

# NUMERICAL ANALYSIS APPLIED TO THE TAXONOMY OF THE GENUS *VALANTIA* L. (*RUBIACEAE*)

by

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## Abstract

AIELLO, M., S. BRULLO & V. PICCIONE (1981). Numerical analysis applied to the taxonomy of the genus *Valantia* L. (*Rubiaceae*). *Actas III Congr. OPTIMA. Anales Jard. Bot. Madrid* 37(2): 577-586.

On the basis of the diacritic characters of the fructiferous corpus a numerical analysis on the *Valantia* species was made. The object of this research is to verify the taxonomic relationships among the 6 known species by cluster analysis, above all in consequence of the recent discovery of two new species. For each species 20 fructiferous corpora were examined and 22 characters of them were taken into consideration. The similarity measurements calculated among all the pairs of OTU's are reported on a matrix to which the cluster analysis was applied. The results confirm the validity of the specific rank given to the 6 taxa of *Valantia* and the primary importance of the diagnostic value of the fructiferous corpus morphology.

## Resumen

AIELLO, M., S. BRULLO & V. PICCIONE (1981). Análisis numérico aplicado a la taxonomía del género *Valantia* L. (*Rubiaceae*). *Actas III Congr. OPTIMA. Anales Jard. Bot. Madrid* 37(2): 577-586 (En inglés).

Basándose en caracteres diacríticos de las fructificaciones se realiza un análisis numérico de las especies de *Valantia*. El objetivo de esta investigación es verificar las relaciones taxonómicas por medio del análisis de agregación entre las seis especies conocidas, especialmente después del reciente descubrimiento de dos nuevas especies. Para cada especie fueron examinadas 20 fructificaciones y de cada fructificación se consideraron 22 caracteres. Las medidas de similitud calculadas entre todos los pares de OTU se presentan en una matriz a la que se le aplicó el análisis de agregación. Los resultados confirman la validez del rango específico dado a los 6 taxones de *Valantia* y la importancia del valor diagnóstico de la morfología de las fructificaciones.

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## INTRODUCTION

The genus *Valantia* is differentiated from the remainder of the *Rubiaceae* because of the presence of a very peculiar inflorescence and fructiferous corpus. The taxonomical importance and the diagnostic value of these parts of the plant were already put in evidence by LINNE (1753) who, because of this, founded a distinct genus. Previously, various authors interested themselves in taxonomic affinities and phylogenesis of the genus *Valantia*; among which: BALDACCI (1893), FAGERLIND (1937), EHRENDORFER (1970).

Due to the recent discovery of two new species of *Valantia* (BRULLO, 1979, 1980), the systematic position of each taxa has been brought up to discussion again. Therefore, we have thought it better to verify the relationships that are existing among the 6 taxa known, on the basis of the morphological characters of the fructiferous corpus. We have chosen this part of the plant because it represents the most important diagnostic character in order to hierarchize at a specific level (Fig. 1).

In order to quantify better the diversities observed among the fructiferous corpora of the single taxa, methods of numerical analysis were used. In this way, the limits among the various taxa and their relationships can be specified objectively.

The cluster analysis according to SOKAL & SNEATH (1963, 1973) was applied to the data subjected to GOWER's (1971) coefficient of similarity. Besides, the arithmetical averages of the data have permitted to evidentiate the taxonomical distances occurring among the taxa.

## MATERIAL

For this research, only herbarium specimens from the collection of the botanical museums of Catania (CAT), Palermo (PAL), Athens (ATH, ATHU) and Patras (UPA), were utilized. The fructiferous corpora were chosen among the ones that were more mature and that were in better conditions; not more than two fructiferous corpora have been examined for each herbarium specimen.

For each taxon, 20 fructiferous corpora were examined for the numerical analysis; for each one, 22 characters relative to the phenotype were taken into consideration.

