ÚSTAV ZEMĚDĚLSKÝCH A POTRAVINÁŘSKÝCH INFORMACÍ

Czech Journal of ANIMAL SCIENCE

ŽIVOČIŠNÁ VÝROBA

ČESKÁ AKADEMIE ZEMĚDĚLSKÝCH VĚD

11

VOLUME 44
PRAGUE
NOVEMBER 1999
ISSN 1212-1819

CZECH JOURNAL OF ANIMAL SCIENCE

An international journal published under the authorization by the Ministry of Agriculture and under the direction of the Czech Academy of Agricultural Sciences

Mezinárodní vědecký časopis vydávaný z pověření Ministerstva zemědělství České republiky a pod gescí České akademie zemědělských věd

Aims and scope: The journal publishes scientific papers and reviews dealing with the study of genetics and breeding, physiology, reproduction, nutrition and feeds, technology, ethology and economics of cattle, pig, sheep, goat, poultry, fish and other farm animal management.
The journal is cited in the bibliographical journal Current Contents – Agriculture, Biology and Environmental Sciences and abstracted in Animal Breeding Abstracts. Abstracts from the journal are comprised in the databases: Agris, CAB Abstracts, Current Contents on Diskette – Agriculture, Biology and Environmental Sciences, Czech Agricultural Bibliography, Toxline Plus, WLAS.

Periodicity: The journal is published monthly (12 issues per year), Volume 44 appearing in 1999.

Acceptance of manuscripts: Two copies of manuscript should be addressed to: Ing. Marie Černá, CSc., editor-in-chief, Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2, Czech Republic, tel.: 02/24 25 34 89, fax: 02/24 25 39 38, e-mail: editor@login.cz.

Subscription information: Subscription orders can be entered only by calendar year (January-December) and should be sent to: Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2. Subscription price for 1999 is 195 USD (Europe), 214 USD (overseas).

Cíl a odborná náplň: Časopis publikuje původní vědecké práce a studie typu review z oblasti genetiky, šlechtění, fyziologie, reprodukce, výživy a krmení, technologie, etologie a ekonomiky chovu skotu, prasat, ovcí, koz, drůbeže, ryb a dalších druhů hospodářských zvířat.
Časopis je citován v bibliografickém časopise Current Contents – Agriculture, Biology and Environmental Sciences a v časopise Animal Breeding Abstracts. Abstrakty z časopisu jsou zahrnuty v těchto databázích: Agris, CAB Abstracts, Current Contents on Diskette – Agriculture, Biology and Environmental Sciences, Czech Agricultural Bibliography, Toxline Plus, WLAS.

Periodicita: Časopis vychází měsíčně (12x ročně), ročník 44 vychází v roce 1999.

Přijímání rukopisů: Rukopisy ve dvou vyhotoveních je třeba zaslat na adresu redakce: Ing. Marie Černá, CSc., vedoucí redaktorka, Ústav zemědělských a potravinářských informací, Slezská 7, 120 56 Praha 2, Česká republika, tel.: 02/24 25 34 89, fax: 02/24 25 39 38, e-mail: editor@login.cz.

Informace o předplatném: Objednávky na předplatné jsou přijímány pouze na celý rok (leden–prosinec) a měly by být zaslány na adresu: Ústav zemědělských a potravinářských informací, vydavatelské oddělení, Slezská 7, 120 56 Praha 2. Cena předplatného pro rok 1999 je 816 Kč.

 F 4886

ASSOCIATION OF THE *RYR1*, *GH*, *LEP* AND *TF* GENES WITH CARCASS AND MEAT QUALITY TRAITS IN PIGS*

ASOCIACE GENŮ *RYR1*, *GH*, *LEP* A *TF* S PRODUKCÍ A KVALITOU MASA PRASAT

L. Křenková, J. Kuciel, T. Urban

Mendel University of Agriculture and Forestry, Department of Animal Genetics, Brno, Czech Republic

ABSTRACT: The genotypes of the *RYR1* gene, the growth hormone gene (*GH-Hae*II, *GH-Msp*I), the leptin (*LEP*) and the transferrin gene (*TF*) were determined in 95 hybrid pigs (Large White x Landrace) x one Large White boar from sire line or one hybrid boar (Large White x Pietrain), using the PCR-RFLP and PAAGE methods. The associations of these genes with growth and carcass traits were investigated by GLM procedure (SAS, 1988) using the model with the effects of studied candidate genes, the effects of hybrid, sex and season of measurements, and the effect of regression with the age by measurement. The determination coefficients of the effects of the used statistical model ranged from 24.05% to 65.69%. The *RYR1* gene showed the associations with the first sacral vertebra backfat ($P < 0.05$), lean meat content ($P < 0.05$), pH_1 value ($P < 0.0001$), electric conductivity ($P < 0.0001$), daily gains to weaning ($P < 0.05$) and body weight at weaning ($P < 0.01$). We found the associations of the *GH-Hae*II with the weight of the right carcass half ($P < 0.05$), daily gain to weaning ($P < 0.05$) and body weight at weaning ($P < 0.01$). The *LEP* gene showed the effect on the weight of the right carcass half ($P < 0.05$), on the daily gain to weaning ($P < 0.01$), and on the body weight at weaning ($P < 0.05$). Transferrin showed the effect on the last thoracic vertebra backfat thickness ($P < 0.01$), the weight of carcass ($P < 0.05$), and pH_1 value ($P < 0.05$). The sex and season influenced the majority of production traits. The hybrid form had no effect on the traits and the regression with the age was significant only for body weight at weaning.

