

## Non-metrical Variation in Three Populations of Roe Deer

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An analysis of genetic differentiation in three populations of roe deer, *Capreolus capreolus* (Linnaeus, 1758) from Poland was carried out on the basis of the frequencies of 76 non-metrical cranial variants. Of 2278 correlation coefficients between the variants only 132 (5.8%) differed statistically from zero at  $p=0.01$ . After deleting all variants correlated with one another and linear dimensions of skulls and age, further analysis was based on the frequency of 39 variants. Mean measures of divergence (MMD) were calculated from samples divided into 5-year periods of captures and births, means of capture and kind of hunting area. A high genetic variability of the investigated populations and the influence of the essential stabilizing effect within each of them are shown. Essential differences in the MMD values between the populations did not have any directional tendency from the forest to field ecotype.

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### 1. INTRODUCTION

Roe deer settled in field biotopes not very long ago (Meisnerowski, 1959; Pielowski, 1970) and have evolved many biological, behavioural adaptations to living in this environment. This fact led to the identification of a separate ecotype, the "field roe deer" (Pielowski, 1970, 1977). Pielowski (1977) found that as a result of adjustments to different habitats there existed physiological and biochemical differences between the field and the forest roe deer. Research on the indices of energetic transformation (Majewska *et al.*, 1981) and partial biometrical investigations (Fruziński *et al.*, 1982) confirmed the occurrence of differences between these two "ecotypes".

A question which results from the above situation is: are the recorded differences a result of oscillatory changes in the genetic structure caused by environmental impact, or are they already directional microevolutionary ones?

In recent years non-metrical traits have been successfully applied to investigating transformations of the genetic structure of populations (Berry, 1963, 1968; Yablokov, 1982; and others). The variability of non-

metrical traits in roe deer was studied by Gromov & Skulkin (1986). Their paper concerns intraspecific classification. It is however, based on a different method of distinguishing variants, which limits making comparisons with them.

The aim of the present paper was to determine the genetic intra- and interpopulation differences between the field and forest roe deer ecotypes on the basis of analysis of non-metrical variants.

## 2. STUDY AREA

Research was carried out in three experimental hunting areas situated in the Wielkopolska Lowland (Fig. 1): (1) The Research Station of the Polish Hunting Association at Czempin ( $16^{\circ}45'E$ ,  $52^{\circ}08'N$ ), about 30 km

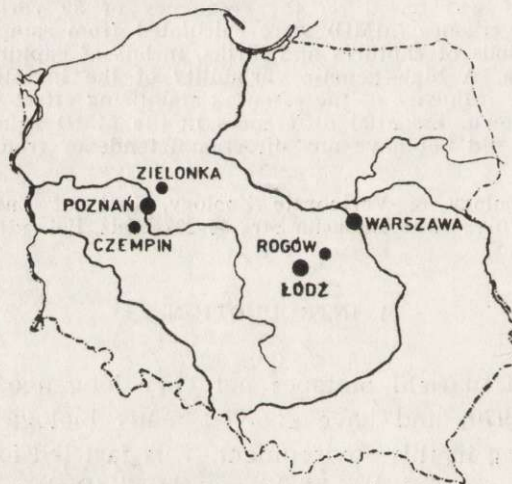


Fig. 1. The localities of the examined experimental hunting areas in Poland.

south of Poznań (about 15,000 ha, including 1,000 ha of forest (7%)). The forests are small (from 50 to 300 ha) and are dominated by pine stands. All of the area is typically agricultural with extensive arable fields, modern, highly mechanized agriculture and high chemicalization of plant protection. (2) Experimental hunting area "Zielonka" of the Agricultural Academy in Poznań ( $17^{\circ}05'E$ ,  $52^{\circ}35'N$ ), situated 22 km south-east of Poznań and about 52 km from Czempin (about 8,000 ha). It is completely covered by forest, and is dominated by pine stands which comprise 85% of the area, with low percentages of mixed, oak-pine and alder swampy forests. (3) Experimental hunting region "Rogów" of the Warsaw Agr. University ( $19^{\circ}53'E$ ,  $51^{\circ}48'N$ ), about 30 km east of Łódź (13,000 ha). Forests cover about 21% of the area and are dominated

by mixed coniferous-deciduous (56%) and coniferous stands (23%). Arable fields cover 86%, orchards 4%, meadows and pastures 5% of the area. The agriculture includes small farming, the average field size being 1 ha.

