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Application of Colorimetric Techniques to the Taxonomy of *Podarcis pityusensis*

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INTRODUCTION

External colour as a taxonomic feature has been frequently used, but the designation and description of colours is subjective and often biased, making comparison between samples impracticable, even with the help of such standard tables as the Munsell System.

A more precise method of designation, quantification and statistical analysis of animal colours is proposed here. As a test species, we have chosen Podarcis pityusensis. The first described subspecies of this animal /P. p. maluquerorum/ was separated from the nominate subspecies only by its very dark colour.

More than 50 subspecies, many of them invalid, have been described since then /Mertens and Wermuth, 1960/ and in several instances, external colours were chosen as diagnostic criteria. These colours differ greatly. Beside melanic forms, there are others with plain grey backs, or striped, spotted or reticulate designs. Colours may be green, lemon blue, orange, reddish, blackish or withish, brown or dull.

Table 1.

STUDIED SAMPLES		
Location	♂	♀
Torretes	4	1
Espardell(a)	5	4
Espardell(b)	2	2
Ibiza (a)	4	7
Ibiza (b)	1	5
Ibiza (c)	2	4
Trocadors	2	4
Caldés	1	3
Espalmador	-	2
Gastabí	-	2
Pou	4	5
Frare	3	3
Vedrà	4	2
Negra Nord	4	4
Bleda plana	4	2
Penjats	4	3
Alga	3	-
Espartar	4	3
Murada	2	5
TOTAL	53	65

MATERIALS AND METHODS

The material consisted of 130 specimens of P. pityusensis from different localities of Ibiza and neighbouring islands /Tab. 1/. The material was sufficiently diverse, although not all populations have been covered. Twelve young specimens, whose data are included only in some joint analyses, were additionally measured.

In each living animal, average colour over an area was measured on the dorsal and ventral surfaces of the body, sometimes also the side, using a reflection photometer /Spectra-Prichard model 1980/ with a standard illuminant /northern sky natural light/. Every measurement gave values for each of the three variables: clarity, chroma and tone. Colour in a tridimensional space may be thus defined following the standard criteria /I.C.I., /1978/.

RESULTS

Mean values

Mean values and standard deviations for clarity and chroma were calculated for every sample and also for joint samples of all male and female backs and bellies and other possible combinations /Tab. 2/. For tone, means were calculated by vectorial summation /Fig. 1/, and deviations by the formula of Gaile and Burt /1980/.

Table 2.

STATISTICAL VALUES	BACK ♂	BACK ♀	BELLY ♂	BELLY ♀	SIDE ♂	SIDE ♀
L						
x	36.91	39.44	64.15	65.66	44.78	42.50
s	7.22	9.40	12.52	12.18	6.99	6.97
N	50	62	54	66	15	6
C						
x	11.76	12.47	17.61	17.71	13.05	8.48
s	5.92	6.58	7.39	7.79	4.91	3.85
N	50	63	55	65	17	7
T						
x	92.84	87.11	104.58	119.20	75.22	96.09
s	1.01	0.9	1.46	1.25	0.79	1.45
Mod	0.60	0.67	0.34	0.46	0.73	0.35
N	50	62	55	64	17	7

Joint comparisons

The three variables have been compared in joint male and female back and belly samples /Tab. 3/. For clarity and chroma, the Student test was performed, while the comparison for tone was done graphically /Batschelet, 1981/ relying on the superimposition of confidence ranges of directional means.

For clarity, we found sharp differences between backs and bellies. Similarly for chroma, although only in males. In all instances, bellies are paler and more chromatic than backs or sides.

Table 3.

TEST OF DIFFERENCES BETWEEN JOINT SAMPLES	CLARITY t	CLARITY %	CHROMA t	CHROMA %
BACK♂-BACK♀	0.887		1.207	
BELLY♂-BELLY♀	0.667		0.733	
SIDE♂- SIDE♀	0.676		1.642	
BACK♂-SIDE♂	1.078		0.362	
BACK♂-BELLY♂	13.716	99.99	3.849	99.9
SIDE♂ -BELLY♂	5.720	99.99	3.355	99.0
BACK♀ -SIDE♀	0.77		1.150	
BACK♀ -BELLY♀	16.405	99.99	1.749	
SIDE♀ -BELLY♀	4.57	99.0	0.388	
BACK♂♀-SIDE♂♀	4.24	99.9	0.802	
BACK♂♀-BELLY♂♀	20.951	99.99	3.825	99.9
SIDE♂♀-BELLY♂♀	7.53	99.9	2.544	99.0

In the case of tone, no significant differences were found in any comparison but one: the bellies of females were on average greenish, while the backs of juveniles were orange, but this is of no importance.

Classification

Multivariate classification of samples was carried out and resultant dendrograms prepared /Fig. 2/. The chosen algorythm in the program was the unweighted stepwise centroid joining /Sneath and Sokal, 1973/ and the required Euclidean distances were obtained previously using another program, both written and implemented by us. The resultant distance matrices and several of the dendrograms obtained are not included in this preliminary paper and are similar to the dendrogram in Fig. 2. Differences are due mainly to small sample sizes.

Three population groups can be separated at a low level of similarity /D = 13/. The first includes mainly melanic populations, or forms with a dark reticulation on the back, the second is formed by populations with low back chromatism, and with darkened reddish tones, and the last group includes four rather more chromatic populations with yellowish components in the tones of the back.

