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# Morphometrical studies on the Hungarian representatives of Ophrys scolopax Cav. agg. (Orchidaceae)

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Abstract: Seven quantitative and four qualitative characters were examined during three years in two native populations of Ophrys scolopax Cavan. ssp. cornuta (Steven) Camus in Hungary (Pécs and Kunpeszér). The total number of the examined individuals was 212. The observations were made on living plants in their original habitat. The locality- and generation-dependent differences were analyzed by univariate statistical tests (F, T and $chi^2$ tests). Significant differences between the two populations were found in some characters. The most consistent ones among them are the length of the horn and the colour of the sepals and petals. Furthermore, a multivariate analysis of all the observed characters was carried out. A similarity matrix was calculated by Gower's formula (GOWER 1971) and a dendrogram was constructed on the basis of the Sokal's weighted pair method (PODANI 1980). The dendrogram shows well separated groups.

## INTRODUCTION

Among the European representatives of the orchid family the genus Ophrys has undoubtedly the most complicated taxonomy, and the most complex group within this genus is the series fuciflorae Rchb. (REICHENBACH 1851). Members of this series occur throughout most of the range of the genus, except for the north and northeast, and are the most variable in the Mediterranean region (DANESCH & DANESCH 1969, 1972, SUNDERMANN 1964a, 1964b). Within this series is a group distinguished by its considerably convex labellum (O. scolopax Cav., O. oestrifera M.B., O. attica (Boiss. et Orph.) Soó, O. schulzei Bornm. et Fleischm. etc.) ranged by SOÓ into the subseries oestriferae (SOÓ 1970).

During the last 150 years the taxonomical identification of the Hungarian populations of this group has changed. Previous names were O. bicornis Sadl. (SADLER 1845, nom illegit.), O. cornuta Stev. 1809, O. oestrifera M.B. ssp. cornuta (Stev.) SOÓ 1931, (BOROS 1936, HORVÁT 1941, 1943, JÁVORKA 1930, KELLER SCHLECHTER & SOÓ 1930-1940) and the last valid name is O. scolopax Cav. 1793 ssp. cornuta (Stev.) Camus 1908. The localities of occurrence of the native populations in Hungary are shown by the map (Fig. 1). Of these only the Pécs population, located in the park Pintérkert and in the forest of Lapis (several dozen exemplars) and the Kunpeszér population (several thousand ones) seem currently to be in existence.

A possible taxonomical difference between the Pécs and Kunpeszér populations has been suspected on the basis of their considerably different ecological circumstances. The Pécs population is located in the Mecsek mountains in the remains of a karstic oak forest (Orno-Quercetum pubescentis mecsekense) situated on a layer of shallow, rocky soil over a bed of limestone. Recent park development has destroyed three-quarters of the native population. The Kunpeszér population, on the other hand, resides in a slowly desiccating marsh-meadow (Molinietum coeruleae and other unidentified - mostly transitional - grassland associations) that is gradually becoming a steppe-

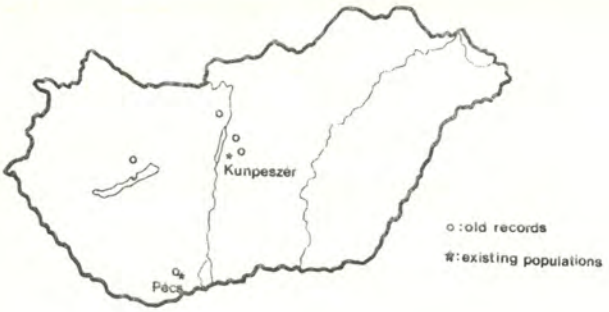



Fig. 1. Map of the native populations of the Ophrys scolopax Cav. agg. in Hungary

meadow; it is situated in a layer of marsh-meadow soil above a sublayer of holocene sandy sediment.

The two populations were compared by means of a morphometrical analysis based on examination of some qualitative and quantitative characters on living plants. We followed the population with observations over the course of several years, because only a certain portion of the population blooms in a given year, and it is uncertain whether the flowering specimens of one year can provide a satisfactory statistical representation of the entire population. Unfortunately it was impossible to make certain complementary studies (e.g. determination of karyotype, comparative biochemical analyses, or reciprocal transplantations), because the cultivation of this plant is not yet fully solved and the collection of samples is precluded, this species being strictly protected because of its endangered status in Hungary (NÉMETH 1985).

## METHODS

The examined species is a tuberous perennial with an endotrophic mycorrhiza. It flowers only in certain years; in others it shoots a sterile rosette. In the first year the observed individuals were marked by aluminium pegs with a chased code on their upper part and sticked into the soil in a certain position to the plant. By this we hoped to obtain some information about the flowering dynamics of the populations and to identify the weather-independent characters by observing the same plants. Unfortunately the number of the re-discovered markings was too small for a precise evaluation. At Kunpeszér, for instance most of the markings has been destroyed by an out of schedule mowing in autumn of 1983 (Table 1.)

Colour slides were made about each examined flower for documentation and subsequent checking, but their value is restricted because of the fluctuating quality of the film (ORWO) and developing. Since this plant cannot yet be successfully cultivated, we had to make our observations in its natural habitat. The flowering of the Pécs population culminates generally in the last week of May. In Kunpeszér this occurs in the second week of June. As the old herbarial samples were qualitatively and quantitatively insufficient for evaluation, we chose not to examine them.