Keywords: pig; *RYR1*; *GH* (*Hae*II and *Msp*I); *LEP*; *TF*; production traits

ABSTRAKT: U 95 hybridních prasat (kombinace bílé ušlechtilé a landrase x kanec plemene bílé ušlechtilé otcovské linie nebo hybridní kanec bílé ušlechtilé x pietrain) byly metodou PCR-RFLP a PAAGE stanoveny genotypy genů ryanodinového receptoru *RYR1*, genu růstového hormonu (*GH-Hae*II, *GH-Msp*I), leptinu (*LEP*) a transferinu (*TF*). K testování asociací těchto genů s ukazateli masné užitkovosti byla využita procedura GLM (SAS, 1988), s modelem zahrnujícím efekty jednotlivých genů, efekt hybridů, pohlaví, období měření a regrese na věk při měření. Determinační koeficienty jednotlivých efektů použitých ve statistickém modelu byly v rozmezí 24,05 až 65,69 %. *RYR1* gen byl asociován s výškou hřbetního tuku na úrovni prvního křížového obratle ($P < 0,05$), s podílem libového masa ($P < 0,05$), s hodnotou pH_1 ($P < 0,0001$), elektrickou vodivostí ($P < 0,0001$), přírůstkem do odstavu ($P < 0,05$) a hmotností při odstavu ($P < 0,01$). Gen růstového hormonu *GH-Hae*II byl asociován s hmotností pravé půlky ($P < 0,05$), s přírůstkem do odstavu ($P < 0,05$) a s hmotností při odstavu ($P < 0,01$). Zjistili jsme průkazný vliv genu *LEP* na hmotnost pravé půlky jatečného těla ($P < 0,05$), na přírůstek do odstavu ($P < 0,01$) a na hmotnost při odstavu ($P < 0,05$). Gen transferinu měl vliv na výšku hřbetního tuku na úrovni posledního hrudního obratle ($P < 0,01$), na hmotnost jatečného těla ($P < 0,05$) a na hodnotu pH_1 ($P < 0,05$). Efekty pohlaví a měsíce měření byly signifikantní u většiny sledovaných ukazatelů, hybridní kombinace prasat neovlivňovala žádný z ukazatelů. Průkazný efekt regrese na věk byl zjištěn pouze u hmotnosti při odstavu.

Klíčová slova: prase; *RYR1*; *GH* (*Hae*II a *Msp*I); *LEP*; *TF*; produkční znaky

INTRODUCTION

As far as the polygenic determination of pig meat production and quality is concerned, several genes have been identified recently which significantly participate in the phenotypic variability. Associations of the ryanodine receptor gene *RYR1* have been investigated for a longer period and it has been found out that recessive alleles influence the rate of pH decrease *post mortem*, contribute to water holding capacity of meat (WHC), and change electric conductivity and colour of meat (Kuciel, Lahučký, 1996; Larzul *et al.*, 1997). The presence of a recessive allele positively influenced weight gains (Fisher, Mellet, 1997) and traits of carcass value (Hardge *et al.*, 1997). On the other hand, Larzul *et al.* (1997) found significantly lower average daily gains in

* This study was supported by the Ministry of Education of the Czech Republic (Project No. CEZ:JO8/98:432100001.)

recessive homozygotes than in heterozygotes and dominant homozygotes; however, they did not observe any association between genotypes of *RYR1* gene and slaughter weight of pigs.

Results of studies on association of different variants of the gene of growth hormone and performance traits are not explicit. Knorr *et al.* (1997) analysed association of individual variants of *GH* genotypes (*Apa*I and *Hin*PI) with performance traits and observed their significant effects on eight parameters of fatness. Casas-Carillo *et al.* (1994) found the association between the *GH* genotypes (DSCP, RFLP) and area of *musculus longissimus lumborum et thoracis* (*MLLT*). Later Casas-Carillo *et al.* (1997) did not observe any associations between *GH* polymorphism (*Dde*I, *Hae*II) on the one hand and daily gains, thickness of backfat, area of *MLLT* and pH_1 value on the other.

Leptin is a product of leptin gene (*LEP*) in adipose tissue. It is supposed that it regulates feed intake and energy expenditure and for that reason it seems to be a very interesting candidate gene for appetite regulation. The mutations are associated with obesity in mice and man (Hauseknecht *et al.*, 1998). The polymorphism of the *LEP* gene pigs was described by Stratil *et al.* (1997), who used a restriction enzyme *Hinf*I. Hardge *et al.* (1998) observed association of this polymorphism in informative families derived from Berlin miniature pigs and Duroc breed with meat : fat ratio and backfat measures. No significant differences between the frequencies of the *LEP* genotypes in the extreme phenotype groups have been found in commercial lines of non-related pigs. According to these authors, the absence of the effect of *LEP* gene in commercial lines indicates that the corresponding mutation (which is not the same mutation as the tested polymorphic site) is possibly fixed in these commercial breeds.

Jensen *et al.* (1968) observed a significant effect of various genotypes of transferrin (*TF*) system of blood serum gene on body weight of piglets. Nyström *et al.* (1995, 1997) described highly significant associations between *TF* genotypes and body weight of Swedish Yorkshire piglets at the age of 6 and 9 weeks. The piglets with genotype *TF BB* showed higher body weights at the age of 3, 6 and 9 weeks than *TF AB* by 130, 340 and 370 grams, respectively.

The aim of this study was to find out possible associations between genotypes of *RYR1, LEP, GH* and *TF* genes and meat production and quality in hybrid pigs slaughtered at the weight of ca 110 kg.