### 3. MATERIAL

The material consisted of 369 complete roe deer skulls, (226♂♂, 143♀♀): Czempień (116), Zielonka (125) and Rogów (128), obtained mainly from hunting in 1980—1984 (214). The other 155 skulls, mainly bucks, were from the collection of the Research Station of the Polish Hunting Association at Czempień (112) and from that of the Department of Wildlife Management of the Agricultural Academy in Poznań (43). Both collections were established mainly in 1967—1979.

Age was determined on the basis of tooth wear (Pielowski, 1970). Some of the Czempień skulls were from roe deer marked or born in captivity; consequently, their age was known.

For interpopulation analysis the material was divided into samples, according to the place and way it was obtained (1 — shot, 2 — found carcasses, killed in road accidents) and year of birth and capture relying on age calculation. Due to the lack of material from 1967—1979 and limited possibilities of comparing materials obtained in 1980—1984, all of the material was cumulated into 5-year periods of captures and births, starting from 1965. This was done in order to gain knowledge on genetic trends in the studied populations.

### 4. METHODS

#### 4.1. Non-metrical Variants

We attempted to choose variants of non-metrical traits analogous to those in the system already known in the laboratory mouse or other mammalian species, of which the genetic mechanism is partially understood (Sjøvold, 1977). However, the differences in the skull structure of various mammalian species made many previously described variants inapplicable and new traits had to be typified. In the present paper only 25 of the total 76 variants used were taken from earlier studies (Grüneberg, 1951; Berry & Searle, 1963; Wiig & Lie, 1984; Markowski & Pucek, in prep.). Definitions of the studied traits are given in Appendix 1. (Fig. 2).

To calculate the mean measure of divergence (MMD) and to analyse all types of correlations among the variants and metrical parameters, and the variants and homogeneity of their frequencies depending on sex, age and areas the following variants were considered: 1 — situation in the median line of the skull, regarded as equal with occurrence on both sides, 2 — of the variants which may appear on both sides only those which occurred symmetrically, taking the skull as a unit.

#### 4.2. Statistical Methods

The application of cumulation formulas for determining the divergency between samples required employing noncorrelated variants (Sjøvold, 1977). The Pearson

