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System of pleiotropic polygenes in the Cucurbitacea *Ecballium elaterium* (L.) Rich. related to durability and size of plant

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Summary. The statistical association between the characters "life durability of plant" and "size of plant" observed in a set of samples – cultivated forming a system of randomly balanced incomplete blocks – and corresponding to filial generations (pure, hybrid or backcross) from hybridization between the monoecious subspecies and the dioecious subspecies of the Cucurbitacea *Ecballium elaterium* (L.) Rich, respectively, is in concordance with the hypothesis that the system of polygenes governing the life durability of the plant in this species and the system of polygenes governing the size of the plants belong to the same system of polygenes. This system of pleiotropic polygenes governs the size and life durability of the plants at the same time.

Key words: Polygenes – Pleiotropy – *Ecballium* – Life durability

Introduction

Of the wild Mediterranean Cucurbitacea, *Ecballium elaterium* (L.) Rich., one monoecious [*E. elaterium* (L.) Rich ssp. *elaterium*] and a dioecious [*E. elaterium* (L.) Rich ssp. *dioicum* Battandier] subspecies grow in the Iberian Peninsula. In both subspecies, apart from the well-known genetic differences inherent in the sex of the plant (Galán 1946, 1951, 1954, 1964), another genetics, difference is the existence of two systems of polygenes: one system governs the life durability of the plant (González-Julián and Galán-Estella 1985) and the other governs the size of the plant and the number of inflorescenses (González-Julián and Galán-Estella 1988).

We studied whether the system of polygenes that governs the live durability of the individual plant and the system governing its size are, in fact, two different ones, or whether both are the same system of polygenes because all the genes are pleiotropic. The present study offers an analysis of the statistical association between the two characters – life durability and size of the plant – governed by the polygenes.

Materials and methods

The observational data used to perform the analysis of the statistical association between the life durability of the plants of *E. elaterium* and their size are the same as those (taken between 1975 and 1981) used in the study, for the same characters, and of heterosis in the hybridization between the monoecious and dioecious subspecies of *E. elaterium*, considering heterosis as experimental evidence of the presence of a system of polygenes.

During the flowering and fructification seasons, 2,840 artificial pollinations – corresponding to the experiments in hybridization between the monoecious and dioecious subspecies – were performed in the Laboratory of Biology, Faculty of Biology, Salamanca, which produced germinating seeds. The seedlings obtained in this way were transferred to individual clay pots. Between September and December of the 4th year of the life cycle, these plants were methodically arranged in a system of balanced, incomplete blocks (Fisher and Yates 1968) in the experimental field; each plant (from an initial total of 2,700) was given an area of 4 m^2.

These plants, which sum up the samples corresponding to filial generations (pure, hybrid or backcross) that can be discerned in the hybridization between the monoecious and dioecious subspecies of *E. elaterium*, were classified according to their parental affinities: (1) Sample "Pm" – with a total of 310 plants, defined as genuine plants of the monoecious subspecies. (2) Sample "Pd" – with a total of 188 plants, defined as the genuine plants of the dioecious subspecies. (3) Sample "F_1" – with a total of 186 plants, defined as the intersubspecific hybrids (between the monoecious and dioecious subspecies). (4) Sample "F_2" – with a total of 608 plants, defined as having as parents only individuals from the "F_1" sample. (5) Sample "R_2m" – with a total of 441 plants, defined by having as parents one individual from the "F_1" sample and the other from the "Pm" sample. (6) Sample "R_2d" – with a total of 473 plants, defined as having as parents one individual from the "F_1" sample and the other individual from the "Pd" sample.

The absolute frequencies of dead and surviving plants were obtained directly from these samples. We also obtained from them the values corresponding to the size of the plants. The size of each plant could be calculated on an approximate basis by measuring the volume of the aerial part of the plant. This was done as follows: we first observed that the branches of the plants in the ground form a more or less spherical (or ellipsoid) shape, in such a way that the apical ends of the branches contact the surface of the globe. We then considered, as easily measurable dimensions of this globe, its basic diameter (immediately above the ground) in the NS direction, its basic diameter in the EW direction and the vertical height of the plant. The volume thus obtained, as an approximate volume of the plant, is proportional to the product of multiplying the three dimensions (diameter NS × diameter EW × height). With these individual phenotypic data, a two-dimensional classification was performed, by the life durability and size of the plant, together with another dichotomous one, classifying the plants as dead or surviving and as small or large. In each of the groups of samples, we studied the statistical association between the two pairs of classes of plants. The defining terms were postulated in the following way: dead during 1978, surviving during the same year; less than 400 diameter cubed in size in 1977, more than 400 diameter cubed in that same year.