## METHOD

For this study only the morphological characters of the fructiferous corpora were compared. Twenty two characters for each species were examined. The comparison was carried out on 120 OTU's (20 specimens for each taxa). GOWER's (1971) formula was applied to the data matrix of 120 OTU's and 22 characters. This estimates the similarities between the data measured by variables defined at different levels of scale.

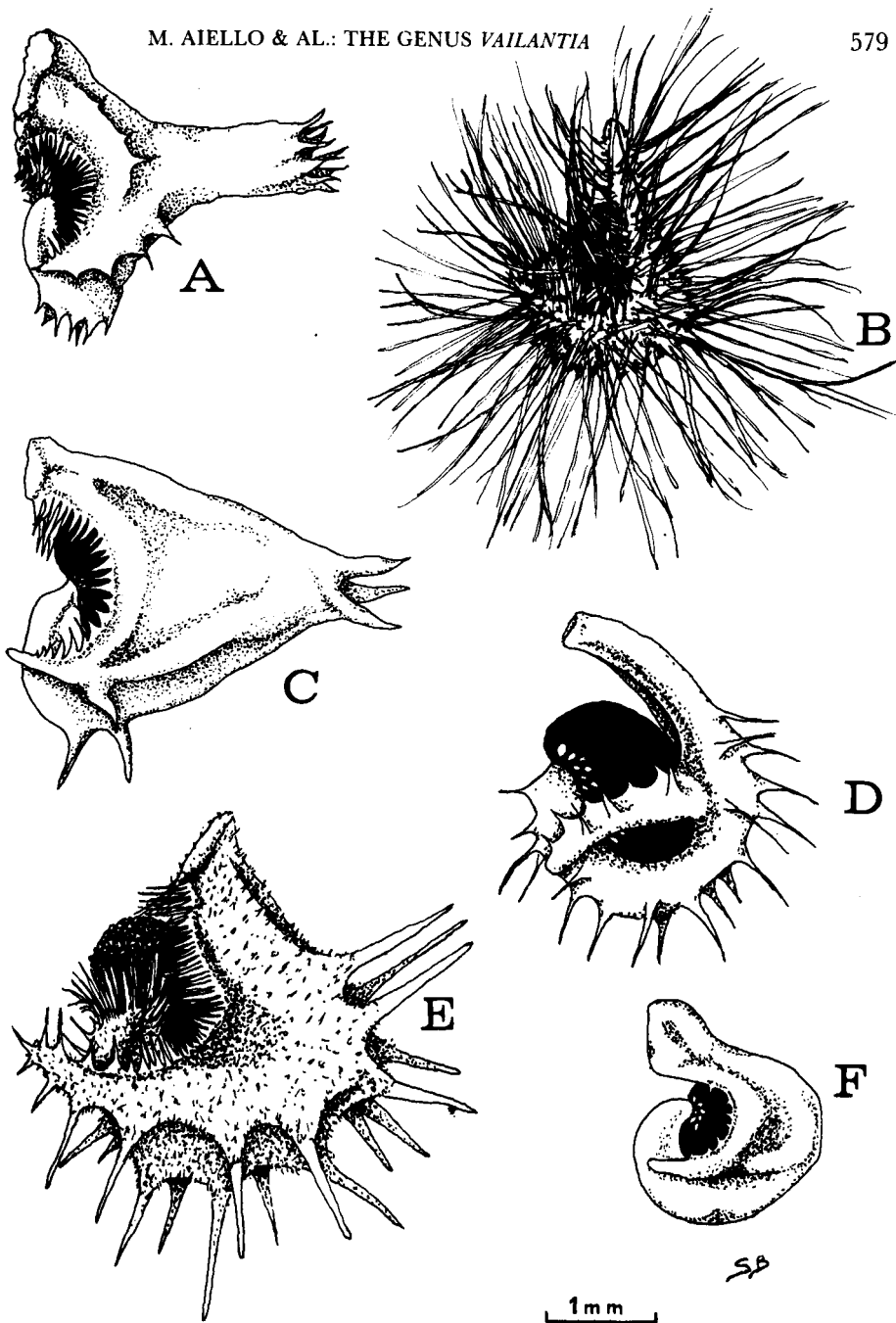


Fig. 1.—Iconography of the fructiferous corpora of *Valantia* species: A) *V. muralis* L.; B) *V. columella* (Ehrenb. ex Boiss.) Baldacci; C) *V. deltoidea* Brullo; D) *V. aprica* (Sibth. & Sm.) Boiss. & Heldr.; E) *V. hispida* L.; F) *V. calva* Brullo.

The cluster analysis was applied to the results and the method used is the *average linkage clustering* with process WVGM (*weighted variable-group method*). A brief description is given. It isolates the pairs of OTU's with a smaller taxonomic distance. These will constitute the initial groups. Then, the distance between every OTU and the initial group is calculated. This procedure is repeated by first recalculating the matrix until all the OTU's are reduced to only one group. The OTU's (or groups of OTU's) are placed in position in the abscissa of a dendrogram and the correlation coefficient scale is placed in the ordinate.

The arithmetic average of the data relative to the fructiferous corpora of each species was made and through GOWER's formula, a matrix was obtained and it represents the absolute taxonomical distances among the 6 species. The numerical values are reported in Fig. 3 in the shape of a triangular semi-matrix (1).

	B	C	D	E	F	
	0.462	0.613	0.401	0.547	0.534	A
		0.341	0.378	0.638	0.550	B
			0.485	0.583	0.629	C
				0.355	0.448	D
					0.550	E

A - *V. muralis*

B - *V. calva*

C - *V. columella*

D - *V. deltoidea*

E - *V. hispida*

F - *V. aprica*

Fig. 3.—The upper part of the matrix of GOWER's (1971) general coefficient. The values are complemented at 1.

## RESULTS

The phenogram of Fig. 2 places each taxon in a distinct cluster. In every cluster the variability is very low and is included between 1.00 and 0.89 phenon level. The highest homogeneity is found in *V. columella*,

(1) For computing procedure the CDC-6600 System of Data Center at the University of Catania (Italy) is used. The programs are written in FORTRAN IV by AIELLO and PICCIONE.