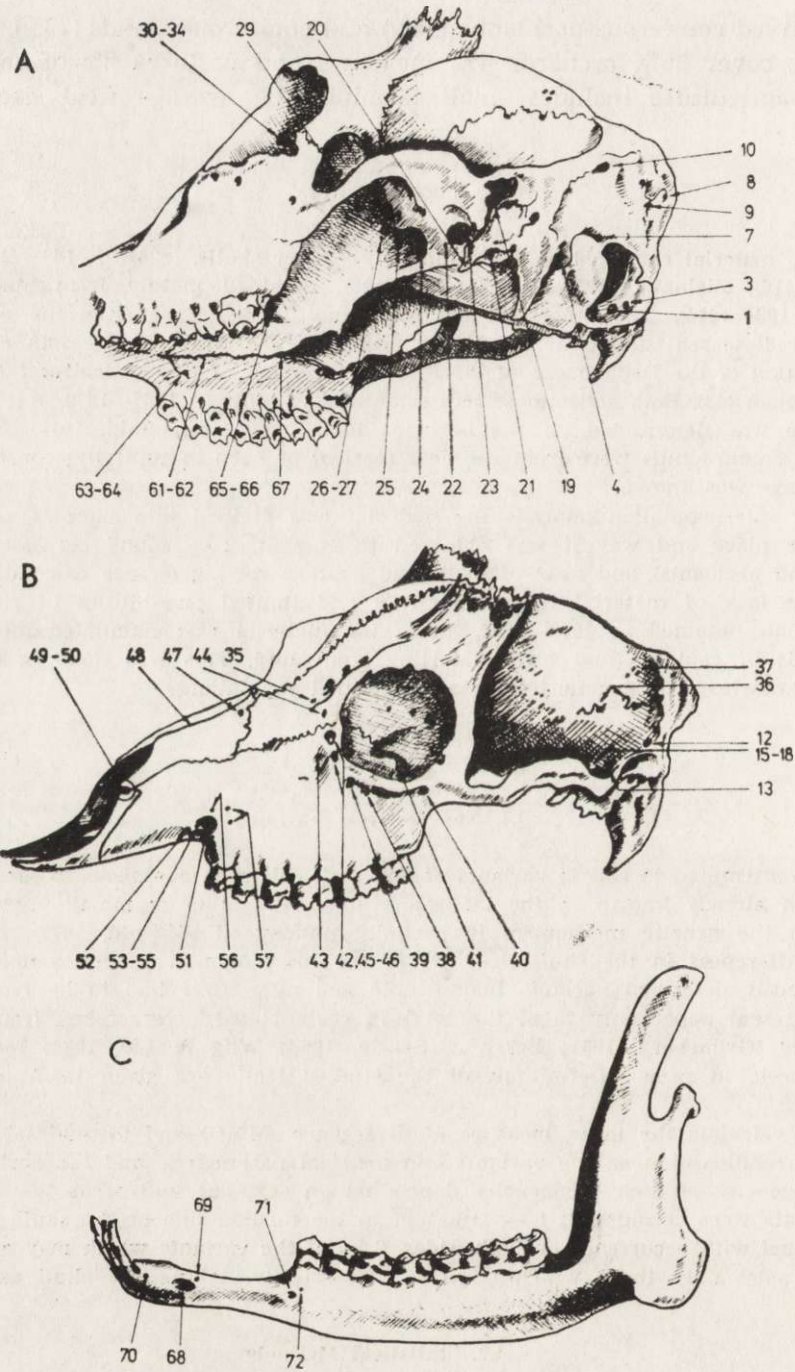


Fig. 2. The location of non-metric traits of the roe deer skull: A) ventrolateral view, B) dorsolateral view, C) mandible.

linear correlation coefficient was used to determine the degree of correlation between the non-metrical variants and metrical parameters: body weight, condylobasal length and mandible length (Sjøvold, 1977). The Pearson coefficient was used to determine the degree of correlation between the variants (Sjøvold, 1977).

The homogeneity of occurrence of non-metrical variants in samples, taking into account the areas, season of capture, age and sex were tested using the Chi-square test.

To determine the genetic differences between the investigated populations the following formula of mean measure of divergence (MMD) proposed by C.A.B. Smith and adapted by Constandse-Westerman (1972) after Finnegan and Coopridge (1978) was used:

$$\text{MMD} = \frac{1}{r} \sum_{i=1}^r \left[ (\theta_{1i} - \theta_{2i})^2 - \left( \frac{1}{n_{1i}} + \frac{1}{n_{2i}} \right) \right]$$

where:  $r$  — number of variants,  
 $n_1, n_2$  — number of individuals in samples,  
 $\theta$  — angular transformation of the percentage incidence ( $p$ ) measured in radians, such that  $\theta = \sin^{-1} (1-2p)$

MMDs were determined with the following equations (Berry, 1963):

$$\text{VAR}_{\text{MMD}} = \frac{4}{r} \left( \frac{1}{n_1} + \frac{1}{n_2} \right) \text{MMD}$$

$$\text{SD}_{\text{MMD}} = \sqrt{\text{VAR}_{\text{MMD}}}$$

Differences were statistically significant if the MMD value was two times higher than the standard deviation of the MMD.

## 5. RESULTS

### 5.1. Correlation Between Variants

Correlation between variants was calculated for the entire material (369 individuals) on the basis of two-way tables. Taking advantage of the fact that the product of the square correlation coefficient and abundance coefficient values had a  $\chi^2$  distribution at one degree of freedom, the critical Pearson coefficient values at  $p=0.01$  ( $r=0.134$ ) and at  $p=0.05$  ( $r=0.102$ ) were calculated.

Of 2278 calculated correlation coefficients between the variants only 132, i.e. 5.8%, were significantly different from zero at  $p=0.01$  and 268, i.e. about 12%, at  $p=0.05$ . The largest number of correlations (from 7 to 12) was found in 9 variants no. 15, 17, 18, 30, 45, 48, 60, 73 and

74. They supplied a total of 83 (about 62%) significant correlations at  $p=0.01$ .

### 5.2. Correlation Between Variants and Body Weight and Linear Skull Parameters

The linear correlation coefficient values between the non-metrical variants and metrical parameters were calculated separately for males and females. Their significance was tested with the Student *t*-test.

The values of the correlation coefficients were very low and only some of them displayed statistically significant correlations with metrical parameters (at  $p=0.05$ ). 10 variants in males (no. 7, 15, 22, 23, 35, 48, 53, 54, 60 and 74) and 5 in females (no. 7, 11, 22, 48 and 73) displayed significant correlation with weight. Only two linear skull parameters were chosen for the correlation: condylobasal length (Cb) and mandible length. Condylobasal length in males was correlated with four variants (no. 24, 27, 32 and 73) and mandible length with two variants (42 and 74). In females Cb was statistically significantly correlated with 5 variants (no. 13, 17, 24, 40 and 45) and only one with mandible length (no. 42).