MATERIAL AND METHODS

Characteristics of pig population

Altogether 95 final hybrid pigs (Large White x Landrace) x LW boar from sire line or (LW x Pietrain) boar were tested in this experiment; progeny originated from a judgement crossing according to the *RYR1* genotype of parents (heterozygous *N/n* mother x homozygous *n/n* father).

Genotypes

DNA was isolated from blood using QIAamp® kit (QIAGEN) and modified proteinase method (Nebola, Dvořák, 1994). Genotypes of selected genes were determined by PCR-RFLP method on the basis of literary data and a modification used in our laboratory. After digestion with restriction endonucleases, amplified DNA showed the following genotypes:

RYR1 N/n 134, 84, 50 bp; *n/n* 84, 50 bp (Brenig, Brem, 1992)

*GH-Hae*II +/+ 333, 173 bp; +/- 506, 333, 173 bp; -/- 506 bp

*GH-Msp*I +/+ 222, 147, 137 bp; +/- 284, 222, 147, 137 bp; -/- 284, 222 bp (Schellander *et al.*, 1994)

LEP TT 152 bp; *CT* 152, 84, 68 bp (Stratil *et al.*, 1997).

Transferrin genotypes (*AA, BB, AB, AC, BC*) were determined by means of PAAGE (Juneja, Gahne, 1987).

Performance traits

Pigs with average live body weight of approximately 110 kg were slaughtered. The following traits of carcass value were estimated: backfat thickness measured by a slide calliper at three points as the shortest line connecting the skin surface with the upper surface of fascia separating backfat from musculature in the direction to the centre of the 2nd thoracic vertebra (T1), the last thoracic vertebra (T2), the first sacral vertebra (T3) and their average (TC) according to Smolák *et al.* (1997). Percentage of lean meat was estimated by means of a two-point method measuring the thickness of musculature in the lumbal region at the plane of a halving cut. Thickness of fat (S) was estimated above the highest point of *musculus gluteus medius* and thickness of musculature (F) was estimated as the shortest line connecting the cranial head of *musculus gluteus medius* with the dorsal edge of spinal channel. The proportion of lean meat was calculated using the equation:

$$LS = 76.67 - 1.0485.F + 0.00794.F^2 - 0.002884.S^2 + 9.015.\ln(F/S)$$

(ČSN Standard 46 6160, cit. by Pulkrábek *et al.*, 1993). The proportion of parameters of meat quality was estimated directly in meat samples one hour after slaughter obtained from *MLLT* by means of a bioptic apparatus and using a digital pH-meter Gryf 209S (pH_1) and a digital conductometer PMV (electric conductivity, EC_{50}). Body weights at weaning (WEIGHT) and weights of the left carcass half (LCW), right carcass half (RCW) and the whole carcass (CW) were determined by weighing on scales.

Statistic analysis

Hardy-Weinberg's genotypic equilibrium was evaluated using χ^2-test. Associations of candidate genes with performance traits were calculated using the procedure GLM (SAS, 1988) and the following model with fixed effects:

$$y_{ijklmnopq} = \mu + RYR1_i + GH(HaeII)_j + GH(MspI)_k + LEP_l + TF_m + H_n + S_o + O_p + b \cdot age_{ijklmnopq} + e_{ijklmnopq}$$

where: $y_{ijklmnopq}$ – variable
μ – population mean
$RYR1_i$ – *i*-th genotype of *RYR1* gene ($i = 1, 2$)
$GH(HaeII)_j$ – *j*-th genotype of *GH(Hae*II) gene ($j = 1, 2, 3$)
$GH(MspI)_k$ – *k*-th genotype of *GH(Msp*I) gene ($k = 1, 2, 3$)
LEP_l – *l*-th genotype of *LEP* gene ($l = 1, 2$)
TF_m – *m*-th genotype of *TF* gene ($m = 1, 2, 3, 4, 5$)
H_n – *n*-th hybrid combination ($n = 1, 2$)
S_o – *o*-th sex ($o = 1, 2$)
O_p – *p*-th month of measurings ($p = 1, ..., 6$)
b – regression coefficient of slaughter age
$age_{ijklmnopq}$ – age at the moment of measuring as covariance for *i, j, k, l, m, n, o, p, q* factors
$e_{ijklmnopq}$ – residual effects

RESULTS AND DISCUSSION

Distribution of genotypes and alleles of genes under study in relative frequencies is presented in Table I. When testing true and expected frequencies of genotypes of individual genes Hardy-Weinberg equilibrium was found out. For *RYR1* gene this equilibrium was not estimated as the offspring population was obtained by intentional crossing of parents with genotypes *Nn* x *nn*.

Effects of individual factors on parameters of carcass value, meat quality and growth intensity to weaning as described in the model equation mentioned above are presented in Table II. Values of coefficients of determination (R^2) ranged from 24.05% to 65.69%. *RYR1* gene was associated with the first sacral vertebra backfat thickness ($P < 0.05$), lean meat content ($P < 0.05$), pH_1 value ($P < 0.0001$), electric conductivity ($P < 0.0001$), gains to weaning ($P < 0.05$) and weight at weaning ($P < 0.01$). *GH-Hae*II gene was associated with the weight of the right carcass half ($P < 0.05$), gains to weaning ($P < 0.05$) and weight at weaning ($P < 0.01$). We found out a significant association of *LEP* gene with the weight of right carcass half ($P < 0.05$), gains to weaning ($P < 0.01$), weight at weaning ($P< 0.05$). The variants of transferrin were associated with the last thoracic vertebra backfat thickness ($P < 0.01$), carcass weight ($P < 0.05$) and pH_1 value ($P < 0.05$).

