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Evolutionary Trends in *Vicia faba* L.

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Summary. 1. Distances have been calculated between thirty natural populations of *Vicia faba*.

2. The results strongly suggest the existence of a Central Nucleus from which different trends of evolution have arisen.

3. The Central Nucleus represents the equilibrium between different genetic tendencies; this equilibrium is postulated for the primitive populations of this species.

4. Disturbance of this balanced system can be produced by cycles of cross and self-fertilization; recombinations following these cycles are the origin of new genetic combinations so that a new equilibrium is reached with a new cycle of disturbance.

5. The Muratova classification is discussed. It is not possible to give a new classification based on these concepts, because of the great number of possible lines of evolution. The species must be considered as a whole, because there are no genetic barriers of isolation, only geographical ones and no sterility barriers have been produced between the subspecies.

6. A description of the Central Nucleus of Evolution is given.

Introduction

It is known that broad and field beans have been cultivated since prehistoric times, from India to the Western Mediterranean countries. They have also been cultivated in Central Europe and the British Isles. Except for the Indian ssp *paucijuga*, populations have not been isolated under natural conditions or by man. Man has taken this species from the original region to some countries, but partial allogamy depends on the indigenous populations: the new variety is "assimilated" more or less quickly by the native ones.

Thus, *Vicia faba* is good material for studying the evolution of differentiation where there is neither geographic nor reproductive isolation.

The taxonomy of *Vicia faba* has been specially studied by Muratova (1931), but nobody has worked on its development as a species. Recently, the existence of a strong central nucleus composed of the *major* and *equina* populations has been discussed (Cubero, 1970), *minor* and *paucijuga* being colateral branches directed in opposite directions in relation to the position of the nucleus. The present research was undertaken to try to understand the different evolutionary states of this species, that is, its evolutional history in its original region.

Material and Methods

Thirty natural populations of *Vicia faba* from several geographical points have been used for this study. Of these, fourteen are classified as *major*, twelve as *equina*, two as *minor* and another two as *paucijuga* (using MURATOVA taxonomy).

The origins of these populations are given in Table 1; the origins of the Spanish ones can be seen in Fig. 1.

Natural populations often consist of mixed botanical varieties. No selection was done, except that atypical seeds of each sample were eliminated. At the time of observation homogeneity or heterogeneity was recorded.

Seventeen characteristics have been studied (Table 2). Twelve were eliminated because they were strongly correlated with others (Table 3).

For the five characteristics (numbers 6, 7, 12, 14 and 15) selected, quadratic distances were obtained (Table 4) (Rao, 1952).

Results

The *equina* populations are very closely grouped together (Table 4), with minimal distances between them. Further, this group is the closest to the others; its central position is evident. Only strain 28 is not included in this group but, nevertheless, it lies near. *Minor* number 32 is quite integrated. The position of

Fig. 1. Origins of Spanish populations

Table 1. *Groups and origin of populations studied (sample number refers to the Instituto Nacional de Investigaciones Agronómicas collection)*

24	*equina*	Spain (Cádiz)
25	*equina*	Italy
26	*equina*	Spain (Valencia)
27	*equina*	Spain (Cádiz)
28	*equina*	Morocco
32	*minor*	Spain (Valencia)
94	*equina*	Morocco
103	*minor*	U.S.A.
104	*major*	Spain (Guadalajara)
107	*major*	Spain (Granada)
109	*major*	Spain (Granada)
110	*major*	Spain (Cáceres)
112	*major*	Spain (Lérida)
113	*major*	Spain (Lérida)
114	*major*	Spain (Sevilla)
115	*major*	Spain (Sevilla)
116	*major*	Spain (Sevilla)
122	*major*	Spain (Alicante)
123	*equina*	Spain (Valencia)
137	*major*	Spain (Badajoz)
138	*equina*	Italy
138.1	*equina*	Italy
140	*major*	Spain (Cádiz)
142	*equina*	Spain (Cádiz)
143	*equina*	Spain (Cádiz)
144	*equina*	Spain (Cádiz)
146	*major*	Spain (Zaragoza)
171	*paucijuga*	India
172	*paucijuga*	India
203	*major*	Greece

both 28 and 32 will be discussed later. No graphical representation of the equina relationship is useful.