### 5.3. Homogeneity to Variants' Occurrence Depending on Sex, Age and Area

The  $\chi^2$  test at  $p=0.01$  was applied to check the independence of trait occurrence in sex and age groups. No significant relations were recorded between sex and frequency of non-metrical traits. Only 3 variants (no. 18, 20 and 55) displayed an essential dependence on age. Only 4 variants (no. 13, 17, 20 and 35) displayed no significant frequency differences between the hunting areas and study periods.

### 5.4. Inter- and Intrapopulation Variability

The analysis of differences was based on mean measures of divergence (MMD) for the calculation of which, 39 variants (displaying no correlation with age, areas, metrical parameters or correlation between them) were used. The frequencies of these variants in the three investigated populations are presented in Table 1 and the MMD and their standard deviations in Table 2. Differences between pairs of compared areas are statistically significant ( $MMD \pm 2SD$ ). The highest value of the uniqueness measure (MU) was found in the Czempin population, a lower one in that of Rogów and the lowest one in that of Zielonka (Table 2).

To determine the divergence of the investigated population resulting from geographical location the MMD measures between samples were calculated rejecting variants depending on the ecotype (no. 14, 36, 39, 44 and 49). The significance of differences in the frequency of given variants was tested at  $p=0.05$  when the value of  $(\theta_1 - \theta_2)^2 > 3 \left( \frac{1}{n_1} + \frac{1}{n_2} \right)$  where  $\theta = \sin^{-1}(1-2p)$ . The MMD values proved to be statistically

Table 1  
Percentage frequencies of non-metrical skull variants.

Trait no.	Czempin n=116	Rogów n=128	Zielonka n=125
1	.17	.20	.30
2	.34	.42	.24
3	.70	.78	.62
4	.50	.45	.48
6	.31	.34	.20
8	.59	.60	.65
9	.10	.23	.17
12	.02	.01	.01
14	.09	.01	.02
21	.16	.09	.23
23	.03	.02	.02
25	.14	.13	.11
26	.09	.16	.13
29	.01	.04	.06
31	.06	.10	.15
34	.26	.16	.18
36	.59	.47	.45
37	.66	.51	.64
38	.85	.84	.93
39	.10	.19	.22
41	.01	.01	.02
43	.39	.29	.42
44	.15	.24	.30
47	.06	.09	.14
49	.32	.51	.48
51	.01	.09	.02
52	.47	.27	.36
57	.59	.62	.63
58	.01	.02	.02
61	.70	.76	.74
62	.42	.63	.46
65	.02	.02	.02
66	.13	.17	.10
67	.48	.30	.40
68	.03	.04	.02
69	.00	.01	.02
70	.04	.04	.02
71	.66	.70	.78
72	.01	.00	.00

Table 2

Mean measures of divergence based on the individual as a unit. Standard deviations are given below. M.U. the measures of uniqueness. Significant differences marked with asterisks.

	Rogów	Zielonka	M.U.
Czempień	.034 *	.025 *	.030
	.008	.006	
Rogów	—	.022 *	.028
		.006	
Zielonka		—	.023

Table 3

Percentage frequencies of non-metrical variants according to five-year periods of birth in the Czempień shoot area.

Trait No.	Periods of birth				
	1961— 1965 n=12	1966— 1970 n=22	1971— 1975 n=52	1976— 1980 n=26	1981— n=4
1	.25	.05	.25	.12	.25
2	.25	.36	.37	.27	.50
3	.75	.64	.71	.73	.50
4	.67	.41	.52	.50	.25
6	.17	.50	.27	.31	.25
8	.67	.55	.60	.58	.50
9	.08	.18	.04	.19	.00
12	.00	.05	.00	.00	.25
14	.08	.05	.08	.15	.25
21	.00	.05	.23	.23	.00
23	.00	.00	.06	.04	.00
25	.25	.14	.12	.15	.00
26	.17	.00	.15	.04	.00
29	.00	.00	.02	.00	.00
31	.00	.09	.08	.04	.00
34	.25	.45	.23	.19	.00
36	.67	.55	.62	.58	.50
37	.50	.55	.73	.77	.25
38	.75	.82	.87	.88	1.00
39	.33	.09	.06	.12	.00
41	.00	.00	.02	.00	.00
43	.33	.27	.38	.46	.75
44	.17	.14	.17	.04	.50
47	.08	.09	.04	.08	.00
49	.17	.41	.27	.46	.00
51	.00	.00	.02	.00	.00
52	.50	.36	.52	.50	.25
57	.58	.36	.71	.54	.50
58	.00	.00	.02	.00	.00
61	.67	.68	.65	.77	1.00
62	.42	.50	.40	.42	.25
65	.00	.05	.02	.00	.00
66	.08	.23	.17	.00	.00
67	.58	.55	.48	.42	.25
68	.00	.00	.04	.08	.00
69	.00	.00	.00	.00	.00
70	.25	.00	.02	.04	.00
71	.42	.77	.67	.62	.75
72	.00	.00	.02	.00	.00