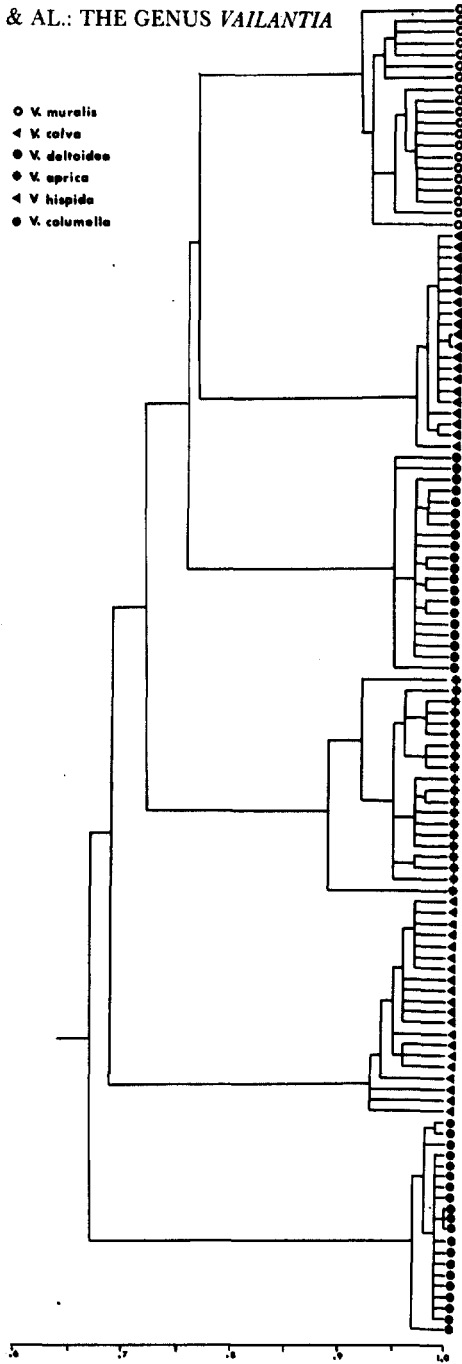


Fig. 2.—Dendrogram of the relationships among 120 OTU's, based on the WPGM clustering method.

whilst the highest variability is found in *V. aprica*. The first cluster that separates itself at 0.67 phenon level is the one relative to *V. columella*, whilst the last two clusters that separate themselves at a 0.77 phenon level are the ones of *V. calva* and *V. muralis*. In other words, the separation of all the clusters occurs between two phenon levels which are quite near. Therefore, the degree of diversity among the 6 taxa is high and this ratifies their differentiations at a specific rank according to the systematic which was used up to now.

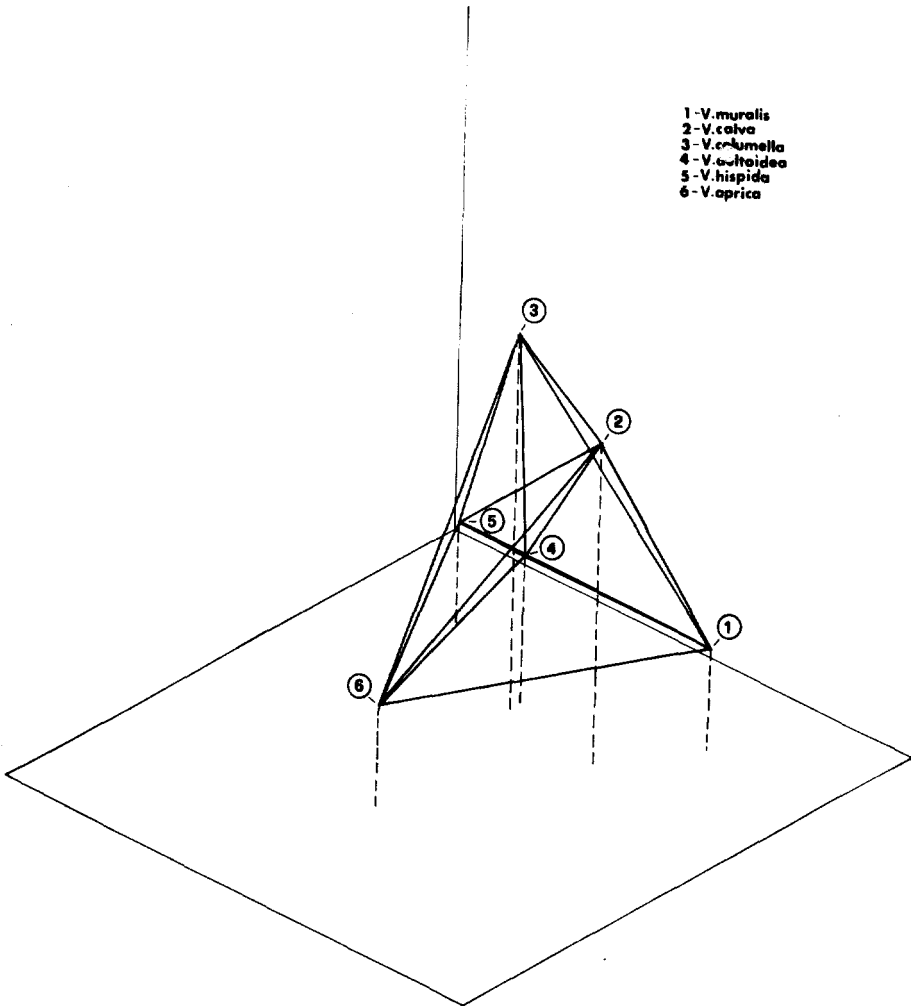


Fig. 4.—3-dimensional model of the taxonomic distances among 6 species of *Valantia*. The dimensions are the three largest principal component extracted from a trasformation of the distance matrix of Fig. 3.