Significant associations of candidate gene polymorphisms with parameters of growth, carcass value and meat quality of hybrid progeny are presented in Tables IIIA–IIID; these associations were classified according to individual groups of genotypes and calculated values of LSM ± SE (least-squares means ± standard error). Genotypes of *RYR1* gene *nn* (Table IIIA) showed significantly lower backfat thickness at the measuring point T3 ($P < 0.05$) and significantly higher lean meat content ($P < 0.05$). On the other hand, however, they showed significantly inferior meat quality as estimated by means of pH_1 ($P < 0.01$) and EC_{50} values ($P < 0.01$) and also significantly lower gains to weaning ($P < 0.05$) and lower weight at weaning ($P < 0.01$) than genotypes *Nn*. Our results agree with data published by Larzul *et al.* (1997), who found in a population of hybrid pigs (Pn x LW) the lowest intensity of growth in *nn* genotypes of *RYR1* gene. According to Fisher and Mellett (1997), the presence of a recessive allele affected growth and *nn* genotypes showed the highest average daily gains. A higher proportion of lean meat in *nn* animals of German Landrace also corresponded with hitherto published data on different pig populations (Hardge *et al.*, 1997). Lower meat quality corresponded with literary data published earlier (Kuciel, Lahučký, 1996; Larzul *et al.*, 1997).

I. The frequencies of the genotypes and alleles of the candidate genes and Hardy-Weinberg genetic equilibrium test

Gene	*n*	Frequencies of genotypes		Frequencies of alleles		χ^2	*P*
RYR1	59	*Nn*	0.621	N	0.31 ± 0.03	–	–
	36	*nn*	0.379	n	0.69 ± 0.03		
*GH-Hae*II	8	-/-	0.084	-	0.35 ± 0.04	2.45 NS	0.29
	50	+/-	0.526	+	0.65 ± 0.04		
	37	+/+	0.389				
*GH-Msp*I	3	-/-	0.032	-	0.19 ± 0.03	0.09 NS	0.95
	30	+/-	0.316	+	0.81 ± 0.03	0.09 NS	0.95
	62	+/+	0.653				
LEP	78	*TT*	0.821	T	0.91 ± 0.03	0.03 NS	0.86
	17	*CT*	0.179	C	0.09 ± 0.03		
TF	8	*AA*	0.084	A	0.33 ± 0.03	1.01 NS	0.80
	44	*AB*	0.463	B	0.64 ± 0.04		
	37	*BB*	0.389	C	0.03 ± 0.01		
	3	*AC*	0.032				
	3	*BC*	0.032				

NS – $P > 0.05$

II. GLM analysis of growth, carcass value and meat quality traits in hybrid pigs – determination coefficients (R^2) and significant values (P) of the effects

Trait	R^2 %	Model				
		RYR1	*GH-Hae*II	*GH-Msp*I	*LEP*	*TF*
		P	*P*	*P*	*P*	*P*
T1	33.99	0.549	0.807	0.804	0.537	0.911
T2	36.71	0.775	0.466	0.067	0.761	**0.009**
T3	24.05	**0.040**	0.749	0.425	0.772	0.991
T	34.54	0.262	0.807	0.361	0.882	0.530
CW	65.69	0.173	0.090	0.507	0.155	**0.027**
LCW	56.28	0.442	0.630	0.723	0.268	0.709
RCW	62.38	0.374	**0.016**	0.880	**0.043**	0.080
LMC	32.83	**0.021**	0.209	0.250	0.529	0.979
pH_1	43.69	**0.0001**	0.820	0.227	0.837	**0.046**
EC_{50}	37.65	**0.0001**	0.232	0.109	0.373	0.331
ADG	29.52	**0.015**	**0.016**	0.315	**0.008**	0.400
WEIGHT	43.62	**0.009**	**0.010**	0.304	**0.017**	0.369

T1 – second thoracic vertebra backfat, T2 – last thoracic vertebra backfat, T3 – first sacral vertebra backfat, T – average backfat, CW – carcass weight, LCW – left carcass half weight, RCW – right carcass half weight, LMCW – lean meat content, EC_{50} – electric conductivity, ADG – average daily gain to weaning, WEIGHT – weight at weaning

IIIA. Associations of polymorphisms of candidate genes with growth, carcass value and meat quality traits in final pig hybrids (least-squares means LSM ± standard error SE) – *RYR1*

Trait		Genotype of *RYR1* gene (LSM ± SE)			
		n	*Nn*	*n*	*nn*
T3	(mm)	59	$14.13^a \pm 1.54$	36	$11.95^b \pm 1.67$
LMC	(%)	59	$56.57^a \pm 1.21$	36	$58.48^b \pm 1.31$
pH_1		59	$6.02^A \pm 0.16$	36	$5.66^B \pm 0.11$
EC_{50}	(mS)	59	$7.03^A \pm 0.70$	36	$9.32^B \pm 0.76$
ADG to weaning	(g)	63	$211.73^a \pm 16.73$	38	$183.49^b \pm 17.22$
Weight at wening	(kg)	63	$7.69^A \pm 0.60$	38	$6.60^B \pm 0.62$

Note: Values with different exponents show significant differences: ^{a} – $P \leq 0.05$, ^{A} – $P \leq 0.01$