According to some data the number of chromosomes even in the same population may vary: 16, 18 and 19 were counted in a population of the Ophrys scolopax Cav. ssp. scolopax in Southern France (SHIMOYA & FERLAN 1952). We, however, made no chromosomal examinations, because the youngest of the buds were already past meiosis at the time of observation. Furthermore, the roottip preparations required for mitosis examination were unavailable to us because of the above-mentioned conservation restrictions. Before chromosomal analysis of these subjects can be made, it will be necessary to produce tissue cultures in greater quantity. The methodology of it is developed on the basis of other works (HARBECK 1963, LUCKE 1971). Similar experiments are already in progress in Hungary (É. SZŐKE pers.comm.). Seeds from the Pécs and Kunpeszér populations have been placed into a sterile nutrient medium, but the cultures have developed rather slowly.

The choice of relevant characters has been exceedingly difficult. Since previous studies have failed to identify and describe exactly the distinguishing features of related races and subspecies, we have considered as many characters as possible and have examined many of them, for the first time, in this study. We received considerable and useful experience in the choice and measurement

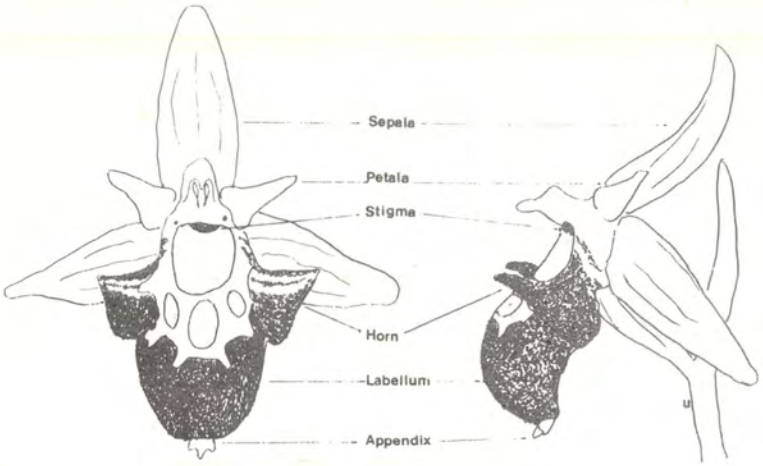



Fig. 2. Parts of the Ophrys flower

of characters as a result of our participation in a previous similar investigation (SAPSÁL 1985), in which a methodological discussion is incorporated. All eleven characters were registered in each plant in order to use the data for a multivariate analysis. Furthermore, the characters were observed uniformly on the uppermost open flower in order to establish a basis for comparative judgement, because many of the features change during blooming. The quantitative characters are as follows:

1. Length of the plant, i.e. length of the flowering stem stretched out from soil level to its apex (to 1 mm precision).
2. Number of flowers on the plant, including both the opened and withered ones and buds.
3. Length of the sepals along the chord between its base and top, measured on the lateral sepal to 0.5 mm precision.
4. Width of the sepals at its widest point, measured without rolling up its rolled edge, to 0.5 mm precision.
5. Length of the petals between its base and top, measured to 0.5 mm precision.
6. Length of the labellum from the upper edge of the zona basalis (from the stigma) to the end of the labellum, excluding the appendix (to 0.5 mm precision).
7. Length of the horn on its internal side, from the juncture with the middle lobe of the labellum to the tip of the horn, measured to 0.5 mm precision.

The following qualitative characters observed:

1. Colour of the sepals, which is a particularly variable feature. It was classified into four categories: white, pink, green, and greenish pink. Ignorance of the whole scale of the possible colours initially rendered registration and therefore, classification somewhat difficult. This situation, however, was eventually rectified by a careful scrutiny of the colour slides.
2. Colour of the petals was determined similarly.
3. Colour of the appendix varies from yellow to dark brown. A thorough inspection of the slides indicated three categories: yellow, brown and intermediate.
4. Shape of the appendix can range from the cut form to the tridentate (Fig. 3) into three classes.

For the identification of the characters see Fig. 2.

The number of bloomed flowers on the plant was a separately observed character which in-




Fig. 3. Shape variants of the appendix

dicates the relative phenophase of the plant at the time of observation. This can be used subsequently to correct the other (especially quantitative) data. The present analysis, however, does not incorporate this correction feature.

The randomized sampling has been a general problem of this subject. In the small population at Pécs we have observed all the measurable specimens but these samplings are certainly disturbed by genetic drift. At Kunpeszér, on the contrary, the rather large population and area caused some problems, as we did not want randomize in the whole area in order to find the markings more easily. Starting from a randomly chosen plant, we observed the 30-50 nearest neighbour around it. Unfortunately the spatial distribution of the different morphological types seems to be contagious, i.e. it is uncertain whether the sampling method is correct. An examination of the spatial distribution of the Ophrys-types is in the process (LOCSMÁNDI & BORI pers. comm.).