In particular, GOWER' (1971) general coefficient applied to the average values listed in Table 1, supplies us with the matrix of the taxonomical distance that exists among the 6 species. The tridimensional model of these distances visualized the relationships among the species on the basis of their position in space (Fig. 4, 5). Among, these, the most isolated is *V. aprica* which has few connections with the remaining species. Another species, that is quite isolated, is *V. muralis* which in a particular way shows a greater affinity with *V. deltoidea* and in a lesser way with *V. calva*, whilst it differentiates remarkably from the others. *V. hispi-*

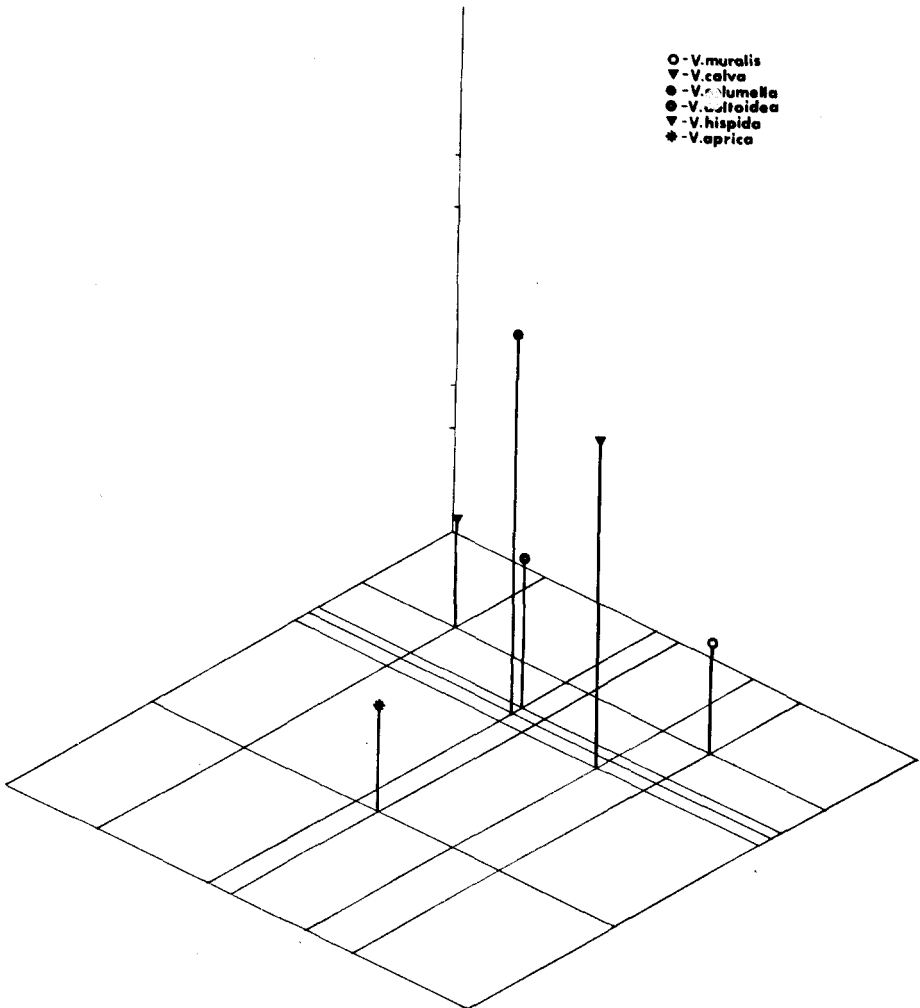


Fig. 5.—3-dimensional model as for Fig. 4, with projection of the vertices on the «x y» plane surface.