significant in each comparison (matrices of initial values). Similarly, excluding variants depending on geographical distribution (no. 37, 51 and 62) the MMD values between the investigated populations were statistically significant, too.

The interpopulation divergence was analysed using the MMD<sub>s</sub> calculated for samples with respect to the area where they obtained, year of collection, year of birth (backaging) and way of collecting (shot or found carcasses). All the comparisons could be made on the Czempin material.

For the Rogów samples the analysis could be made with respect to year of birth and for the Zielonka samples with respect to year of collection and year of birth. Taking into account the main road network the Czempin hunting area was divided into 8 smaller subareas. Differences in the MMD<sub>s</sub> between these subareas were statistically insignificant. Also, the divergence measures for samples comprising five year periods of collection were statistically insignificant. In contrast, for samples comprising five year birth periods only one comparison (1966/1970—1971/1975) was significant and the other measures did not differ (Tables 3, 4). No significant differences were recorded between samples of shot animals and these found dead or killed in road accidents.

In Rogów the MMD<sub>s</sub> for the two five-year birth periods were statistically significant (Table 5).

In the Zielonka area the MMDs for five-year collection periods were statistically insignificant, while in most cases of samples covering five-year birth periods the MMDs were statistically significant (Tables 6, 7).

Table 4

Mean measures of divergence based on the samples according to five-year periods of birth in the Czempin shoot area. Significant differences are marked with an asterisk.

	1966— 1970	1971— 1975	1976— 1980	1981—
1961—	.033	.016	.007	.069
1965	.021	.013	.009	.048
1966—		.046 *	.028	.081
1970		.017	.015	.050
1971—			.010	.089
1975			.008	.050
1976—				.081
1980				.049

Table 5

Percentage frequencies of non-metrical variants according to five-year periods of birth in the Rogów shoot area. Mean measure of divergence (standard deviation)=0.026 (0.010).

Trait No.	Periods of birth	
	1976—1980 n=83	1981 n=44
1	.16	.25
2	.39	.48
3	.80	.77
4	.46	.43
6	.29	.43
8	.67	.45
9	.24	.20
12	.01	.00
14	.00	.02
21	.08	.09
23	.02	.02
25	.12	.14
26	.16	.14
29	.05	.02
31	.14	.02
34	.14	.18
36	.55	.32
37	.55	.43
38	.86	.84
39	.22	.14
41	.00	.02
43	.34	.18
44	.28	.18
47	.10	.07
49	.57	.41
51	.08	.11
52	.30	.20
57	.64	.57
58	.04	.00
61	.77	.73
62	.73	.43
65	.02	.00
66	.20	.11
67	.30	.30
68	.04	.02
69	.01	.00
70	.04	.05
71	.71	.66
72	.00	.00

Table 6

Percentage frequencies of non-metrical variants according to five-year periods of birth in the Zielonka shoot area.

Trait No.	Periods of birth				
	1961— 1965 n=13	1966— 1970 n=12	1971— 1975 n=16	1976— 1980 n=64	1981— n=20
1	.23	.17	.19	.36	.30
2	.23	.25	.06	.31	.15
3	.62	.58	.50	.63	.75
4	.23	.50	.44	.47	.70
6	.15	.25	.13	.20	.25
8	.69	.50	.50	.72	.60
9	.31	.17	.13	.17	.10
12	.00	.00	.06	.00	.00
14	.23	.00	.00	.00	.00
21	.00	.25	.25	.30	.15
23	.00	.00	.00	.02	.05
25	.31	.08	.13	.09	.05
26	.08	.00	.06	.22	.00
29	.00	.00	.13	.03	.15
31	.31	.25	.13	.14	.05
34	.08	.08	.06	.27	.15
36	.46	.42	.50	.45	.40
37	.77	.58	.69	.64	.55
38	1.00	1.00	.94	.89	.95
39	.38	.33	.19	.20	.15
41	.00	.00	.06	.02	.05
43	.62	.58	.56	.33	.35
44	.31	.25	.13	.36	.30
47	.31	.08	.13	.14	.10
49	.46	.33	.50	.53	.40
51	.00	.08	.00	.02	.00
52	.77	.50	.44	.25	.30
57	1.00	1.00	.81	.48	.50
58	.00	.00	.00	.00	.10
61	.69	.58	.69	.78	.80
62	.54	.67	.69	.41	.30
65	.08	.00	.00	.02	.00
66	.08	.25	.06	.06	.15
67	.38	.25	.56	.42	.30
68	.00	.00	.13	.00	.00
69	.00	.17	.00	.00	.00
70	.00	.00	.00	.03	.00
71	.85	.75	.69	.78	.80
72	.00	.00	.00	.00	.00