Major relationships are more complicated (Fig. 2). Two groups lie near *equina*: those formed by 110, 113 and 137 (C-I) on one hand, and 114, 115 and 203 (C-II) on the other. It can be seen (Table 4) that in some results a few of these populations are included among the *equina* group. Also near, but with its components clearly differentiated from those of *equina*, is a third *major* group composed of 112 and 122 (C-III); there is a shorter distance from the first to second group than from the third to either the first or the second.

Equina and the two first *major* groups (C-I and C-II) form a strong nucleus (the third *major* group could be integrated) from which the rest of the populations branch (Fig. 3). These populations are:

a. *Paucijuga* populations (group P). The two specimens studied lie together, the most extreme sample being 172. It is easy to see that its evolutionary path-way diminished the characteristics values in relation to the overall mean (Table 2 and 4).

b. *Minor* populations (group A). — The *minor* sample 103 also shows extreme characteristics: its distance from the central groups is large, but in a different direction from *paucijuga* (Fig. 4); increased characteristics are flowers per node, leaflets per

Table 2.

		Plant		Pod				Seed				
Sample Number	Group (1)	Height (dm)	Number of leaves	Length (cm)	Width (cm)	Width / thickness	Number of seeds	Weight (gr)	Length (mm)	Width (mm)	Thickness / length	Width / thickness
24	B	4,6	16,4	7,0	1,5	1,51	3,0	0,76	14,2	10,8	0,51	1,51
25	B	5,6	16,8	6,5	1,6	1,52	2,2	0.90	15,3	11,1	0,48	1,53
26	B	5,4	15,6	8,7	1,6	1,42	3,0	1,19	17,6	12,7	0,43	1,72
27	B	4,4	14,6	7,0	1,5	1,30	2,6	0,88	15,4	11,6	0,49	1,55
28	B	7,6	20,4	7,5	1,3	1,12	3,1	0,84	15,1	10,4	0,49	1,43
32	A	4,8	16,0	7,0	1,2	1,23	3,2	0,55	12,3	8,9	0,54	1,32
94	B	5,3	13,7	6,3	1,4	1,11	3,0	0,81	14,6	20,6	0,51	1,45
103	C	7,6	23,0	5,4	1,1	1,24	2,3	0,51	10,0	7,7	0,64	1,19
104	C	4,1	13,1	16,3	2,1	1,75	3,8	1,80	22,6	16,2	0,29	2,48
107	C IV	5,2	11,9	10,2	2,5	1,91	2,4	2,38	26,4	19,1	0,26	2,79
109	C	5,9	18,8	17,7	2,1	1,79	4,2	1,47	25,6	16,0	0,26	2,57
110	C I	5,4	13,4	11,5	2,2	1,62	3,2	2,30	23,9	17,6	0,28	2,65
112	C III	4,0	12,1	13,8	2,2	1,89	4,2	1,84	22,2	17,1	0,29	2,64
113	C I	4,4	12,9	14,8	2,2	2,08	3,4	1,85	22,9	17,3	0,29	2,64
114	C II	5,3	13,8	10,3	2,2	1,80	2,9	2,04	23,8	17,1	0,31	2,32
115	C II	4,8	14,7	9,1	2,2	1,83	2,2	2,01	24,3	17,3	0,29	2,48
116	C	4,3	12,3	16,7	2,2	1,93	4,7	2,19	24,1	17,9	0,30	2,50
122	C III	4,0	10,4	12,0	2,2	1,73	3,8	1,84	23,1	16,9	0,29	2,51
123	B	6,0	19,8	7,0	1,4	1,13	2,8	0,86	14,7	10,2	0,50	1,39
137	C I	5,0	12,5	9,3	2,0	1,70	3,0	1,74	22,4	16,2	0,30	2,40
138	B	5,2	15,2	6,1	1,5	1,32	2,5	0,98	15,5	10,9	0,49	1,61
138-1	B	4,9	12,1	7,1	1,6	1,49	2,6	1,08	17,0	12,3	0,40	1,83
140	C IV	3,5	12,3	8,3	2,2	1,85	1,8	2,33	25,1	17,9	0,29	2,52
142	B	4,7	14,7	5,4	1,3	1,22	2,6	0,67	13,0	10,0	0,54	1,42
143	B	4,5	14,6	7,4	1,6	1,46	2,8	1,01	16,5	12,2	0,45	1,65
144	B	5,1	15,2	6,6	1,4	1,46	2,7	0,83	14,5	10,4	0,48	1,51
146	C IV	5,0	15,0	11,6	2,2	1,72	2,8	2,05	25,1	16,3	0,27	2,58
171	P	3,0	9,1	3,7	1,0	1,19	2,3	0,26	8,9	7,1	0,66	1,20
172	P	2,5	7,6	3,1	0,8	1,10	3,0	0,13	6,6	5,1	0,75	1,03
203	C II	4,1	14,3	9,8	2,0	1,79	2,7	1,65	22,9	15,8	0,30	2,34