TABLE 1  
SYNTHETIC TABLE OF THE 120 OTU'S CHARACTERS

WITHIN BRACKETS THE MAX. AND MIN. VALUES RELEVED IN THE OTU'S, OUTSIDE BRACKETS THE MEAN VALUES. THE MEASURES ARE GIVEN IN MM. ELEVATED NUMERICAL QUANTITIES ARE INDICATED WITH<sup>+</sup>

	<i>V. muralis</i>	<i>V. calva</i>	<i>V. columella</i>	<i>V. deltoidea</i>	<i>V. hispida</i>	<i>V. aprica</i>
<b>Fructiferous corpus</b>						
Length	(2.0-3.1)	2.485 (1.4-2.2)	1.835 (1.5-2.2) 1.865	(2.5-3.2)	2.805 (3.0-5.8)	3.865 (2.2-3.0)
Width	(2.0-3.5)	2.775 (1.2-1.8)	1.550 (1.2-2.0) 1.610	(2.3-3.2)	2.805 (2.5-4.5)	3.135 (1.9-2.6)
Color	white	white	white	yellowish	yellowish	yellowish
Length of the rostrum	(1.0-2.2)	1.610	—	(0.2-1.0)	0.470	
Indumentum					yes	
Max. width of the side	(0.5-1.0)	0.675 (0.7-1.1)	0.905 (0.2-0.4) 0.315	(1.0-1.5)	1.215 (1.2-2.2)	1.690 (0.3-0.5)
<b>Bristles of fructiferous corpus</b>						
Mean length	(0.25-0.5)	0.348	(1.3-2.0) 1.650	(0.35-0.7)	0.558 (0.7-1.2)	0.973 (0.4-0.6)
Number total	(13-39)	21.850	+	4-13)	8.200 (14-32)	23.400 (24-48)
N. of dorsal	(6-12)	8.350	+	(2-5)	3.400 (4-18)	11.050 (5-15)
N. of right horn	(2-9)	3.650	+	(0-2)	1.350 (2-5)	3.350 (4-14)
N. of left horn	(2-6)	3.550	+	(0-3)	1.250 (2-5)	3.750 (4-14)
N. of central horn	(3-10)	5.050	+	(1-4)	2.200 (3-10)	5.450 (4-12)
<b>Seedbearing annulus</b>						
Thickening at the lateral borders	yes	—	—	—	—	—
N. of the bristles of lateral borders	(0-7)	1.250	—	—	—	—
N. of cilia in $\frac{1}{2}$ mm.	(14-22)	17.900 (2-7)	4.650	(8-12)	9.800 (7-10)	8.500
Mean length of cilia	(0.2-0.3)	0.223 (0.1-0.1)	0.100	(0.2-0.25)	0.240 (0.25-0.4)	0.300
<b>Mericarp</b>						
Length	(0.5-1.0)	0.745 (0.5-1.0)	0.800 (0.4-0.8) 0.555	(1.0-1.5)	1.300 (1.0-1.3)	1.130 (1.2-1.8)
Width	(0.4-0.8)	0.570 (0.5-0.8)	0.635 (0.3-0.6) 0.495	(0.6-1.2)	0.995 (0.8-1.1)	0.950 (1.4-2.0)
Projection of the fructiferous corpus	(0.0-0.3)	0.070 (0.3-0.5)	0.43 (0.4-0.6) 0.455	(0.2-0.5)	0.335 (0.5-1.0)	0.830 (1.2-1.8)
Indumentum	smooth	smooth	papillose	smooth	papillose	smooth
Colour of hairs	golden-yellow	golden-yellow	white	white	white	golden-yellow
Number	1	1	2	1	2	1



*da* shows some affinities only with *V. deltoidea*. Even *V. columella* presents itself well isolated taxonomically and shows a greater affinity only with *V. calva*.