## ANALYSIS

The observed plant individuals belong to two subsamples on the basis of their locality (Pécs and Kunpeszér) and to three ones based on their time of observation (1983, 1984, 1985). There is no overlap between the first two groups. We did not consider the occurrence of the same plants in the consequent years to be a disturbant factor, because they contribute to the reproduction of the population to two three times greater extent than the other specimens, flowering only one time in the three years; it was considered to be a kind of self-weighting. Furthermore, the number of the consequently flowering plants was relatively small (Table 1). The univariate analyses were carried out on a COMMODORE 64 personal computer by a commercial statistical programme package (ISES 1, 2, 3). The multivariate analyses ran on a Hungarian TPA computer and the programme for it was written by KOVÁCS L. and KOVÁCS G. Both of the programmes required a certain transformation of the qualitative data, i.e. they have been transformed onto a binary nominal scale, as follows:

- colour of the sepals and petals was considered as a combination of presence and absence of two colour factors, that of the green and pink ones. The possible code numbers of the colours are 1,0 (green), 0,1 (pink), 1,1 (greenish pink) and 0,0 (white).
- colour of the appendix was definied similarly: 1,0 (yellow), 0,1 (brown), 1,1 (brownish-yellow). The code 0,0 was not interpreted.
- shape of the appendix was definied as the combinations of two shape-factors, i.e. tridentate and cut. The codes were 1,0 (tridentate), 0,1 (cut) and 1,1 (transitional), see Fig. 3. The code 0,0 was not interpreted.

Such coding may not be fully correct for the two last characters, but we could not find any other method to transform them from an ordinal to a nominal scale. First we determined the distribution of the variables in the subsamples and then in the total sample. An example of the distribution of the length of the horn is shown in histograms (Fig. 4). The frequency data of the qualitative characters are given in Table 2. Normality of the distribution of the quantitative characters was tested by $chi^2$ test and most of the tests were negative. We calculated the means and standard deviations of the characters (Table 3). Paired significance tests were made for each character between the following subsamples: Pécs-Kunpeszér (locality), 1983-1984, 1983-1985, 1984-1985 (generation), Pécs 1983-1984, Pécs 1983-1985, Pécs 1984-1985, Kunpeszér 1983-1984, Kunpeszér 1983-1985, Kunpeszér 1984-1985 (generations at the same place), i.e. F and T tests for the qualitative characters and $chi^2$ test for the qualitative ones (Tables 4. and 5).

The multivariate analysis was made in two steps. First a similarity matrix was composed including both the qualitative and quantitative characters (GOWER 1971). The calculation is as follows:

$$S_{ij} = \sum_{i=1}^{v} w_{ijk} s_{ijk} \Big/ \sum_{i=1}^{v} w_{ijk} ,$$

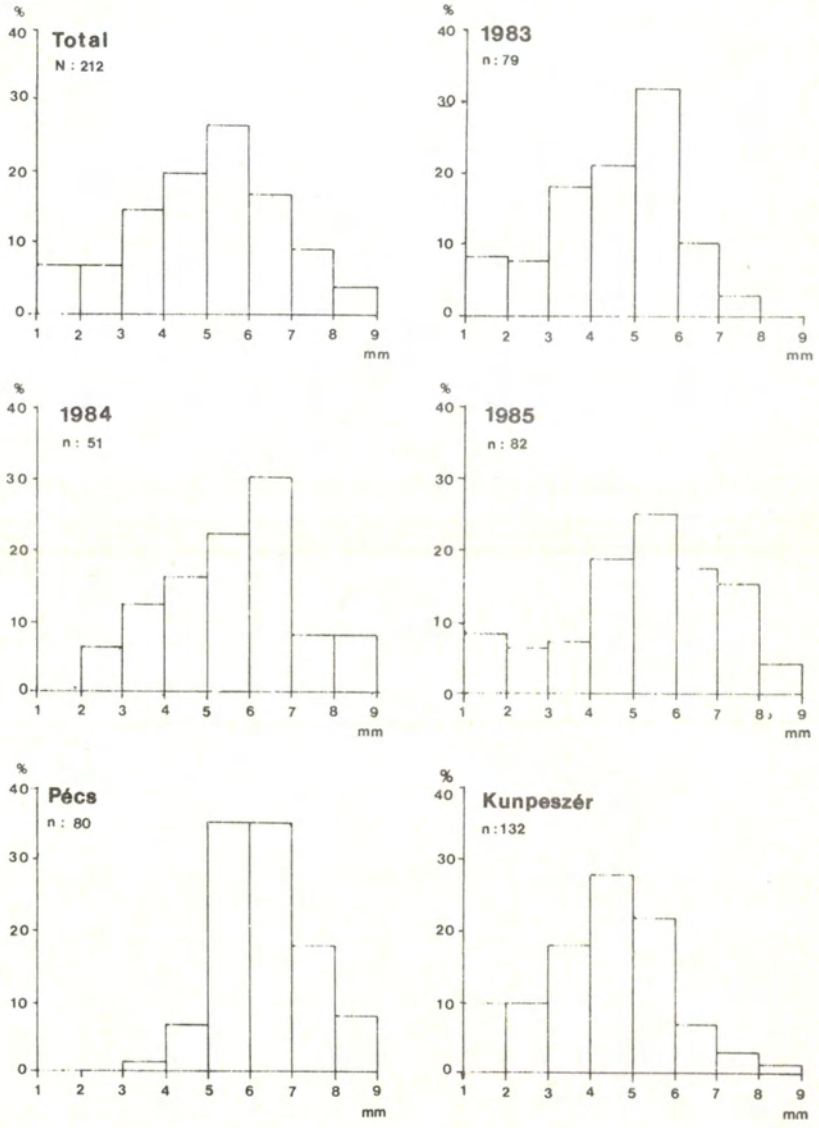



Fig. 4. Distribution of the length of horn in the total sample and subsamples

where

$S_{ij}$ = the coefficient of similarity between the j and k individuals; it ranges from 0 (maximal difference in all characters) to 1 (no difference in any character)

v = number of the examined characters

$w_{ijk}$ and $s_{ijk}$ = partial coefficients of similarity for the i-th single character. They are calculated as follows:

- for binary nominal characters:

| | |
|---|---|
| $w_{ijk} = 1$ and $s_{ijk} = 0$ | in case of difference; |
| $w_{ijk} = 1$ and $s_{ijk} = 1$ | in case of common presence of the character |
| $w_{ijk} = 0$ and $s_{ijk} = 0$ | in case of common absence of the character |

- for quantitative characters:

$$w_{ijk} = 1 \quad \text{and}$$

$$s_{ijk} = 1 - |x_{ij} - x_{ik}| / R_i ,$$

where

$x_{ij}$ = value of the i-th character of the j-th individual

$x_{ik}$ = value of the i-th character of the k-th individual

$R_i$ = range of the i-th character in the whole sample

The matrix obtained by this way was analyzed by the weighted pair group method (PODANI 1980). The similarity between the h, i and j clusters is given by the formula

$$s_{hi,j} = \frac{s_{hj} + s_{ij}}{2}$$

where s markings are similarity values specified by their indices.

For a more convenient evaluation we made some simplifications in the dendrogram (Fig. 5), i.e. the groups of the same localities have been merged into one unit. The value of linkage of these united groups is the lowest value of the original cluster.

## RESULTS

According to the publications cited in the introduction, the differential marks of the species and subspecies of the subseries Oestriferae (SOÓ 1970), i.e. length and width of the labellum, length of the horn, width of the hairless edge of the labellum are defined with an unsatisfactory accuracy: the measuring points on the labellum or the intervals of the horn length are not determined, etc. Some single specimens of all the four subspecies of the group were found, e.g. ssp. oestrifera (wider than long labellum), ssp. heldreichii (longer than 13 mm labellum), ssp. scolopax (short and obtuse horn), ssp. cornuta (long and acute horn). It is clear that the differential characters can be explained only by a statistical approach, and they can be used in this sense for taxonomical classification. For these reasons we declined to give a taxonomical revision, although it is visible that the Pécs population is more closely related to the ssp. cornuta than the Kunpeszér one which corresponds to the ssp. scolopax or rather to the trans. balcanica (scolopax-cornuta, SOÓ 1936).

On the basis of the univariate analyses, remarkable differences were found between the two populations (tables 4 and 5), namely at 0.1 % significance level in the following characters: number of flowers, length of the horn, the colour factors of sepals and petals and length and width of the sepals. From these the number of flowers, the length of horn and the colour factors of the sepals

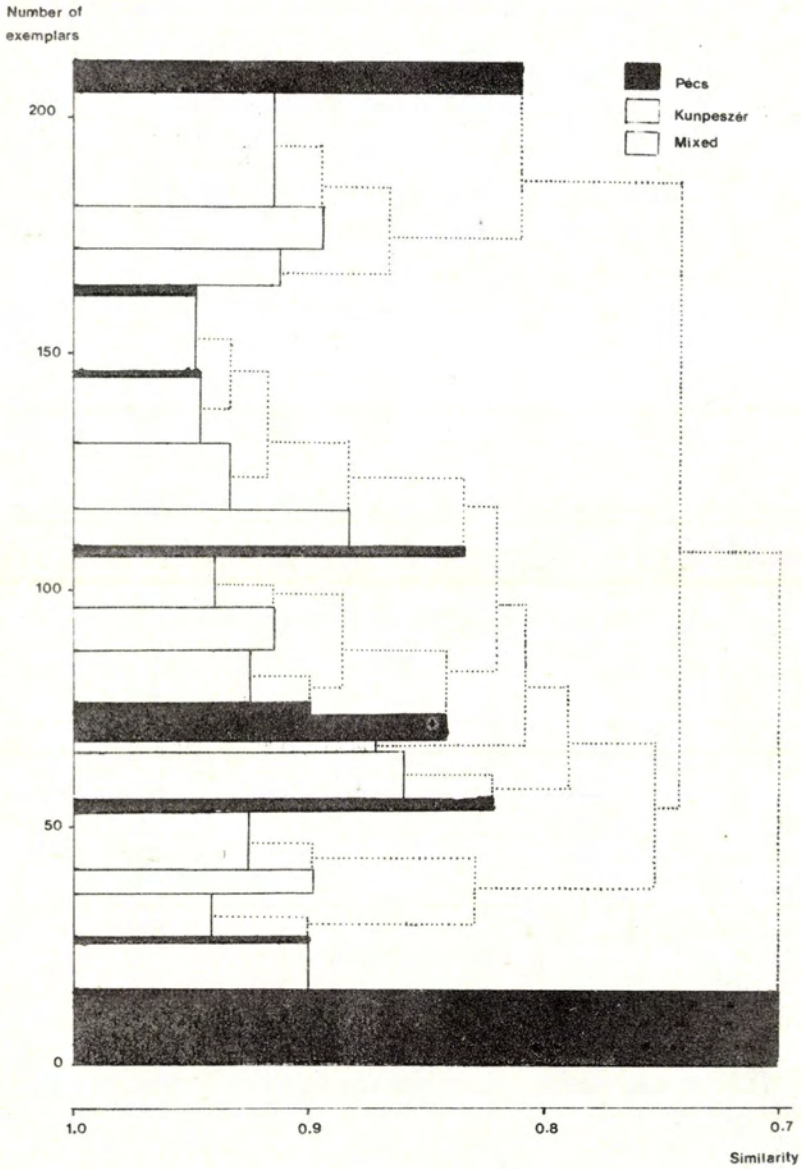



Fig. 5. Dendrogram of similarity of the exemplars

and petals show the same trend in differences in each examined year. The number of flowers is consequently higher in the Kunpeszér population than in Pécs. There is an inverse trend in the length of the horn. At Kunpeszér the dominating colour factor is pink, white is very rare, and green or greenish pink never occur, in contrast with the Pécs population where all kinds of colour are present in a remarkable proportion. These discrepancies can be explained by genetical differences between the two populations. The reason for the significant differences in the size of the sepals is not so clear, because there are also remarkable differences between the subsamples. Weather-dependence of the length of plant is not surprising but this feature is unexpected at the length of labellum.

