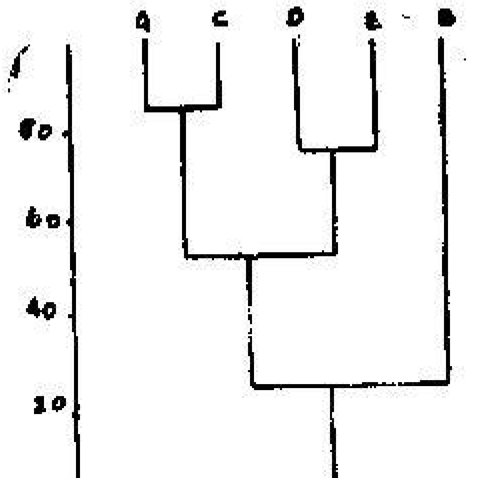

Table 2. *Similarity matrix based on arbitrarily coded characters*

OTUs	I	II	III	IV	V	VI	VII	VIII
I	xx							
II	.74	xx						
III	.66	.72	xx					
IV	.31	.44	.55	xx				
V	.33	.27	.33	.45	xx			
VI	.45	.37	.30	.41	.75	xx		
VII	.78	.78	.78	.34	.34	.40	xx	
VIII	.85	.77	.73	.30	.36	.42	.89	xx

Table 3. *Similarity matrix based on standardised character states*

OTUs	I	II	III	IV	V	VI	VII	VIII
I	xx							
II	.70	xx						
III	.63	.70	xx					
IV	.26	.50	.56	xx				
V	.31	.34	.31	.51	xx			
VI	.40	.34	.36	.43	.75	xx		
VII	.65	.71	.80	.50	.34	.26	xx	
VIII	.69	.71	.69	.40	.34	.28	.81	xx

Table 4. *Similarity matrix based on median character states*

OTUs	I	II	III	IV	V	VI	VII	VIII
I	xx							
II	.60	xx						
III	.46	.62	xx					
IV	.20	.50	.58	xx				
V	.60	.27	.36	.55	xx			
VI	.48	.30	.48	.46	.73	xx		
VII	.61	.69	.57	.36	.32	.25	xx	
VIII	.67	.71	.53	.26	.32	.30	.75	xx

RESULTS AND DISCUSSION

In this study as many characters were picked up as possible from the included taxa and then the element of subjectivity was introduced by arbitrarily coding the various characters by keeping in view the gaps in the magnitude of quantitative characters and the state of qualitative characters.

To eliminate the variance in the sampling of character, the process of standardization was carried out. This approach also helped to eliminate subjectivity and introduce objectivity. Likewise use of median values was intended to introduce objectivity in achieving the results.

The phenogram generated by these three coding methods are presented in figures 1, 2 and 3 respectively. Surprisingly, there isn't much of a difference in these figures. It may safely be concluded that if a researcher takes taxonomic decision after studying all aspects of organism, it may be as good a decision as by someone who records all the available information about the organisms and then derives a conclusion from the data or to put it in simple words, the experience and thorough going study of a taxonomist helps him to get the similar results both by subjective as well as objective methods.

The element of subjectivity and objectivity could thus be considered as terms associated with immature and mature classifications respectively. For instance, if a classification is based only on a few specimens and has had no statistical consideration, the results achieved are definitely going to be subjective. On the other hand if a classification has taken into consideration all aspects of the organism, and then scanned out one or two characters, the classification is going to be as good as the one based on many characters (objective). In sum, behind the current use of subjective and objective methodologies is hidden the weakness or the strength of intutive power of a scientist for decision making. The intutive power when strong enough and reflected in the arbitrary coding (subjectivity), will still yield results which are likely to be obtained through the objective approach; that is, using statistical methods as advocated by Numerical Taxonomists. And, this has been demonstrated quite explicitly in the present study of the beetles by the identical shape of the three phenograms.

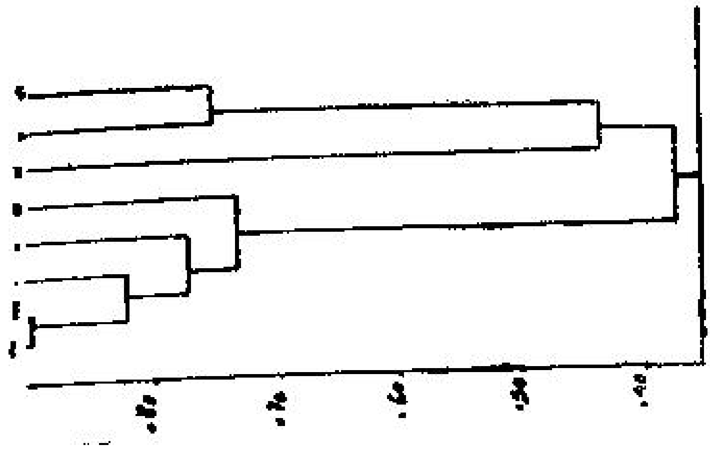

FIG. 1. PHENOGRAM BASED ON UNWEIGHTED [illegible] CHARACTERS.

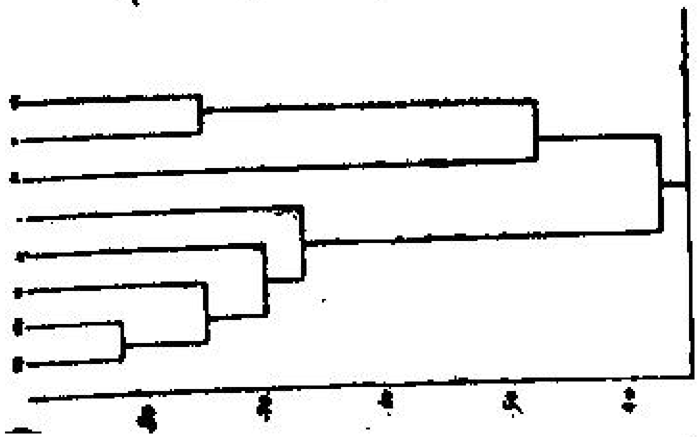

FIG. 2. PHENOGRAM BASED ON STANDARDISED CHARACTERS.

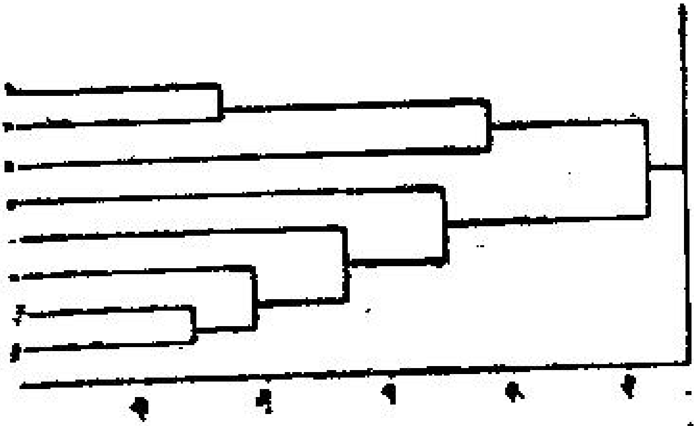

FIG. 3. PHENOGRAM BASED ON CHARACTER [illegible] BASED ON MEDIAN VALUES

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