#### DISCUSSION

These observations are to be found even in the considerations deduced from the comparative analysis of the morphological characteristics of the fructiferous corpora and also from the observations regarding the habit, ecology, chorology and the Caryological data. On the basis of this, *V. aprica* can be considered the most isolated taxonomically, since it is the only perennial species of the genus, and it is characterized by a rather narrow distribution (it is known only for some mountains of the S. Balkan and of Crete) and has a fructiferous corpus with peduncle and flowering pedicels not incrassate and briefly coalescent, and not enclosing the mericarp. In fact, the other species are always annual and have the fructiferous corpora with peduncle and flowering pedicels manifestly incrassate and coalescent, more or less enclosing the mericarp (or the mericarps). Among these, *V. hispida* and *V. muralis* have a wide pan-mediterranean distribution, whilst *V. columella* has a distribution limited to steppe countries in the C. E. North-Africa and they all have a fructiferous corpus well distinct morphologically. Finally, *V. calva*, endemic to the Island of Linosa, and *V. deltoidea*, endemic to Rocca Busambra (Sicily), have a very localized distribution; their fructiferous corpora, although very peculiar, have some affinities with those of *V. muralis*.

Regarding the phylogenesis, we may suppose that *V. aprica* probably represents the most primitive taxon of the genus; in fact, from the morphology of its fructiferous corpus, from its habit and as it is the only species with a diploid chromosome complement with a basic number  $x = 11$ , it is the one that is more similar to the species of the genus *Galium*; therefore, it represents the taxon of connection between the two genera. The diploid annual species with  $x = 9$ , such as *V. hispida* and *V. muralis* have probably been originated by dispoloidy phenomena from a taxa with chromosome complement of  $2n = 22$ . Instead, *V. deltoidea* and *V. columella*, both tetraploid, have probably originated through allopolyploidy processes; the former, with  $2n = 36$ , would have originated by hybridation between two taxa with  $2n = 18$ ; whilst the latter, that has  $2n = 40$ , would have originated from the hybridation through unreduced gamets between a taxon with  $2n = 18$  and one with  $2n = 22$ . Finally, *V. calva* is undoubtedly a neo-endemism being localized on a small volcanic island with a post-pliocenic origin, which compared to other species of *Valantia*, presents a fructiferous corpus with the smallest dimension and completely without bristles; it has probably originated itself from *V. muralis* by a series of mutations.

On the basis of the morphological characters of the fructiferous corpus the following key is given:

1. Fructiferous corpus not incrassate, but only lightly canaliculate in the ventral part. Mericarp up to 2 mm long,  $\pm$  entirely projecting ..... **V. aprica**
1. Fructiferous corpus incrassate, with a deep ventral cavity. Mericarp up to 1.5 mm long,  $\pm$  enclosed ..... 2
2. Fructiferous corpus without any bristles..... **V. calva**
2. Fructiferous corpus always provided with bristles..... 3
3. Fructiferous corpus entirely covered by flat bristles which are up to 2 mm long ..... **V. columella**
3. Fructiferous corpus partly covered by flat bristles which are up to 1.2 mm long ..... 4
4. Fructiferous corpus hispid, with bristles 0.7-1.2 mm long, without dorsal coronule. Mericarps 2, papillose ..... **V. hispida**
4. Fructiferous corpus glabrous with dorsal coronule and with bristles 0.2-0.7 mm long. Mericarp 1, smooth ..... 5
5. Fructiferous corpus with dorsal subcylindric rostrum up to 2 mm long provided with an apical coronule of 6-15 bristles. Terminal horns with 2-12 bristles each..... **V. muralis**
5. Fructiferous corpus without or with a very short dorsal rostrum provided with an apical coronule of 2-5 bristles. Terminal horns with 0-5 bristles each..... **V. deltoidea**

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