(1) See the text.

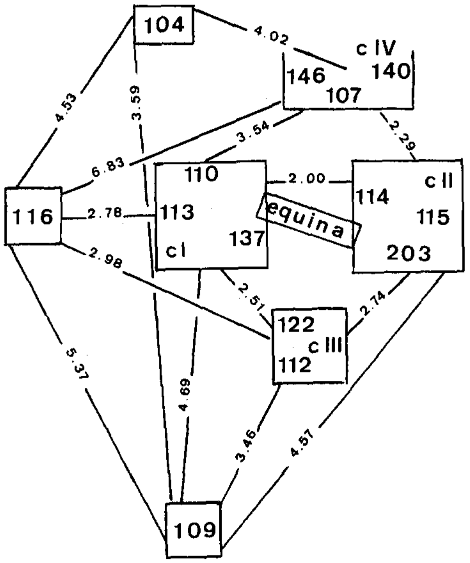

Fig. 2. Major Relationships

leaf and leaflet length, while diminished characteristics are seeds per pod and the weight of one seed (Table 5).

c. *Major* populations. There are six populations not situated near the central groups, three of which can be assembled into a fourth group: 107, 140 and

Mean Values

Flower	Leaf		Leaflet		
Number per raceme	Rhachis length (cm)	Number of leaflets	Length (cm)	$\frac{\text{Width}}{\text{length}}$	Surface (cm^2)
2,8	7,8	5,3	7,3	0,44	14,5
3,0	8,2	5,5	7,4	0,47	16,0
3,2	8,8	5,9	7,6	0,46	16,4
2,4	6,9	5,3	6,5	0,41	16,9
4,0	8,7	6,9	7,2	0,42	20,8
3,4	6,9	5,4	6,7	0,40	12,8
3,0	7,8	6,1	7,5	0,41	16,0
6,4	10,4	6,2	8,2	0,55	27,0
4,5	7,1	5,2	6,9	0,43	14,7
2,7	7,8	5,4	8,1	0,48	22,2
4,3	12,0	6,4	11,0	0,49	41,8
3,1	7,9	5,9	7,7	0,47	19,5
2,1	8,4	5,3	8,3	0,46	22,2
2,4	7,0	5,8	7,1	0,44	15,5
2,1	8,1	5,8	7,8	0,43	18,2
2,1	7,4	5,7	7,4	0,45	17,8
1,9	8,2	6,2	7,4	0,42	16,0
2,0	6,7	5,1	7,3	0,41	15,8
3,9	7,6	6,1	7,5	0,37	15,0
2,6	7,2	5,9	7,2	0,43	16,2
2,5	6,6	5,4	6,6	0,46	14,5
2,4	7,3	5,4	7,3	0,44	17,0
2,4	6,6	5,1	7,0	0,43	15,1
2,4	6,8	5,3	6,3	0,46	12,9
3,4	7,5	5,5	6,7	0,44	14,0
3,4	7,8	5,6	7,3	0,46	16,0
3,1	7,1	5,1	7,3	0,45	17,2
2,2	3.5	4,0	3,9	0,44	4,6
1,0	3,0	3,0	3,5	0,41	4,3
1,7	6,8	5,3	7,2	0,39	14,2