Table 7

Mean measures of divergence based on the samples according to five-year periods of birth in the Zielonka shoot area. Significant differences are marked with an asterisk.

	1966— 1970	1971— 1975	1976— 1980	1981
1961—	.001	.062 *	.149 *	.167 *
1965	.003	.030	.038	.047
1966—		.001	.101 *	.064 *
1970		.004	.032	.030
1971—			.039 *	.017
1975			0.18	.014
1976—				.018
1980				0.11

## 6. DISCUSSION

It appears that non-metrical traits are usually not correlated with sex. Despite significant correlations between several variants and sex found by Berry and Jakobson (1975) and Truslowe (1976) they usually considered them as exceptional. Further studies on other mammalian species, such as red fox (Sjøvold, 1977), striped field mouse (Sikorski, 1982), hooded seal (Wiig & Lie, 1984) and lynx (Wiig & Anderson, in prep.) showed the occurrence of correlations between non-metrical variants and sex. It is assumed that these correlations result from the occurrence of dimorphic differences, which is also supported by the existence of connections between some of these traits and body size (Sjøvold, 1977; Wiig & Andersen, in prep.).

Lack of correlations between non-metrical variants and sex in the roe-deer of the studied material may result from small differences in sex dimorphism which were recorded in this species with respect to body size (Fruziński *et al.*, 1982) as well as to skull size (Markowski & Markowska, in prep.). Or, it may result from the analysis of correlations coefficients omitting divisions into investigated areas.

According to Falconer's model (1964), in which non-metrical variants are continuous in their genetic structure, their correlations with body size might be expected (Sjøvold, 1977). In the case of roe deer a slightly higher number of variants was correlated with metrical parameters in males (15) than in females (11). These differences might possibly result from the greater numbers of younger males in the samples, as a consequence of overshooting of males (Fruziński & Łabudzki, 1982). Wiig

and Andersen (in prep.) detected in the lynx a higher percentage of correlations in females. It turned out that their female samples comprised individuals younger than those of males. Having considered corrections for age, only one correlation proved significant.

Roe deer age affected variants' frequency less than body size, which contrasts the study of Wiig & Andersen (in prep.). In roe deer, variants (no. 18, 20 and 55) were correlated with age but did not exhibit any relation with metrical parameters which may partially be connected with the fact that a larger skull does not have to belong to an older specimen.

The relation between body size and non-metrical variants may be explained in two ways: (1) changes in variants' frequencies may be a direct function of body size, or (2) these changes may be a function of genetic differences between large and small individuals within a given sex (Sjøvold, 1977).

The use of non-metrical variants in population studies necessitates the lack of correlations between them (Sjøvold, 1977). In roe deer the number of correlations between the variants of non-metrical traits was low and did not exceed 6% (at  $p=0.01$ ) and 12% (at  $p=0.05$ ). On the whole, the degree of correlation was low and did not exceed  $r=0.250$ , while certain high values of the correlation coefficient resulted from high variability in the number of foramens and their size, e.g. group variants of the supra-orbital foramens (no. 31, 32, 33 and 34) or variants located in the anterior fossa of the zygomatic process of the temporal bone (no. 17 and 18). Sometimes it was impossible to determine decisively where they belonged and such variants were scored separately. In fact, they may represent a single variant of multivariety expression. Another group was formed by variants of high frequency and generally low variability (e.g. variants 27, 41, 45, 60, 73 and 74), which resulted in high correlation values. The number of significant correlations for the 76 investigated variants was higher than it would be if they had a random distribution and except for the 12 above mentioned ones (see Chapter 5.1), values of correlation coefficients did not exceed  $r=0.250$ . Similar regularities in variants' correlations were obtained also in other mammals (Sjøvold, 1977; Sikorski, 1982; Wiig & Andersen, in prep.).