T3 – first sacral vertebra backfat, LMC – lean meat content, EC_{50} – electric conductivity, ADG – average daily gain to weaning

IIIB. Associations of polymorphisms of candidate genes with growth, carcass value and meat quality traits in final pig hybrids (least-squares means LSM ± standard error SE) – growth hormone

Trait		Genotype of *GH-Hae*II gene (LSM ± SE)					
		n	+/+	*n*	+/-	*n*	-/-
RCW	(kg)	37	$41.90^a \pm 1.43$	50	$40.62^{ab} \pm 1.55$	8	$38.24^b \pm 1.92$
ADG to weaning	(g)	39	$219.37^a \pm 17.02$	54	$185.37^b \pm 16.82$	8	$188.10^{ab} \pm 23.86$
Weight at weaning	(kg)	39	$7.97^a \pm 0.61$	54	$6.66^b \pm 0.61$	8	$6.80^{ab} \pm 0.86$

Note: Values with different exponents show significant differences: ^{a} – $P \leq 0.05$, ^{A} – $P \leq 0.01$

RCW – right carcass half weight, ADG – average daily gain to weaning

Associations of various genotypes of *GH-Hae*II gene with meat production traits are presented in Table IIIB. Significant differences ($P < 0.05$) were found between homozygous genotypes +/+ and -/- of *GH-Hae*II locus in the weight of the right carcass half and between genotypes +/+ and +/- in average daily gains to weaning ($P < 0.05$) and in weight at weaning ($P < 0.05$). Our observations are original as far as the polymorphism detected by means of restriction enzymes is concerned and partly corroborate data published by Hardge *et al.* (1997) and Knorr *et al.* (1997) who used other restrictases.

In the population under study, only genotypes *TT* and *CT* were found out in *LEP* gene. Highly significant and significant differences were found out between the groups of individuals with these genotypes (Table IIIC)

IIIC. Associations of polymorphisms of candidate genes with growth, carcass value and meat quality traits in final pig hybrids (least-squares means LSM ± standard error SE) – leptin

Trait		Genotype of *LEP* gene (LSM ± SE)		
	n	*TT*	*n*	*CT*
ADG to weaning (g)	82	$218.79^{A} \pm 15.08$	19	$176.44^{B} \pm 20.15$
Weight at weaning (kg)	82	$7.83^{a} \pm 0.54$	19	$6.46^{b} \pm 0.73$
RCW (kg)	48	$45.81^{a} \pm 1.42$	17	$40.61^{b} \pm 1.93$

Note: Values with different exponents show significant differences: $^{a} - P \leq 0.05$, $^{A} - P \leq 0.01$
RCW – right carcass half weight, ADG – average daily gain to weaning

IIID. Associations of polymorphisms of candidate genes with growth, carcass value and meat quality traits in final pig hybrids (least-squares means LSM ± standard error SE) – transferrin

Trait	Genotype of transferrin (LSM ± SE)					
	n	*AA*	*n*	*AB*	*n*	*BB*
T2 (mm)	8	$13.76^{a} \pm 2.41$	44	$19.91^{b} \pm 1.62$	37	$21.31^{b} \pm 1.58$
	n	*AC*	*n*	*BC*		
	3	$23.51^{b} \pm 3.42$	3	$15.20^{ab} \pm 3.49$		
	n	AA^{ab}	*n*	AB^{a}	*n*	BB^{a}
CW (kg)	8	102.40 ± 3.96	44	106.55 ± 2.66	37	105.91 ± 2.59
	n	AC^{a}	*n*	BC^{b}		
	3	110.78 ± 5.62	3	93.09 ± 5.44		
	n	*AA*	*n*	*AB*	*n*	*BB*
pH_1	8	$5.92^{ab} \pm 0.14$	44	$5.88^{ab} \pm 0.10$	37	$5.81^{ab} \pm 0.09$
	n	*AC*	*n*	*BC*		
	3	$6.17^{a} \pm 0.20$	3	$5.42^{b} \pm 0.21$		

Note: Values with different exponents show significant differences: $^{a} - P \leq 0.05$, $^{A} - P \leq 0.01$
T2 – last thoracic vertebra backfat, CW – carcass weight

in gains to weaning ($P < 0.01$), weight at weaning and the weight of the right carcass half ($P < 0.05$), resp.; *TT* genotypes showed better values. As far as we know, there is no paper available that could be compared with our results.

Data published by Nyström *et al.* (1995, 1997) about linkage of *TF* system to body weight of piglets at the age of 6 and 9 weeks (i. e. that piglets with *BB* genotypes showed significantly higher body weights than those with AB genotypes) could not be compared with our results because of the lack of relevant data. We observed (Table IIID) significant differences between *TF* genotypes *AA* and *AB* in backfat thickness above the last thoracic vertebra ($P < 0.05$). The lowest carcass weights were found out in pigs with *BC* genotypes ($P < 0.05$). Other genotypes did not show any differences in carcass weights. As far as the meat quality was concerned (pH_1), significant differences were found only between genotypes *AC* and *BC* ($P < 0.05$).

REFERENCES

Brenig B., Brem G. (1992): Molecular cloning and analysis of the porcine "halothane" gene. Arch. Tierz., *35*: 129–135.

Casas-Carillo E., Prill-Adams A., Price S. G., Kirkpatrick B. W., Smith C., Gavora J. S., Benkel B., Chesnais J., Fairfull W., Gibson J. P., Kennedy B. W., Burnside E. B. (1994): Association of growth hormone and insulin-like growth factor-1 genotypes with growth and carcass traits in offspring of purebred swine. In: Proc. 5th WCGALP, Guelph, Canada, 7–12 August: 272–275.