Table 3. Correlation Coefficients

	1. Plant Height	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2. Leaves per Plant	0,87 **															
3. Pod Length	–0,01	–0,05														
4. Pod Width	–0,07	–0,20	0,80 **													
5. Pod $\frac{\text{Width}}{\text{Thickness}}$	–0,21	–0,27	0,78 **	0,92 **												
6. Seeds per Pod	–0,09	–0,11	0,75 **	0,32	0,34											
7. Weight of one Seed	–0,07	–0,23	0,73 **	0,97 **	0,88 **	0,27										
8. Seed Length	–0,01	–0,14	0,80 **	0,98 **	0,89 **	0,32	0,97 **									
9. Seed Width	–0,07	–0,21	0,79 **	0,99 **	0,91 **	0,34	0,98 **	0,99 **								
10. Seed $\frac{\text{Thickness}}{\text{Length}}$	0,00	0,12	–0,81 **	–0,97 **	–0,88 **	–0,36	–0,94 **	–0,99 **	–0,98 **							
11. Seed $\frac{\text{Width}}{\text{Thickness}}$	–0,13	–0,27	0,82 **	0,97 **	0,92 **	0,38	0,96 **	0,97 **	0,98 **	–0,96 **						
12. Flowers per Raceme	0,72 **	0,77 **	0,06	–0,17	–0,24	–0,02	–0,19	–0,14	–0,20	0,12	–0,19					
13. Rhachis Length	0,75 **	0,71 **	0,45 *	0,31	0,24	0,29	0,25	0,36	0,31	–0,38	0,26	0,63 **				
14. Leaflets per Leaf	0,80 **	0,69 **	0,37 *	0,29	0,15	0,23	0,28	0,35	0,32	–0,39	0,22	0,53 **	0,84 **			
15. Leaflet Length	0,59 **	0,54 **	0,59 **	0,53 **	0,44 *	0,33	0,45 *	0,58 **	0,52 **	–0,60 **	0,49 **	0,46 **	0,94 **	0,77 **		
16. Leaflet $\frac{\text{Width}}{\text{Length}}$	0,41 *	0,31	0,06	0,07	0,13	–0,15	0,05	0,04	0,04	–0,01	0,08	0,49 **	0,49 **	0,20	0,38	
17. Leaflet Area	0,60 **	0,55 **	0,52 **	0,39 *	0,32	0,30	0,32	0,45 *	0,38	–0,44 *	0,39	0,53 **	0,90 **	0,66 **	0,92 **	0,54 **

Level of Significance * 5%; ** 1%.

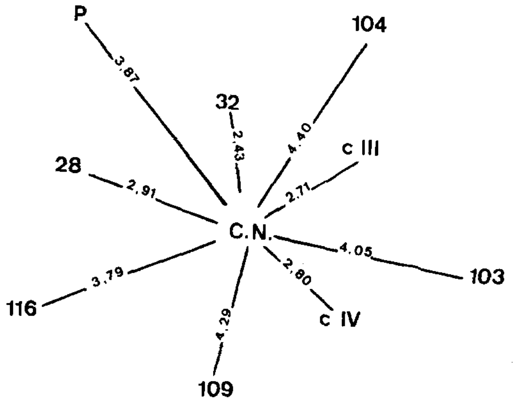

Fig. 3. Distances from the central nucleus

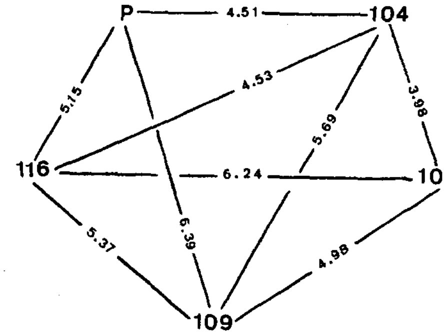

Fig. 4. Relationships among extreme populations

146 (C-IV) (Fig. 2). This group is heterogeneous, but it is better to have it to avoid excessive scattering. It develops positively the weight of the seeds and negatively a weak trend in seeds per pod and leaflet number per leaf (Table 5).

Other *major* populations are:

Sample number 104. — It has developed in a positive way (compared with the mean) in seeds per pod, flowers per node and weight of one seed, and negatively in leaflets per leaf. It lies nearer to the C-I group than to the other central groups (Fig. 2).