A considerable part of the characters (size of the petals, colour and shape of the appendix) follows a much more ambivalent trend, i.e. they show high significant differences between certain subsamples, but seem to be homogeous in others of the same range. This can be partly explained by the difficulties of scaling. The ranging of some really continuous characters into 2-3 classes was not always unambiguous and reproducable. Furthermore, the sampling error mentioned above can be a relevant explanation too. The multivariate analysis also verified the existence of well-separated groups of homogeneous localities (Fig. 1). Two isolated groups of the Pécs population can be observed with considerably low values of linkage with the others. These groups are rather heterogeneous in themselves too. The distribution of the intermediate forms is also ordered into more or less homogeneous groups on the basis of their locality.

## CONCLUSIONS

The taxonomical investigation of the genus Ophrys is be set by some special difficulties:

- many populations are genetically heterogeneous
- the original descriptions are insufficient
- the garden culture is unsolved
- the characters can be well observed only on living plants
- some characters change during flowering
- the scaling of some qualitative characters is problematic
- the flowering specimens of one year do not represent the whole population.

Some of these problems have remained unsolved in our investigation, e.g. the nomenclatural identification, the scaling of some qualitative characters or the correct method of sampling. Certain examined characters have proved to be of diagnostic value (length of the horn, colour of the sepals and petals, in contrast with some others) sizes of the flower parts, colour and shape of the appendix. These latter characters are unsuitable for further analysis, but we can propose some new ones for examination. The density of the inflorescence can be composed from the length of inflorescence and the number of flowers; this latter one is itself a distinguishing character. Another possible character is the pattern on the labellum, but to scale it seems to be extremely difficult. A similar examination was made on Ophrys sphegodes (SAPSÁL 1985) without convincing results; it was caused probably by the scaling problems.

According to the descriptions, the hairless edge of the labellum is considered to be an important distinguishing character, but we could not determine it unambiguously, because it has a continuous transition into the papillous part of the labellum. Some other characters e.g. the length of the bractea and the position of the medial sepal may be differential in certain Mediterranean races (DANESCH, SUNDERMANN), but not in the Hungarian ones. They were observed in the first year and we have found them strongly dependent on the phenophase.

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Table 1. Number of the identified and marked specimens

| | Pécs | | | Kunpeszér | | |
|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1985 | 1983 | 1984 | 1985 |
| Number of the new markings | 28 | 0 | 0 | 51 | 0 | 50 |
| Number of the identified flowering exemplars | - | 5 | 0 | - | 0 | 0 |
| Number of the identified budding exemplars | - | 0 | 0 | - | 1 | 0 |
| Number of the identified sterile exemplars | - | 9 | 3 | - | 0 | 0 |
| Number of the identified extinct exemplars | - | 3 | 3 | - | 0 | 0 |
| Total number of the identified markings | - | 17 | 6 | - | 1 | 0 |
| Total number of the lost markings | - | 11 | 22 | - | 50 | 51 |

Table 2. Distributions of the qualitative characters

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 22 | 51 | 73 |
| | presence | 6 | 0 | 6 |
| 1984 | absence | 18 | 30 | 48 |
| | presence | 3 | 0 | 3 |
| 1985 | absence | 22 | 51 | 73 |
| | presence | 9 | 0 | 9 |
| Total | absence | 62 | 132 | 194 |
| | presence | 18 | 0 | 18 |

a./ green factor of sepala

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 9 | 1 | 10 |
| | presence | 19 | 50 | 69 |
| 1984 | absence | 8 | 1 | 9 |
| | presence | 13 | 29 | 42 |
| 1985 | absence | 10 | 1 | 11 |
| | presence | 21 | 50 | 71 |
| Total | absence | 27 | 3 | 30 |
| | presence | 53 | 129 | 182 |

b./ pink factor of sepala

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 21 | 51 | 72 |
| | presence | 7 | 0 | 7 |
| 1984 | absence | 20 | 30 | 50 |
| | presence | 1 | 0 | 1 |
| 1985 | absence | 22 | 51 | 73 |
| | presence | 9 | 0 | 9 |
| Total | absence | 63 | 132 | 195 |
| | presence | 17 | 0 | 17 |

c./ green factor of petala

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 9 | 0 | 9 |
| | presence | 19 | 51 | 70 |
| 1984 | absence | 6 | 1 | 7 |
| | presence | 15 | 29 | 44 |
| 1985 | absence | 8 | 0 | 8 |
| | presence | 23 | 51 | 74 |
| Total | absence | 23 | 1 | 24 |
| | presence | 57 | 131 | 188 |

d./ pink factor of petala

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 4 | 6 | 10 |
| | presence | 24 | 45 | 69 |
| 1984 | absence | 4 | 5 | 9 |
| | presence | 17 | 25 | 42 |
| 1985 | absence | 5 | 2 | 7 |
| | presence | 26 | 49 | 75 |
| Total | absence | 13 | 13 | 26 |
| | presence | 67 | 119 | 186 |

