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Biplot Graphic Display of Iberian and North African Populations of *Podarcis* (Sauria: Lacertidae)

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INTRODUCTION

Within the setting of a broad study on the systematic interelationships of the species of the Genus Podarcis /sensu Arnold, 1973/ in the Iberian Peninsula and North Africa /Perez-Mellado & Galindo, in prep./ numerous multivariate analyses have been carried out on the populations of these species. The aim of these analyses is to elucidate the differentiating characters and evaluate the described subspecies.

Other important purpose is to demonstrate a clear discrimination between P. hispanica, P. bocagei and P. muralis, for the whole of the study area and to elucidate those characteristics of major importance in such a discrimination.

METHODOLOGY

1315 adults specimens of both sexes from a total of 354 sites in the Iberian Peninsula, Morocco, Algiers and Tunisia were studied. Owing to the lack of space, the present work does not include the locality of these sites; a complete list of them and the number of individuals collected at each site may be found elsewhere /Perez-Mellado & Galindo, in prep./ Seventy nine variables corresponding to 17 multistate characters are considered /each of that variables is treated as a binary character in our analyses/:

1/ Pattern and colouring. Six characters are considered:

a/ Dorsal pattern (7 states), b/ vertebral zone pattern (4 states), c/ costal pattern (4), d/ Ventral zone pattern (6), e/ gular zone pattern (4), f/ pattern of submaxillary scales (4).

2/ Scales characters:

g/ relation between rostral and internasal scales (3 staters/, h/ size and arrangement of masseteric shield (6), i/ dorsals (6), j/ gulars (5), k/ ventrals (5), l/ femoral pores (4), m/ lamellae (4).

3/ Body proportions:
n/ SVL (4 states), o/ HH/WP index (ratio between height of head and width of the pileus) (5), p/ LP/WP index (ratio between length of the pileus and its width) (5), and q/ relative height of eye sockets (3).

The grouping into 5 sets of populations was derived from the previous application of the same multivariate techniques saparately to 16 populations of P. hispanica, 9 of P. muralis and 4 of P. bocagei /Perez-Mellado & Galindo, op. cit./.

Each of the populations was characterized by the frequency of the positive state of each variable. Populations and variables were represented as points on a two dimension scatter diagram /Golub & Reinsch, 1970/ for their later interpretation. The plotting technique employed was and HJ-Biplot /Galindo, 1985/ which is a variant of the biplot graphic display proposed by Gabriel /1971/. It has been shown theoretically /Galindo, op. cit./ that the quality of plotting both for populations and for variables, is very superior to that achieved with similar techniques. To make the equilibrium points of the two clouds /variables and populations/ coincide, the data were subjected to a double centering. The analysis was carried out in such a way that the discriminatory power of the variables would be a function of their relative variability.

RESULTS

MALES: As can be seen from Fig. 1 the eigenvalues are clearly separated: accordingly, both of the first two factors are well individualized and their interpretation is feasible. We interpreted the relative contributions of variables and populations to the inertia explained by each factor. For axis 1, the variables of greatest explicative power were, among others, No 25 /grey or black reticulated gular zone/, 29 /submaxillary scales with longitudinal lines/ and 13 /black reticulated costal zone on a brownish or green background/. We were also interested in discovering which elements deviate from the centre in the same direction of the axis since the interest of these lies in the fact that they represent more specifically the quality associated with the axis and are thus essential for interpretative purposes. Accordingly, the variables for which the relative contribution of factor 1 is greatest are: 25, 29 and 13, which already appeared previously with a high explicative power, 10 /a clearly visible vertebral line on the front or hind part of the back/, 45 /less than 21 gular scales/ and 8 /absence of vertebral line/. Thus, related with axis 1 appear two typical character states of P. hispanica /8 and 13/, and 4 typical of P. muralis corresponding to variables of design and certain scalation characteristics, such as the number of gular scales. Axis 11 discriminates the males between P. hispanica and P. bocagei. The variables with the greatest explicative power are in this case No 1 /uniform brownish back/ and 18 /rounded black ocelli situated on the centre of the outer ventral scales/. Apart from 1 and 18, another characteristic element of this axis is 72 (LP/WP index greater than 2.14), among others. Hence, in the males, the discrimination between the three species mainly takes place thanks to variables of design on the I-II plane, with a certain contribution by some scale characteristics and proportions.

FEMALES /Fig. 2/: Axis 1 separates P. muralis from P. hispanica and P. bocagei. The variables with high discriminant power with respect to axis 1 are 13, 8 and 25. Other factors contributing to discrimination are 65 /SVL greater than 59.1 mm./, 12 /uniform brownish costal zone/, 25, 29 and 11 /clearly visible vertebral line/. With respect to axis 11,18 [illegible]d 53 / [illegible]tralia between 28 and 31/, among others, are of high discriminant power.

In the case of both the males and the females, the position of the variables on the plane also reveals, apart from their importance in the discrimination, their degree of relationship with each of the three species, such that those variables close to a population correspond to character states which belong /though not exclusively so/ to that population.