Sample number 109. — It lies nearest the C-III group (Fig. 2) but there are very long distances from the other groups: the longest distance obtained in this study was from 109 to *paucijuga*. 109 develops positively all the characters except (perhaps) the weight per seed, and shows the opposite evolutional trend to *paucijuga* (Fig. 4).

Sample number 116. — This is a great distance from *paucijuga* and 109 and lies near both C-I and C-III (Fig. 2), whose trends are represented in 116: a great number of seeds per pod, few flowers per node (C-III), heavy seeds (C-I and C-III) and a large number of leaflets per leaf (C-I) (Table 5).

Discussion

Let us consider again the three isolated *major* populations in relation to both *minor* and *paucijuga*

Table 4. Quadratic Distances (D^2 Values)

	24	25	26	27	28	32	94	103	104	107	109	110
25	1,97											
26	1,74	2,34										
27	1,58	1,64	1,35									
28	11,05	11,43	5,20	7,63								
32	2,12	5,46	3,83	4,27	12,42							
94	1,94	2,72	0,85	1,32	4,66	5,52						
103	15,58	13,37	12,49	17,14	15,63	11,51	15,87					
104	20,42	24,39	16,52	21,21	21,97	11,83	23,56	15,86				
107	9,35	6,12	7,25	8,37	20,39	11,84	11,65	18,50	18,48			
109	11,47	16,25	14,07	19,89	28,67	14,99	15,55	24,76	32,36	20,59		
110	9,46	9,45	4,45	7,32	9,75	9,39	8,60	16,44	9,08	4,83	22,61	
112	5,31	10,96	7,00	8,84	20,12	7,49	9,05	28,78	19,64	11,52	8,83	9,80
113	5,95	7,61	2,51	3,68	6,85	7,45	4,50	20,98	13,80	7,83	21,48	1,86
114	5,17	4,14	2,83	3,20	11,24	9,95	4,41	22,68	22,22	3,69	18,51	3,93
115	8,19	4,24	4,97	4,35	12,76	13,51	6,59	22,58	26,25	3,41	25,89	5,69
116	16,51	23,09	11,87	14,69	12,62	17,79	13,36	38,90	20,51	23,31	28,88	9,63
122	4,61	8,81	4,69	5,56	15,29	5,38	7,30	24,83	13,63	8,14	15,16	4,97
123	3,00	3.14	0,69	2,48	3,63	3,89	1,43	8,35	15,75	9,85	16,13	5,92
137	5,46	5,26	1,62	2,59	5,41	7,75	3,27	17,80	15,82	6,32	21,90	1,93
138	2,10	1,14	1,34	0,19	7,73	4,76	1,73	15,46	20,64	6,81	20,59	6,54
138-1	1,04	0,77	1,83	0,91	11,42	5,17	1,94	18,26	24,50	6,49	14,71	8,59
140	13,67	8,18	10,48	9,94	21,96	15,95	14,94	21,22	21,60	1,54	32,45	6,70
142	1,89	1,95	1,80	0,12	7,18	4,56	1,27	17,27	22,77	10,28	21,36	8,84
143	3,21	3,84	1,35	2,15	5,99	2,32	3,27	9,69	10,62	7,79	19,84	3,88
144	0,99	1,16	0,71	1,29	7,54	2,27	1,55	9,91	16,89	7,43	14,16	6,73
146	8,45	7,86	6,41	7,99	17,47	6,86	11,59	14,08	8,04	2,36	21,56	2,68
171	10,45	11,54	11,27	7,38	16,98	6,78	12,91	21,02	16,57	17,80	40,46	14,29
172	14,03	19,61	19,65	14,11	32,05	9,89	21,07	37,15	24,12	26,44	41,13	24,54
203	3,34	2,73	3,36	2,10	14,23	8,06	4,36	23,97	24,57	4,41	18,23	6,84

(Fig. 4). 104 is farther from 109 than from *paucijuga* or *minor* but, nevertheless, is a typical *major*. It is also interesting to consider that both 104 and 109 have developed positively the number of flowers per raceme (Table 5). They are the only *major* populations to show this. This character (great number of flowers per raceme) is generally considered as typical of *minor* botanical varieties. If we accept a classification based on the shape of grain, it is necessary to concede that the rest of the characteristics are sparsely distributed in this species.