e./ yellow factor of appendix

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 18 | 32 | 50 |
| | presence | 10 | 19 | 29 |
| 1983 | absence | 15 | 21 | 36 |
| | presence | 6 | 9 | 15 |
| 1985 | absence | 18 | 49 | 67 |
| | presence | 13 | 2 | 15 |
| Total | absence | 51 | 102 | 153 |
| | presence | 29 | 30 | 59 |

f./ brown factor of appendix

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 12 | 6 | 18 |
| | presence | 16 | 45 | 61 |
| 1984 | absence | 0 | 2 | 2 |
| | presence | 21 | 28 | 49 |
| 1985 | absence | 21 | 21 | 42 |
| | presence | 10 | 30 | 40 |
| Total | absence | 33 | 29 | 62 |
| | presence | 47 | 103 | 150 |

g./ tridentate factor of appendix

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | absence | 7 | 15 | 22 |
| | presence | 21 | 36 | 57 |
| 1984 | absence | 15 | 11 | 26 |
| | presence | 6 | 19 | 25 |
| 1985 | absence | 4 | 11 | 15 |
| | presence | 27 | 40 | 67 |
| Total | absence | 26 | 37 | 63 |
| | presence | 54 | 95 | 149 |

h./ cut factor of appendix

Table 3. Mean ($\bar{x}$), standard deviation (s) and sample size (n) of the quantitative characters

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | $\bar{x}$ | 21,17 | 25,43 | 24,23 |
| | s | 5,54 | 5,21 | 5,72 |
| | n | 28 | 51 | 79 |
| 1984 | $\bar{x}$ | 23,63 | 26,66 | 25,57 |
| | s | 5,18 | 4,66 | 5,10 |
| | n | 21 | 30 | 51 |
| 1985 | $\bar{x}$ | 33,68 | 23,51 | 27,79 |
| | s | 5,94 | 4,73 | 7,17 |
| | n | 31 | 51 | 82 |
| Total | $\bar{x}$ | 26,93 | 25,32 | 25,93 |
| | s | 8,02 | 5,04 | 6,36 |
| | n | 80 | 132 | 212 |

a./ length of plant (cm)

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | $\bar{x}$ | 3,36 | 5,16 | 4,52 |
| | s | 1,09 | 2,19 | 2,06 |
| | n | 28 | 51 | 79 |
| 1984 | $\bar{x}$ | 4,33 | 6,20 | 5,43 |
| | s | 1,11 | 1,49 | 1,63 |
| | n | 21 | 30 | 51 |
| 1985 | $\bar{x}$ | 3,84 | 5,24 | 4,71 |
| | s | 0,93 | 1,52 | 1,49 |
| | n | 31 | 51 | 82 |
| Total | $\bar{x}$ | 3,80 | 5,42 | 4,81 |
| | s | 1,10 | 1,84 | 1,78 |
| | n | 80 | 132 | 212 |

b./ number of flowers

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | $\bar{x}$ | 0,86 | 1,02 | 0,97 |
| | s | 0,10 | 0,14 | 0,15 |
| | n | 28 | 51 | 79 |
| 1984 | $\bar{x}$ | 1,05 | 1,21 | 1,14 |
| | s | 0,12 | 0,12 | 0,14 |
| | n | 21 | 30 | 51 |
| 1985 | $\bar{x}$ | 0,99 | 1,12 | 1,07 |
| | s | 0,12 | 0,13 | 0,14 |
| | n | 31 | 51 | 82 |
| Total | $\bar{x}$ | 0,96 | 1,10 | 1,05 |
| | s | 0,14 | 0,15 | 0,16 |
| | n | 80 | 132 | 212 |

c./ length of sepala (cm)

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| 1983 | $\bar{x}$ | 0,41 | 0,47 | 0,45 |
| | s | 0,07 | 0,06 | 0,07 |
| | n | 28 | 51 | 79 |
| 1984 | $\bar{x}$ | 0,47 | 0,56 | 0,52 |
| | s | 0,07 | 0,06 | 0,08 |
| | n | 21 | 30 | 51 |
| 1985 | $\bar{x}$ | 0,50 | 0,49 | 0,50 |
| | s | 0,06 | 0,07 | 0,07 |
| | n | 31 | 51 | 82 |
| Total | $\bar{x}$ | 0,46 | 0,50 | 0,48 |
| | s | 0,07 | 0,07 | 0,08 |
| | n | 80 | 132 | 212 |

d./ width of sepala (cm)

Table 3 (continued)

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| | $\bar{x}$ | 0,37 | 0,40 | 0,39 |
| 1983 | s | 0,06 | 0,08 | 0,08 |
| | n | 28 | 51 | 79 |
| | $\bar{x}$ | 0,45 | 0,45 | 0,45 |
| 1984 | s | 0,07 | 0,07 | 0,06 |
| | n | 21 | 30 | 51 |
| | $\bar{x}$ | 0,41 | 0,46 | 0,44 |
| 1985 | s | 0,07 | 0,11 | 0,10 |
| | n | 31 | 51 | 82 |
| | $\bar{x}$ | 0,41 | 0,44 | 0,43 |
| Total | s | 0,07 | 0,10 | 0,09 |
| | n | 80 | 132 | 212 |