It seems that causes of variants correlations are due to the genetic effects of the same alleles or some environmental factors (Sjøvold, 1977). Low values of correlation coefficients enable, according to Sjøvold (1977) treating non-metrical variants as if they were independent of one another, which should not distort results. This conclusion might be ensured if in further analysis those variants which display a certain value of correlation are taken into account.

No statistical differences in the MMDs both for the established territorial division and for five-year periods of collection indicate a higher homogeneity of symmetric non-metrical variants' occurrence in the roe deer populations at Czempin, despite various habitat conditions in the region, which determine ecological differences in the organization of mid-field forest and open field populations (Pielowski & Bresiński, 1982) and even morphological differences in size and skull growth rate (Markowski & Markowska, in prep.). No genetic differences between roe deer of mid-field forest and open field is explainable in light of results by Pielowski and Bresiński (1982). They showed roe deer's preference for the forest environment, fast saturation of the forest habitat by the deer from fields after total removal of these animals from the forest, existence of high density of roe deer in the forest and weak migration from forest into fields.

Significant differences were recorded between subsequent five-year of birth periods, lower ones at Czempin, and higher ones at Zielonka and Rogów. Tables 3, 5 and 6 show a higher genetic variability in the latter two. No differences between samples of subsequent obtaining periods would support the fact that gene pool stabilization takes place there.

An analysis of tendencies in frequency changes of given variants is difficult to interpret at the intra- and interpopulation level. This ensues from lack of knowledge on adaptation values of the given variants and lack of data on other field and forest populations of roe deer in Poland and elsewhere.

Essential differences between the studied populations are definite and the degree of difference between them does not depend on their distance. The two closely situated populations of Czempin and Zielonka (about 50 km apart) differed more from each other than the populations of Zielonka and Rogów (about 215 km apart). This might be explained by a more basic physiological difference of the Czempin roe deer. Analysis of asymmetry of non-metrical variants supports this assumption (Markowski, in prep.). Roe deer of the Czempin population are characterized by a higher asymmetry of variants' occurrence (mean 16.8%), displaying a decline tendency from 20% to 15% from 1960—1980. Roe deer from Zielonka had a lower asymmetry (mean 13.6%), with slight fluctuations in 1960—1980.

The recorded interpopulation differences result rather from dynamic ecological processes modifying the gene pool separately in each of the populations than a directional tendency in microevolutionary processes and express the adaptability of this species to changing environmental conditions.

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#### NIEMETRYCZNA ZMIENNOŚĆ TRZECH POPULACJI SARN

##### Streszczenie

W oparciu o częstości występowania 76 cech niemetrycznych przeprowadzono analizę zróżnicowania genetycznego trzech populacji sarny, *Capreolus capreolus* (Linnaeus, 1758) z terenu Polski. Sarny pochodziły z doświadczalnych obwodów łowieckich: Czempień, Zielonka (woj. poznańskie), Rogów (woj. skierniewickie). Stwierdzono niską korelację między cechami niemetrycznymi oraz pomiędzy niemetrycznymi i metrycznymi. Nie stwierdzono cech skorelowanych z płcią a tylko trzy warianty wykazywały istotne skorelowania z wiekiem. Po odrzuceniu wariantów wykazujących istotne wzajemne skorelowania, dalszą analizę oparto o częstości 39 cech (Tabele 1, 3, 5, 6). Obliczono średnie miary dywergencji (MMD) dla prób, uwzględniających podział na 5-letnie okresy pozyskań i urodzeń, sposób pozyskania (odstrzał, znalezione martwe) i teren. Wykazano istotne różnice miar MMD między badanymi populacjami. W populacji saren leśnych z Zielonki oraz saren z Rogowa różnice miar MMD między próbami obejmującymi 5-letnie okresy urodzeń w większości przypadków okazały się istotne statystycznie a w populacji sarny polnej z Czempinia tylko w jednym przypadku. Stwierdzono brak istotnych różnic miar między próbami obejmującymi 5-letnie okresy pozyskań w obrębie każdej populacji.

Uzyskane wyniki wykazują odrębności genetyczne badanych populacji oraz działanie efektów stabilizujących częstości cech niemetrycznych w obrębie każdej z nich.

Zarejestrowane istotne różnice statystyczne miar MMD między populacjami nie mają charakteru zmian kierunkowych (od formy leśnej do polnej) i są wynikiem procesów ekologicznych zmieniających pulę genową.