The generalized systematic of *Vicia faba* L. (Muratova, 1931) may be useful, but it is not natural. A natural system should include a more complete knowledge of the pathways followed by the populations.

How many paths can there be? If we consider *n* characteristics and three possibilities for each one (to augment, to diminish and to rest at the original value), there will be, obviously, 3 *n* trends. Actually, number *n* is undetermined. In this study, out of 17 characteristics we have maintained only five, but only three were naturally uncorrelated (the other two were slightly correlated with those three). An attempt to reduce the number of variates (Rao, 1952; Legras, 1963) has been made, but was unsuccessful, so a space of at least five dimensions is necessary to explain our results. In *Cicer arietinum* a reduction is possible: four variates are enough (Cubero, 1970).

Perhaps some combinations of characteristics are not possible, but this is impossible to foresee. Thus, evolution in *Vicia faba* seems to happen as an "explosion" in a space of *n* ($n \geqq 5$) dimensions. The "explosion" is the rupture of the primitive equilibrium and the recombination of independent characters; theoretically it will have as many such trends as the number of possible combinations between them. We must now examine the elements of this assertion.

a. *Primitive equilibrium*

The results show a scattering of populations from a central point wich may represent the ancestral form of the species. The group of populations which we have named "the central nucleus" is the nearest to that hypothetical form; other populations have minimal distances from it. It is not a "passage point" from some original varieties to others (as if *paucijuga* were the oldest population), but an authentic central point: 1°) It maintains a maximum of potentiality or variability (it is formed by many different varieties in origin and use); 2°) if it were a "passage point" the populations which form it should be more scattered, but they lie together, forming a closed group. It would be difficult to explain how such a "passage point" is so particular.

b. *Recombination of independent characteristics*

Original equilibrium refers to the maintenance of mean values for characteristics; these values may be obtained by adequate ratios of genes with positive and negative actions. Linkage between both sorts of genes maintains some populations near to the primitive values; they are the "primitive populations" which form the "Central Nucleus".

Disturbance of this equilibrium between positive and negative genes changes the ratios between them so that two ways for each character are possible — to increase or to decrease the characters values. Mutations and new recombinations can enhance these trends and may also return the new values to the original ones, but if two or more characters are considered at the same time, it is very difficult to recover all the mean values simultaneously. When the equilibrium in the original population is broken, evolutionary changes are progressives and act as a "water-valve": they will never permit a decrease in the

Table 4. (continued)

	112	113	114	115	116	122	123	137	138	138-1	140	142	143	144	146	171	172
113	6,66																
114	7,05	2,43															
115	13,65	5,16	1,22														
116	10,26	5,19	12,05	18,71													
122	1,52	2,68	4,41	9,26	7,48												
123	11,04	4,54	5,80	7,40	15,04	8,03											
137	8,95	0,57	1,61	2,96	8,44	4,59	3,06										
138	10,01	3,86	2,83	3,26	16,24	6,30	2,28	2,33									
138-1	6,97	5,37	2,53	3,97	17,59	5,51	3,74	4,07	0,98								
140	19,00	10,09	5,85	3,25	28,11	12,85	12,64	7,73	7,86	9,36							
142	10,40	4,64	4,41	5,40	15,81	6,97	2,57	3,38	0,39	1,38	11,62						
143	9,79	3,08	5,40	6,93	13,64	5,41	1,17	2,41	1,93	4,05	9,57	2,52					
144	8,49	5,03	4,68	6,27	17,28	6,18	0,86	3,68	1,16	1,54	10,40	1,55	1,24				
146	10,03	5,82	6,07	7,17	18,69	5,50	7,93	5,62	6,87	8,06	4,09	9,69	4,32	6,29			
171	20,54	11,53	15,75	15,95	24,47	12,76	10,91	11,41	7,54	11,68	16,03	7,11	5,99	9,14	11,18		
172	18,52	18,93	23,38	26,90	28,59	13,51	21,58	21,24	15,61	17,10	27,41	14,15	14,75	16,88	18,50	5,13	
203	6,38	4,13	0,92	2,16	15,38	4,19	6,55	3,36	2,01	1,07	6,55	3,08	5,61	3,99	6,73	12,88	17,67

number of the old population, only a progression towards a new equilibrium.