Casas-Carillo E., Prill-Adams A., Price S. G., Clutter A. C., Kirkpatrick B. W. (1997): Relationship of growth hormone and insulin-like growth factor-1 genotypes with growth and carcass traits in swine. Anim. Genet., *28*: 88–93.

Fisher P., Mellett F. D. (1997): Halothane genotype and pork production. 1. Growth, carcass and meat quality characteristics. S. Afr. Tydskr. Veek., *27*: 22–30.

Hardge T., Köpke K., Leuthold G., Wimmers K., Paulke Th. (1997): Differences in allele frequencies of candidate genes for growth, carcass value and meat quality between extreme phenotypes of commercial pig breeds. In: Book of Abstr. of 48th Ann. Meet. of the EAAP, Vienna, August 25-28, Session P 5.8.

Hardge T., Köpke K., Wimmers K., Leuthold G. (1998): Association between polymorphism of the leptin gene (LEP) and performance traits in a porcine resource family and in commercial outbreed populations. In: XXVIth Int. Conf. on Animal Genetics, ISAG, August 9–14, Auckland, New Zealand, E 046, 107.

Hauseknecht K. L., Baile C. A., Matteri R. L., Spurlock M. E. (1998): The biology of leptin: A review. J. Anim. Sci., *76*: 1405–1420.

Jensen E. L., Smith C., Baker L. N., Cox D. F. (1968): Quantitative studies on blood group and serum protein system in pigs. II. Effects of production and reproduction. J. Anim. Sci., *27*: 856–862.

Juneja R. K., Gahne B. (1987): Simultaneous phenotyping of pig plasma inhibitor (PI 1, PO 1A, PO 1B, P 12) and four other proteins (PO_2, TF, CP, HPX) by simple method of 2D horizontal electrophoresis. Anim. Genet., *18*: 197–211.

Knorr C., Moser G., Müller E., Geldermann H. (1997): Associations of GH gene variants with performance traits in F_2 generations of European wild boar, Piétrain and Meishan pigs. Anim. Genet., *28*: 124–128.

Kuciel J., Lahučký P. (1996): Vliv genů s velkým účinkem na kvalitu vepřového masa. Živoč. Výr., *41*: 475–480.

Larzul C., Le Roy P., Gueblez R., Talmant A., Gogue J., Sellier P., Monin G. (1997): Effect of halothane genotype (*NN, Nn, nn*) on growth, carcass and meat quality traits of pigs slaughtered at 95kg or 125kg live weight. J. Anim. Breed. Genet., *114*: 309–320.

Nebola M., Dvořák J. (1994): Kapa-kaseinová alela E u skotu v České republice. Živoč. Výr., *39*: 849–850.

Nyström P. E., Juneja R. K. (1995): Relation between piglet traits and transferrin phenotypes. In: Book of Abstr. of 46th Ann. Meet. of EAAP, Praque, 4–7 September, Session 5, G5.5: 54.

Nyström P. E., Juneja R. K., Johansson K., Anderson-Eklund L., Andersson K. (1997): Association of the transferrin locus on chromosome 13 with early body weights in pigs. J. Anim. Breed. Genet., *114*: 366–368.

Pulkrábek J., Wolf J., Fiedler J., Houška L., Adamec T., Jakubec V., Štefunka F. (1993): Objektivní klasifikace jatečných prasat. Zemědělec, 4. 8. 1993: 12.

Schellander K., Peli J., Kneissi F., Schmoll F., Mayr B. (1994): Variation of the growth hormone gene in ryr 1 genotyped Austrian pig breeds. J. Anim. Breed. Genet., *111*: 162–166.

Smolák M., Ivánek J., Novák I. (1997): Výsledky hybridizačních programů v chovu prasat testovaných v České republice. Náš Chov (Praha), 1997 (3): 13–14.

Stratil A., Peelmann L., Van Poucke M., Čepica S. (1997): A HinfI PCR-RFLP at the porcine leptin (*LEP*) gene. Anim. Genet., *28*: 371–372.

SAS.SAS/STAT (1988). User's Guide (Release 6.03). SAS Inst. Inc., Cary, NC.

Received for publication on March 9, 1999
Accepted for publication on June 22, 1999

Contact Address:

Ing. Leona K ř e n k o v á , Mendelova zemědělská a lesnická univerzita, Agronomická fakulta, Zemědělská 1, 613 00 Brno, Česká republika, tel.: 05/45 13 31 78, fax: 05/45 13 31 76

DISTRIBUTION OF MINERALS IN ORGANS OF SHEEP AFTER INTOXICATION WITH COPPER FROM INDUSTRIAL EMISSIONS*

DISTRIBÚCIA MINERÁLIÍ V ORGÁNOCH OVIEC PO INTOXIKÁCII MEĎOU Z PRIEMYSELNEJ EMISIE

A. Elgerwi[1]**, J. Bíreš**[2]

[1] *Al-Fateh University, Faculty of Veterinary Medicine, Department of Pharmacology and Forensic Medicine & Toxicology, Tripoli, Libya*

[2] *University of Veterinary Medicine, Department of Internal Diseases of Ruminants and Swine, Košice, Slovak Republic*