## APPENDIX 1

## The list of non-metric traits

Trait	Authors
1. Internal hypoglossi foramen double	Markowski & Pucek (in prep.)
2. Accessory internal hypoglossi foramen present	Sjøvold (1977)
3. Internal condylar foramen present	
4. External condylar foramen opens into a mutual canal with external hypoglossi foramen	
5. External condylar foramen double	
6. Foramina in fossa condylaris	Markowski & Pucek (in prep.)
7. Supracondylar foramen present	Wiig & Lie (1984)
8. External supraoccipital foramen present (Foramen situated at the base of crista nuche)	
9. Medial supraoccipital foramen present	
10. Mastoideum foramen present	
11. Meatus temporale foramen present	
12. Meatus temporale double	Rees (1969)
13. Accessory meatus temporale foramen present	Rees (1969)
14. Accessory meatus temporale foramen double	
15. Foramen temporalis I (Foramen situated in posterior part of fossa temporalis) present	
16. Foramen temporalis I double	
17. Foramen temporalis II (Foramen situated in anterior part of fossa temporalis) present	
18. Foramen temporalis II double	
19. Postglenoid foramen double	
20. Processus muscularis present	
21. Lateralo-basilar foramen present	
22. Anterior accessory foramen near foramen ovale present	Rees (1969)
23. Posterior accessory foramen near foramen ovale present	
24. Accessory foramen I by foramen orbito-rotundum present	Sjøvold (1977)
25. Accessory foramen II by foramen orbito-rotundum present	
26. Accessory foramen I by foramen opticum present	
27. Accessory foramen II by foramen opticum present	
28. Foramen penetrating dorsum sellae	
29. Ethmoidale foramen double	Berry & Searle (1963)
30. Foramen supraorbitale inferior I double	
31. Foramen supraorbitale inferior II present	
32. Accessory foramen I by foramen supraorbitale inferior present	
33. Accessory foramen II by foramen supraorbitale inferior present	
34. Accessory foramen III by foramen supraorbitale inferior present	
35. Accessory foramen by foramen supraorbitale superior	
36. Two and more foramina in sutura parietooccipitalis	
37. Two and more foramina in parietal bone	Rees (1969)
38. Zygomaticum anterior foramen present	
39. Accessory zygomaticum anterior foramen present	
40. Zygomaticum posterior foramen present	Rees (1969)
41. Intersutura fontanele between lacrimal and zygomatic bone present	

## Appendix 1. concluded.

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42. Lacrimale foramen double	
43. <b>Infralacrimale foramen present</b>	
44. <b>Supralacrimale foramen present</b>	
45. Lacrimale superior foramen (on the lacrimal crest) present	
46. Lacrimale inferior foramen (on the lacrimal crest) present	
47. Foramen penetrating nasal bone present	Sjøvold (1977)
48. Sutura internasalis present	
49. Intermaxillare bone connected with nasal bone	
50. Nasal bone protruding from the distal line of maxillar bone	
51. <b>Infraorbitale foramen double</b>	Rees (1969)
52. Accessory infraorbitale foramen present	
53. Accessory foramen I inside infraorbitale foramen present	
54. Accessory foramen II inside infraorbitale foramen present	
55. Accessory foramen III inside infraorbitale foramen present	
56. Accessory foramen supra-infraorbitale present	
57. Foramina maxilla above premolar I present	
58. Canine teeth present	Grüneberg (1951) Stube (1965)
59. Accessory upper premolar absent	Grüneberg (1951) Stube (1965)
60. Upper molar III present	Grüneberg (1951) Stube (1965)
61. Suture intermaxillae serrated	
62. Foramina inside sutura maxillae present	
63. Palatal foramen off suture present	Rees (1969)
64. Accessory foramen by palatal foramen present	Sjøvold (1977)
65. Posterior palatal foramen double	Rees (1969)
66. Accessory foramen by posterior palatal foramen present	
67. Palatal notch cross palatal edge	
68. Mental foramen double	Berry & Searle (1963)
69. Superior accessory mental foramen present	
70. Inferior accessory mental foramen present	
71. Posterior mental foramen present	Rees (1969) Sjøvold (1977)
72. Posterior accessory mental foramen present	
73. Lower praemolar I absent	Grüneberg (1951) Stube (1965)
74. Lower molar III absent	Grüneberg (1951) Stube (1965)
75. External tuberculum articulare on the left mandible	
76. Accessory foramina below foramen mandible present	

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