(Positive and negative genes are not necessary to explain the hypothetical equilibrium in the original population, but they are useful in developing these ideas.)

Table 5. *Evolutive tendencies of studied groups*[1]

	Seeds per pod	Flowers per raceme	Weight of one grain	Leaflets per leaf	Leaflet length
B 28	0	+	−	+	0
A 103	−	+	−	+	+
C 104	+	+	+	−	0
C 109	+	+	0	+	+
C 116	+	−	+	+	0
P	0	−	−	−	−
C III	+	−	+	0	0
C IV	(−)	0	+	(−)	0

[1] Tendencies with regard to Central Nucleus: +, −, 0: Respectively to increase, to diminish and to maintain the mean values. (−): Weak tendency.

c. *Rupture of equilibrium in the original population*

Paragraphs a) and b) agree with our experimental results. But how is this equilibrium broken? To answer this question, we must remember a biological characteristic of this species — its reproductive system. From Darwin (1857) onwards, the existence of partial allogamy has been noted by many authors, and also the depression of production in self-fertilization conditions (Fyfe, 1951; Fyfe and Bayley, 1951; Drayner, 1959; Rowlands, 1958, 1960, 1961, 1964; Holden and Bond, 1960, Picard, 1960). Recently it has been suggested that *Vicia faba* has a homeostatic genetic system (Cubero, 1970); with only one self-fertilization, nearly all the correlations found in natural populations are weakened or annulled. On the other hand, self-fertilization occurs naturally; the autogamy rates range from zero to about sixty per cent if we consider isolated plants (Cubero, 1969). The hybrid plants (originated by cross pollination) are self-fertile; the plants produced by selfpollination show self-sterility (to very different degrees).

The cycles of self- and cross-fertilization thus act as the "evolutive motor" of this species. All the populations of *Vicia faba* are in active evolution; only when a population becomes isolated and autogamy is fixed (for example, some strains of *paucijuga*, such as 172), does the motor stop, and also the possibilities for evolution.

(The rate of autogamy is an important characteristic of populations, but it is more exact to speak of a "tendency towards allogamy or autogamy", which can be measured in self-fertilization conditions; nevertheless, we have not considered it in this study. It is very much influenced by environmental conditions.)

As the populations forming the Central Nucleus are only partially self-fertilized (i.e., not completely autogamous), we must conclude that in *Vicia faba* autogamy is an acquired form of reproduction, weak allogamy being the primitive form (i.e., allogamy without strong self-incompatibility).

From the nucleus, new populations continuously reach their own individuality. Strain number 28 is a good example: it cannot be included among the "central" one, but it lies near; it may represent a new line of evolution beginning to emerge from the core of the species.

Does the actual systematic of *Vicia faba* agree with these results? Two subspecies are recognized, *paucijuga* and *faba*, with three botanical varieties in the latter, followed by a multitude of forms, groups and so on. *Paucijuga* was separated from the rest of the species because of its geographical isolation and has developed some particularities: a strong tendency towards autogamy, a small number of leaflets per leaf, small sizes for seeds, few flowers per raceme, indehiscent pods, a large number of stems per plant, low height . . . perhaps many others. But, and this is important, no one of these characters is exclusive to *paucijuga*: seeds as small as those of this subspecies are found in some *minor* populations; the number of flowers and pod structure are like some *major* ones; selection towards autogamy is possible in isolated conditions; low height and low number of leaflets are found in natural populations. Recent studies have shown polygenic control for all these characters (Cubero, 1969). Furthermore, *paucijuga* crosses very well, even exceptionally well, with other populations. It is also visited by pollinating insects.