The choice of 1978 for computing the dead and surviving plants, and 1977 for measuring their size was to avoid results that, although correct, would be unsuitable for studying the statistical association. This would be the case in the first years of life of the plants, in which few die, and the last years of their life durability, in which there are few survivors.

Results

The results of the statistical association between the characters "life durability of plant" and "size of plant" for sample Pm, Pd, F_1, F_2, R_2m, R_2d are shown in synoptic form in the respective contingency tables (Tables 1–6) and appear numerically expressed as the corresponding χ^2 values at the bottom of the tables. The numbers in bold type express absolute frequencies and the numbers in italics, the expected frequencies.

According to the quantitative estimations provided by the χ^2 values (together with their levels of significance, P) for the statistical association, the results can be summarized in the following statement: There is positive statistical association between the classes of "dead" and of "less than 400 diameter cubed", on the one hand and, evidently, between "survivors" and of "more than 400 diameter cubed" in each of the six samples ("Pm", "Pd", "F_1", "F_2", "R_2m", "R_2d"). (This implies negative statistical association between "survivors" and of "less than 400 diameter cubed", on the one hand, and between "dead" and of "more than 400 diameter cubed", on the other.) This is because the values of P significance corresponding to the values of χ^2 are all less than 0.01, except one (the "Pd" sample that, although greater 0.01, is less than 0.02).

Table 1. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample Pm

Pm	Dead	Survivors	
Size of plant <400 dm³	**132** *123*	**139** *148*	271
Size of plant >400 dm³	**9** *18*	**30** *21*	39
	141	169	310

$\chi^2 = 8.5$; $0.01 < P < 0.001$; $Q = 0.52$

Table 2. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample Pd

Pd	Dead	Survivors	
Size of plant <400 dm³	**28** *22*	**98** *104*	126
Size of plant >400 dm³	**5** *11*	**57** *51*	62
	33	155	188

$\chi^2 = 5.95$; $0.02 < P < 0.01$; $Q = 0.53$

Table 3. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample F_1

F_1	Dead	Survivors	
Size of plant <400 dm³	**19** *11*	**46** *54*	65
Size of plant >400 dm³	**12** *20*	**109** *101*	121
	31	155	186

$\chi^2 = 10.80$; $0.01 < P < 0.001$; $Q = 0.58$

Table 4. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample F_2

F_2	Dead	Survivors	
Size of plant <400 dm³	**182** *164*	**239** *257*	421
Size of plant >400 dm³	**55** *73*	**132** *114*	187
	237	371	608

$\chi^2 = 10.50$; $0.01 < P < 0.001$; $Q = 0.29$

Table 5. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample R_2m

R_2m	Dead	Survivors	
Size of plant $<400\ dm^3$	**107** *92*	**158** *173*	265
Size of plant $>400\ dm^3$	**46** *61*	**130** *115*	176
	153	288	441

$\chi^2 = 9.37$; $0.01 < P < 0.001$; $Q = 0.31$

Table 6. Contingency table of statistical association between dead and surviving plants and sizes smaller or larger than 400 diameter cubed for sample R_2d

R_2d	Dead	Survivors	
Size of plant $<400\ dm^3$	**64** *45*	**189** *208*	253
Size of plant $>400\ dm^3$	**21** *40*	**199** *180*	220
	85	388	473

$\chi^2 = 20.77$; $P < 0.001$; $Q = 0.52$

Conclusions

In *Ecballium elaterium*, the polygene system governing the life durability of the individual plant and the system of polygenes governing the size of the same plant are not two completely different systems of polygenes, different due to the specificity of their action or observable phenotypic effect and also different owing to their independent genetic location. However, since the statistical association between the two characters is quantitatively large, as shown by the numerical values obtained for the association coefficient, Q, the experimental results obtained are in agreement with the hypothesis that it is only a single system of pleiotropic polygenes that governs both the life durability and the size of the plant. It is not possible to rule out the possibility that they may be two systems of polygenes specifically different in the phenotypic effect, although in regard to their genetic location, many of the polygenes belonging to one of the two systems might be strongly linked to many others belonging to the other system.

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