e./ length of petala

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| | $\bar{x}$ | 1,14 | 1,16 | 1,15 |
| 1983 | s | 0,09 | 0,13 | 0,12 |
| | n | 28 | 51 | 79 |
| | $\bar{x}$ | 1,30 | 1,40 | 1,36 |
| 1984 | s | 0,05 | 0,08 | 0,08 |
| | n | 21 | 30 | 51 |
| | $\bar{x}$ | 1,04 | 1,08 | 1,07 |
| 1985 | s | 0,09 | 0,08 | 0,09 |
| | n | 31 | 51 | 82 |
| | $\bar{x}$ | 1,15 | 1,18 | 1,17 |
| Total | s | 0,13 | 0,16 | 0,15 |
| | n | 80 | 132 | 212 |

f./ length of labellum

| | | Pécs | Kunp. | Total |
|---|---|---|---|---|
| | $\bar{x}$ | 0,58 | 0,44 | 0,49 |
| 1983 | s | 0,08 | 0,14 | 0,14 |
| | n | 28 | 51 | 79 |
| | $\bar{x}$ | 0,69 | 0,52 | 0,60 |
| 1984 | s | 0,11 | 0,15 | 0,16 |
| | n | 21 | 30 | 51 |
| | $\bar{x}$ | 0,74 | 0,45 | 0,56 |
| 1985 | s | 0,09 | 0,15 | 0,19 |
| | n | 31 | 51 | 82 |
| | $\bar{x}$ | 0,67 | 0,46 | 0,54 |
| Total | s | 0,11 | 0,15 | 0,17 |
| | n | 80 | 132 | 212 |

g./ length of horn

Table 4. Homogeneity tests (F- and t-values) of the quantitative characters

| | | Pécs-Kunpeszér | 1983-1984 | 1983-1985 | 1984-1985 | Pécs 1983-Kunp.1983 | Pécs 1984-Kunp.1984 |
|---|---|---|---|---|---|---|---|
| Length of the plant | F | $2.529^{xxx}$ | 1.260 | $1.572^{x}$ | $1.979^{xx}$ | 1.131 | 1.236 |
| | t | $1.797^{x}$ | 1.356 | $3.466^{xxx}$ | $1.924^{x}$ | $3.399^{xx}$ | $2.183^{x}$ |
| Number of flowers | F | $2.826^{xxx}$ | $1.605^{x}$ | $1.925^{xx}$ | 1.199 | $4.037^{xxx}$ | $1.802^{x}$ |
| | t | $7.155^{xxx}$ | $2.667^{xx}$ | 0.667 | $2.633^{xx}$ | $4.873^{xxx}$ | $4.876^{xxx}$ |
| Length of sepala | F | 1.166 | 1.127 | 1.228 | 1.089 | $1.960^{x}$ | 1.000 |
| | t | $6.690^{xxx}$ | $6.707^{xxx}$ | $4.629^{xxx}$ | $2.954^{xx}$ | $5.339^{xxx}$ | $4.776^{xxx}$ |
| Width of sepala | F | 1.020 | 1.283 | 1.066 | 1.368 | 1.361 | 1.361 |
| | t | $3.414^{xxx}$ | $5.833^{xxx}$ | $4.826^{xxx}$ | $1.928^{x}$ | $4.005^{xxx}$ | $4.918^{xxx}$ |
| Length of petala | F | $1.702^{xx}$ | $1.570^{x}$ | $1.820^{xx}$ | $2.857^{xxx}$ | $1.903^{x}$ | 1.000 |
| | t | $2.050^{x}$ | $5.043^{xxx}$ | $3.694^{xxx}$ | 0.699 | $1.746^{x}$ | 0.000 |
| Length of labellum | F | $1.460^{x}$ | $1.909^{xx}$ | $1.826^{xx}$ | 1.045 | $2.086^{x}$ | $2.560^{x}$ |
| | t | $1.904^{x}$ | $10.915^{xxx}$ | $5.090^{xxx}$ | $18.896^{xxx}$ | 0.723 | $3.548^{xxx}$ |
| Length of the horn | F | $1.752^{xx}$ | 1.224 | $1.740^{xx}$ | $1.422^{x}$ | $3.063^{xxx}$ | $1.860^{x}$ |
| | t | $10.754^{xxx}$ | $3.873^{xxx}$ | $2.604^{xx}$ | 1.101 | $5.645^{xxx}$ | $4.427^{xxx}$ |
| Number of exemplars | $n_1$ | 80 | 79 | 79 | 51 | 28 | 21 |
| | $n_2$ | 132 | 51 | 82 | 82 | 51 | 30 |

Significance levels: $^{x}$ (P=5%)
$^{xx}$ (P=1%)
$^{xxx}$ (P=0.1%)

Table 5. Homogeneity tests ($Chi^2$-values) of the qualitative characters

| | Pécs-Kunpeszér | 1983-1984 | 1983-1985 | 1984-1985 | Pécs 1983-Kunp.1983 | Pécs 1984-Kunp.1984 |
|---|---|---|---|---|---|---|
| Sepala green | $32.400^{xxx}$ | 0.141 | 0.544 | 0.998 | $8.971^{xx}$ | 2.339 |
| Sepala pink | $40.600^{xxx}$ | 0.618 | 0.020 | 0.440 | $12.289^{xxx}$ | $8.019^{xx}$ |
| Petala green | $30.400^{xxx}$ | 2.550 | 0.201 | 3.670 | $11.065^{xxx}$ | 0.033 |
| Petala pink | $38.800^{xxx}$ | 0.156 | 0.114 | 0.495 | $15.453^{xxx}$ | $4.684^{x}$ |
| Appendix yellow | 1.890 | 0.618 | 0.723 | 2.460 | 0.001 | 0.024 |
| Appendix brown | $4.530^{x}$ | 0.737 | $6.870^{xx}$ | 2.220 | 0.012 | 0.041 |
| Appendix tridentate | $8.940^{xx}$ | $8.470^{xx}$ | $13.900^{xxx}$ | $31.700^{xxx}$ | $8.244^{xx}$ | 0.224 |
| Appendix cut | 0.476 | $7.120^{xx}$ | 2.070 | $15.700^{xxx}$ | 0.024 | $4.663^{x}$ |