Paucijuga is, therefore, a "good subspecies" if it is characterized by a large number of characteristics instead of only a few, *provided that isolation conditions remain*. If agriculture, for example, carries populations of *faba* ssp near those of *paucijuga*, the barrier between them may be broken. The two subspecies may be maintained, but in *Vicia faba* the subspecies concept is really a very weak one. *Paucijuga* is really only the bottom of an evolutionary trend, as there is no genetic isolation, nor intersterility, even weak. If the subspecies concept is an evolutional one, that is, a species in formation, as modern taxonomy wants, *paucijuga* can not be maintained as this kind of taxon.

It might be better to consider the species as a whole as only one major group, from which certain populations have become isolated only by geographical barriers.

The second and more important subspecies is *faba*, with three botanical varieties distinguished according to width/length: *major*, *equina* and *minor*; this coefficient is negatively correlated with grain weight (Muratova, 1931). We have seen that there can be a greater distance between two *major* populations than between these two and *paucijuga*. Furthermore, our "central nucleus" is formed by most *equina* and many typical *major* populations. It is difficult, therefore, to maintain these varieties as natural entities; it can be practical, but not real. It is old Taxonomy, not Systematics.

A classification based on evolutionary trends is not practical, but it is real. It cannot be written in the form of keys, because of the large number of trends but it can obviously be an aid to plant breeders. It does not permit graphical representation (five dimensions at least for *V. faba*) nor simple genealogical trees (like the usual designs in text-books), but does Nature really act according to such a design?

The only practical point of such a system is the description of the central nucleus of evolution as it may be useful to know the potentialities kept in the species core. For *Vicia faba*, in our experimental conditions, and noting that numbers given are mean and not individual values, this description is as follows:

The Central Nucleus of Evolution of *Vicia faba* L. is formed by populations with a seed weight ranging from 0.55—2.00 grams/seed, 2—4 grains per pod, coefficient width/length of the seed 0,6 as maximum, length of pod from 5.5—15.0 cm, 2—5 flowers/raceme, 5—6 leaflets per leaf, leaf rhachis length 6.5—9.0 cm; variable height according to climatic conditions.

Literature

1. Cubero, J. I.: Herencia de quince caracteres cuantitativos en *Vicia faba* L. Tesina de Graduación en la Facultad de Ciencias de Madrid (1968). — 2. Cubero, J. I.: Unpublished data (1969). — 3. Cubero, J. I.: Influencia de la homocigosis y heterocigosis en la fertilidad de *Vicia faba* L. Tesis de graduación para el Doctorado en la Escuela Técnica Superior de Ingenieros Agrónomos de Madrid (1970). — 4. Darwin, Ch.: In: "Cross and self-fertilization of plants", pag. 487 ss, 2nd ed. London 1900. — 5. Drayner, J. M.: Self and cross-fertility in field beans (*Vicia faba* L.). J. Agric. Sci. **41**, 371—378 (1959). — 6. Fyfe, J. L., Bayley, W. T. J.: Plant breeding studies in leguminous forage crops. I. Natural cross-breeding in winter beans. J. Agric. Sci. **45**, 141—147 (1951). — 7. Holden, J. H., Bond, D. A.: Studies on the breeding system of the field bean, *Vicia faba* L. Heredity **15**, 175—192 (1960). — 8. Legras, J.: Précis d'analyse numéɹique. Paris: Dunod 1963. — 9. Muratova, V.: Common beans (*Vicia faba* L.). Suppl. 50, Bull. appl. Bot. Genet. Plant Breed. 285 pp. (1931). — 10. Picard, J.: Données sur l'amélioration de la féverole de printemps. Ann. Amélior. Plantes **10**, 121—153 (1960). — 11. Rao, C. R.: Advanced statistical methods in biometric research. New York: John Wiley & Sons, Inc. 1952. — 12. Rowlands, D. G.: The nature of the breeding system in the field bean (*Vicia faba* L.) and its relationship to breeding for field. Heredity **12**, 113—126 (1958). — 13. Rowlands, D. G.: Fertility studies in the field bean (*Vicia faba* L.) I. Cross and self-fertility. Heredity **15**, 161—173 (1960). — 14. Rowlands, D. G.: Fertility studies in field bean (*Vicia faba* L.). II. Inbreeding. Heredity **16**, 497—508 (1961). — 15. Rowlands, D. G.: Fertility studies in the broad bean (*Vicia faba* L.). Heredity **19**, 271—277 (1964).

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