The multidimensional studies conducted separately for each type of variable /i.e. pattern, scales and body proportions/ confirmed that the discriminating factors between the three species are mainly defined by pattern /see Perez-Mellado & Galindo, op. cit./, though the importance of such characters decreases slightly in the case of females in favour of others concerning scales and body proportions. The use of methodology described here also allowed us to elaborate a key to the determination and a more precise definition of the subspecies found in the Iberian Peninsula and North Africa.

It has been shown that discrimination between the three species occurs as a result of the linear combination of numerous variables which prevent a precise definition of any of the three forms by 1 or 2 exclusive characters, as is the case in the dichotomic keys.

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REFERENCES

ARNOLD, E. N. /1973/: Relationships of the Palearctic lizards assigned to the genera Lacerta, Algyroides and Psammodromus /Reptilia, Lacertidae/. - Bull. Brit. Mus. Nat. Hist. /Zool./, 25 : 289-366.

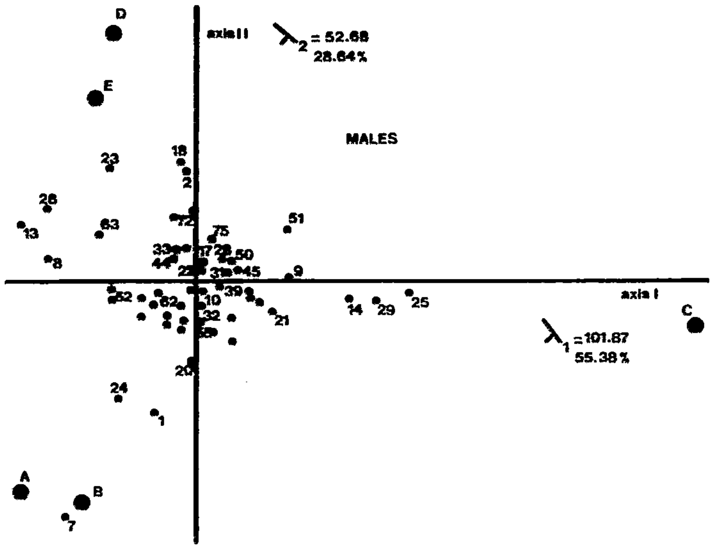
GABRIEL, K. R. /1971/: The biplot graphic display of matrices with application to principal components analysis. - Biometrika, 58 : 453-467.

GOLUB, G. H., REINSCH, C. /1970/: Singluar value descomposition and Least Squares Solutions. - Numer. Math., 14 : 403-420.

GALINDO, M. P. /1985/: Contribuciones a la representación simultánea de datos multidimensionales. - Tesis Doctoral. Univ. de Salamanca. /unpublished/.

PEREZ-MELLADO, V., GALINDO, M. P. /in prep./: Sistemática de Podarcis /Sauria, Lacertidae/ Ibéricas y norteafricanas mediante técnicas multidimensionales.

1



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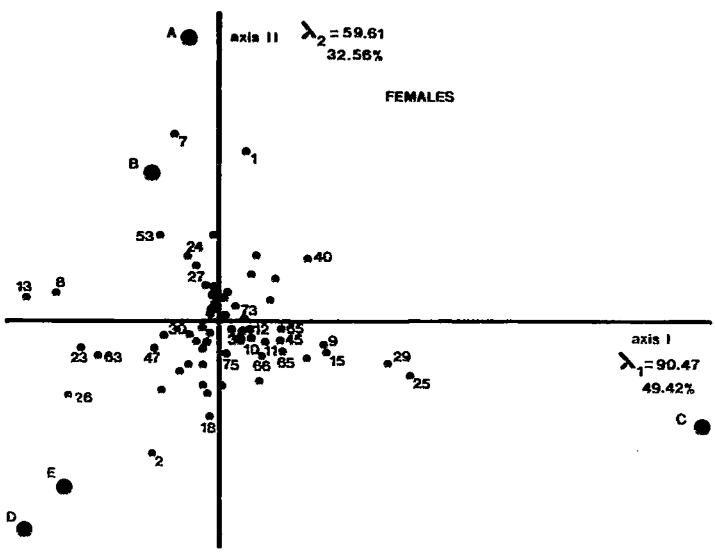

Fig. 1: Biplot graphic display of males. Projection of variables and populations on the first principal plane. A: P. bocagei from the Sistema Central.; B: P. bocagei from Galicia, Portugal and Cordillera Cantábrica.; C: P. muralis from the Iberian Peninsula; D: P. hispanica from the Iberian Peninsula, and E: P. hispanica from North Africa. Only the most important variables involved in the analysis have been plotted, both for its explanatory and/or discriminant power. We give also the eigenvalues /λ_1 and λ_2/ for each factor respectively and its percentage of absorbed variance. Fig. 2: Biplot graphic display of females.