Degree of freedom: 1

Significance levels: $^{x}$ (P=5%)
$^{xx}$ (P=1%(
xxx (P=0.1%)

- : $Chi^2$ is uncountable because of division by zero

Table 4 (continued)

| Pécs 1985-<br>Kunp.1985 | Pécs 1983-<br>Pécs 1984 | Pécs 1983-<br>Pécs 1985 | Pécs 1984-<br>Pécs 1985 | Kunp.1983-<br>Kunp.1984 | Kunp.1983-<br>Kunp.1985 | Kunp.1984-<br>Kunp.1985. |
|---|---|---|---|---|---|---|
| 1.577$^{x}$ | 1.144 | 1.150 | 1.315 | 1.250 | 1.213 | 1.030 |
| 8.561$^{xxx}$ | 1.581 | 8.340$^{xxx}$ | 6.297$^{xxx}$ | 0.780 | 1.949$^{x}$ | 2.911$^{xx}$ |
| 2.671$^{xx}$ | 1.037 | 1.374 | 1.425 | 2.160$^{x}$ | 2.076$^{x}$ | 1.041 |
| 4.622$^{xxx}$ | 0.063 | 1.824$^{x}$ | 1.724$^{x}$ | 2.303$^{x}$ | 0.214 | 2.765$^{xx}$ |
| 1.174 | 1.440 | 1.440 | 1.000 | 1.361 | 1.156 | 1.174 |
| 4.519$^{xxx}$ | 6.041 | 4.494$^{xxx}$ | 1.768$^{x}$ | 6.193$^{xxx}$ | 3.738$^{xxx}$ | 3.094$^{xx}$ |
| 1.361 | 1.000 | 1.361 | 1.361 | 1.000 | 1.361 | 1.361 |
| 0.402 | 2.969$^{xx}$ | 5.319$^{xxx}$ | 1.654 | 6.517$^{xxx}$ | 1.549 | 4.575$^{xxx}$ |
| 2.470$^{xx}$ | 1.457 | 1.457 | 1.000 | 1.306 | 1.891$^{x}$ | 2.470$^{xx}$ |
| 2.265$^{x}$ | 4.301$^{xxx}$ | 2.343$^{x}$ | 2.022$^{x}$ | 2.841$^{xx}$ | 3.150$^{xx}$ | 0.447 |
| 1.266 | 3.240$^{xx}$ | 1.000 | 3.240$^{xx}$ | 2.641$^{xx}$ | 2.641$^{xxx}$ | 1.000 |
| 2.093$^{x}$ | 7.916$^{xxx}$ | 4.263$^{xxx}$ | 13.333$^{xxx}$ | 9.132$^{xxx}$ | 3.744$^{xxx}$ | 17.382$^{xxx}$ |
| 2.778$^{xx}$ | 1.891$^{x}$ | 1.266 | 1.494 | 1.148 | 1.148 | 1.000 |
| 9.738$^{xxx}$ | 4.056$^{xxx}$ | 7.185$^{xxx}$ | 1.796$^{x}$ | 2.418$^{x}$ | 0.348 | 2.028$^{x}$ |
| 31 | 28 | 28 | 21 | 51 | 51 | 30 |
| 51 | 21 | 31 | 31 | 30 | 51 | 51 |

Significance levels: $^{x}$ (P=5%)
$^{xx}$ (P=1%)
$^{xxx}$ (P=0.1%)

Table 5 continuing

| Pécs 1985-<br>Kunp.1985 | Pécs 1983-<br>Pécs 1984 | Pécs 1983-<br>Pécs 1985 | Pécs 1984-<br>Pécs 1985 | Kunp.1983-<br>Kunp.1984 | Kunp.1983-<br>Kunp.1985 | Kunp.1984-<br>Kunp.1985 |
|---|---|---|---|---|---|---|
| 13.793$^{xxx}$ | 1.024 | 0.137 | 0.815 | - | - | - |
| 12.740$^{xxx}$ | 0.014 | 0.083 | 0.019 | 0.127 | 0.510 | 0.127 |
| 13.793$^{xxx}$ | 2.221 | 0.003 | 3.314$^{x}$ | - | - | - |
| 11.800$^{xxx}$ | 0.353 | 0.062 | 0.010 | 0.073 | - | 0.073 |
| 2.283 | 0.002 | 0.028 | 0.418 | 0.082 | 1.221 | 2.440 |
| 16.184$^{xxx}$ | 0.043 | 4.928$^{x}$ | 0.474 | 0.177 | 15.351$^{xxx}$ | 8.837$^{xx}$ |
| 4.435$^{x}$ | 13.195$^{xxx}$ | 2.756 | 21.132$^{xxx}$ | 0.128 | 9.873$^{xx}$ | 9.432$^{xx}$ |
| 0.476 | 8.594$^{xx}$ | 0.734 | 16.055$^{xxx}$ | 0.184 | 0.465 | 1.480 |

Degree of freedom: 1

Significance levels: $^{x}$ (P=5%)
$^{xx}$ (P=1%)
$^{xxx}$ (P=0,1%)

- : $Chi^2$ is uncountable because of division by zero