ABSTRACT: Diagnostics of experimental copper intoxication by industrial emission from a copper smelter on the basis of accumulation and distribution of Cu, Zn, Fe, Mo, Se, As, Cd and Pb in the liver, kidneys, spleen, lung, heart, muscles, uterus, ovaries and bones were evaluated. The experiment was carried out on 10 Improved Vallachian breed non-pregnant ewes aged 5 years transported from a farm near the copper smelter. The animals were housed and fed daily with 1.5 kg of meadow hay, 0.30 kg BAK compound feed and were given water *ad libitum* throughout the course of the study. The ewes were randomly divided into two groups ($n = 5$), both groups receiving 2.5 g of industrial fallout daily until the 45th day, plus group B extra addition of ammonium molybdate and sodium sulphate to the 24th day; after that toxic substances were stopped. The first animal from group B died of copper poisoning on the 36th day and in group A on the 38th day of the experiment. The highest concentration of Cu was found in liver in both groups A and B. Significantly higher ($P < 0.05$) Fe concentration was confirmed in bones and uterus in group B and the Mo concentration increased in the kidneys ($P < 0.05$) and bones ($P < 0.01$) in group A. The lowest concentration of Zn was found in the ovaries in group A, while the lowest amount of Se was observed in bones and heart from group B. A higher amount of As was observed in the liver, bones and uterus in ewes from group B than in group A, while high Cd was found in kidneys of ewes from group B compared to group A (0.225 ± 0.124 mg.kg^{-1}, 0.135 ± 0.0387 mg.kg^{-1}, respectively). However, the Pb concentration in the spleen and lungs was higher in group B than in group A. The distribution of risk elements in the analysed organs of ewes which were chronically intoxicated with industrial emission from the copper-producing plant proved the complexity of interactions between the toxic elements. The administration of ammonium molybdate and sodium sulphate had no unambiguous effect on accumulation of individual elements in the organs of ewes investigated.

Keywords: ewes; copper intoxication; risk elements; target organs

ABSTRAKT: Diagnostika experimentálnej intoxikácie meďou z priemyselnej emisie zo závodu na výrobu medi bola robená na základe kumulácie a distribúcie Cu, Zn, Fe, Mo, Se, As, Cd, a Pb v pečeni, obličkách, slezine, pľúcach, srdci, svalovine, maternici, vaječníkoch a kosti. Experiment prebehol na 10 negravidných ovciach plemena zošľachtená valaška vo veku päť rokov, ktoré pochádzali z farmy v blízkosti závodu na výrobu medi. Zvieratá boli v priebehu experimentu ošetrované a kŕmené denne 1,5 kg lúčneho sena, 0,30 kg kŕmnej zmesi BAK a vodou s adlibitným príjmom. Ovce boli náhodne rozdelené do dvoch skupín ($n = 5$), obidve skupiny dostávali denne na kus 2,5 g priemyselnej emisie až do 45. dňa a skupina B dostávala navyše molybdenan amónny a síran sodný do 24. dňa. V skupine B uhynulo prvé zviera na intoxikáciu meďou na 36. deň a v skupine A na 38. deň experimentu. Z rizikových prvkov sa najvyššia koncentrácia Cu v obidvoch skupinách zistila v pečeni. Signifikantne vyšší obsah Fe ($P < 0.05$) sa zistil v kosti a maternici v skupine B. Celkový obsah Mo vykazoval zvýšenú koncentráciu v obličkách ($P < 0.05$) a kostiach ($P < 0.01$) v skupine A. Najmenšie množstvo Zn sa zistilo vo vaječníkoch v skupine A, zatiaľ čo najmenšie množstvo Se sa pozorovalo v kostiach a srdci zvierat zo skupiny B. Vyššie množstvo As sa pozorovalo v pečeni, kostiach a maternici u oviec v skupine B ako A, zatiaľ čo vyššie množstvo Cd bolo zistené v obličkách oviec zo skupiny B ako v skupine A ($0,225 \pm 0,124$ mg.kg^{-1}, resp. $0,135 \pm 0,0387$ mg.kg^{-1}). Avšak kumulácia Pb v slezine a pľúcach bola vyššia v skupine B ako v skupine A. Distribúcia rizikových prvkov v analyzovaných orgánoch oviec potvrdila zložitosť interakcií toxických prvkov. Aplikácia molybdenanu amónneho a síranu sodného sa jednoznačne neprejavila na ukladaní jednotlivých prvkov vo vyšetrovaných orgánoch oviec.

Kľúčové slová: ovce; intoxikácia meďou; rizikové prvky; parenchymatózne orgány

* Supported by a grant VEGA (Project number 1/4177/96).

INTRODUCTION

Industrialization and chemicalization of the countryside has led to an increase in the levels of heterogeneous substances in the food chain. Elevated accumulation of risk elements in farm and free-living animals has been observed in industrial areas (Blanusa *et al.*, 1990; Froslie *et al.*, 1984). In Slovakia, from the viewpoint of husbandry and the predisposition of species, sheep appear to be the most endangered animals (Bíreš *et al.*, 1992). Element toxicity upon the biological systems of animals is affected by the route and form of ingestion as well as the interactions between essential and toxic elements (Chowdhury, Chandra, 1987). To assess elemental toxicity in sheep, knowledge of the kinetics of the elements is essential. Great importance is ascribed to the specific organs that accumulate the elements (Buratti *et al.*, 1992; Kessels *et al.*, 1990). Based on the relationship between the element and the organ in which it accumulates, the toxicity of the chemical can be estimated (Steinbach, Wolterbeek, 1992).