At greater similarity /D = 7.5/, there are nine groups, not always easy to discriminate visually: 1: Formentera-Frare, melanic; 2: Vedra, with yellow reticulation in the back; 3: Murada, melanic with purple components; 4: Bleda Pana, melanic and achromatic;

3: Espartar-Gastabí, light brown with reddish components; 6: Penjats-Ibiza /c/ - Negra Nord, light brown with yellowish components; 7: Trocadors, light grey; 8: Ibiza /a/ - Espalmador, brown-yellow; 9: Ibiza /b/, lemon yellow, very chromatic.

DISCUSSION AND CONCLUSIONS

The following conclusions can be made from these preliminary results:

/a/ Use of colorimetric techniques in animal taxonomy is an excellent research tool, although somewhat difficult to manage. It can be applied to the majority of animal groups and therefore is of general interest to zoologists.

/b/ Subjective descriptions of animal colours do not correspond, in general, to photometric data, because human eye perceptions are biased by surrounding colours.

/c/ Colorimetric measurements may also be biased, because the same average colour can result from several different pairs. The human eye can thus perceive colour differences where the colorimeter does not.

/d/ As predators seem to perceive average colours, the photometric values may have more ecological importance than visual ones. This perhaps explains the overal similarity of colour in all samples.

/e/ In Podarcis pityusensis, backs and sides are darker than bellies. This could be related to thermoregulation and cryptic adaptation.

/f/ Contrary to visual perception, the colours of P. pityusensis are dull as the dorsal black reticulation lowers the chromatic level. Colours are mainly orange to green, although some populations have blue tones.

/g/ The male sides are significantly more chromatic than those of females. This appears to be related to sexual display.

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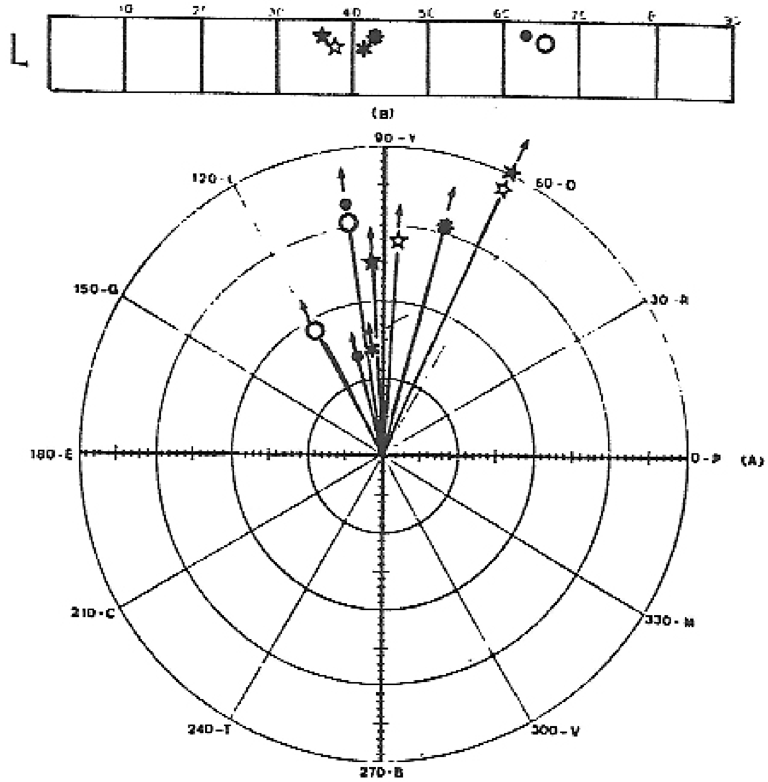
1



2

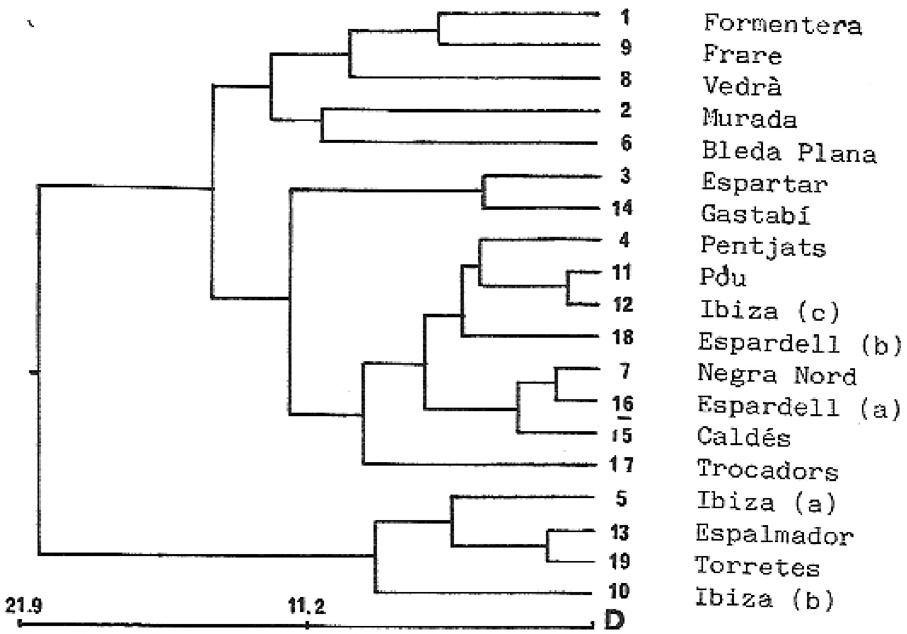


Fig. 1: Joint clarity means /above/ and mean tone vectors /below/. ★ male backs; ☆ female backs; ● male bellies; O female bellies; ✸ male sides; ✳ female sides; ☆★ young backs; O● young bellies. Fig. 2: Distance dendrogram for colour variables of *Podarcis pityusensis* /female backs/.