Metals accumulating in organs with high metabolic activity are likely to be more toxic (Baranski, 1987). As most toxic elements accumulate in the liver, all vital functions are disturbed (Freundt, Ibrahim, 1991). Individual tissues differ greatly in their susceptibility to variations in dietary intake of copper. Liver, kidneys, blood, spleen, lungs, brain, and bones are particularly responsive to such changes, while the endocrine glands, the muscles and heart are much less so (Henninget *et al.*, 1974). Contamination of natural environment with metals, the use in the practice of veterinary medicine of drugs containing salts of metals, the use of feed additives containing the so-called micro- and macroelements, and the possibility of intaking metal salts by animals in the course of the so-called bad breeding practice are the factors which potentially change the natural physiological level of metals in animal tissues and organs (Bírešová *et al.*, 1994; Bírešová, Naď, 1997).

The aim of our experiment was to determine the copper, zinc, iron, molybdenum, selenium, arsenic, cadmium and lead content in internal organs and muscles of ewes after oral application of the industrial fallout alone and the industrial fallout plus ammonium molybdate and sodium sulphate.

MATERIALS AND METHODS

The experiment was carried out on 10 Improved Vallachian non-pregnant ewes, aged 5 years, transported from a farm near the copper smelter plant, where copper intoxication in sheep caused by emissions of an ore-processing plant under both spontaneous and experimental conditions was first described by Vrzgula *et al.* (1986) and Bíreš *et al.* (1993). Already at the beginning of the experiment the experimental ewes showed symptoms of chronic copper intoxication (poor nutritional state, apathy, loss of wool, anemia of mucous membranes and conjuctivities with a hint of icteria alternate inapetence) to the same extent as described by Bíreš *et al.* (1993) in the area close to the industrial plant mentioned above.

The animals were housed and each was given 1.5 kg meadow hay daily, 0.30 kg BAK concentrates and *ad libitum* water throughout the course of the study. The BAK is a compound feed for ewes. The ewes were randomly allocated into two groups ($n = 5$). Before the experiment the animals in group A (GA) averaged body weight 28.6 ± 5.639 kg average body weight and in group B (GB) 29.2 ± 2.588 kg. The GA received 2.5 g of industrial fallout daily by stomach tube after the morning feeding. The GB in addition to 2.5 g of industrial fallout, received 400 mg of ammonium molybdate and 800 mg of sodium sulphate daily by stomach tube after the morning feeding. The treatment was discontinued after 24 days. The industrial fallout was obtained from the copper smelter by dedusting the electrostatic filters from the factory chimney. The amount of Cu, Fe, Zn, Mo, Se, As, Cd, and Pb in one dose of the industrial fallout is illustrated in Table I. Most described elements were used in the form of oxides and sulphates as in an industrial fallout.

The first animal died in the GB on the 36th day and in the GA on the 38th day of the experiment. The remaining ewes were slaughtered at the end of the experiment. The experiment lasted 45 days. After slaughtering the animals, post mortem examination was carried out immediately. The 10–20g samples from the right liver lobe, cortical part of the right kidney, spleen, biceps femoris muscle, corpus uteri, left ovary, heart, lung and from the carpal bone of left thoracic limb were collected and sent to the laboratory.

The concentrations of Cu, Zn, Fe, Mo, Se, As, Cd, and Pb in the samples of organs, the industrial fallout and food were determined by the method of atomic absorption spectrophotometry using the Perkin Elmer apparatus, type 1100 and 4100 ZL. Mineralizations of the fallout and organs were carried out in the mixture of HNO_3 and H_2O_2 in the microwave system (Milestone mls 1200).

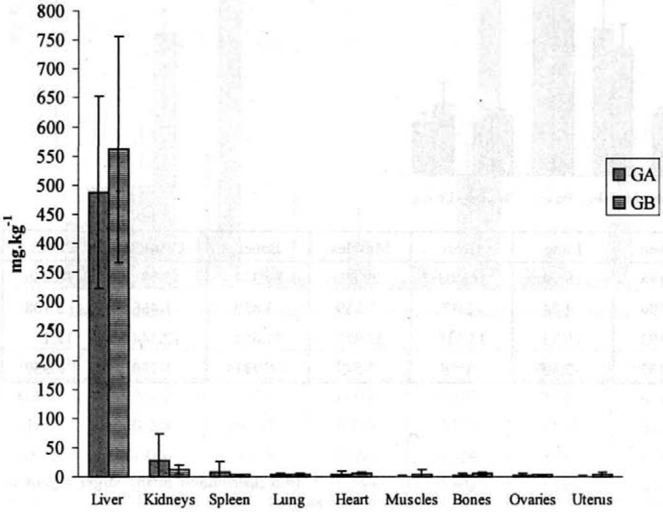
The results of the analysis of risk elements in the fresh tissues of organs were expressed by the mean values ($\bar{x}$) with a standard deviation (± SD). Statistical comparisons of the results in the examined organs between experimental groups were performed by the Student *t*-test.

RESULTS

The concentration of Cu in the liver of ewes from group B was much higher than in group A (561.918 ± 194.903 mg.kg^{-1} and 488.118 ± 165.611 mg.kg^{-1}, respectively, Fig. 1). The accumulation of Cu in kidneys appeared higher in group A than in group B (28.478 ± 46.116 mg.kg^{-1} and 12.534 ± 7.658 mg.kg^{-1}, respectively) and also the concentration of Cu in spleen was

I. Intake of elements contained in the fallout and feed in mg per head and day

Daily intake		Cu	Zn	Fe	Mo	Se	As	Cd	Pb
Fallout	(2.5 g)	429.00	124.34	976.60	0.104	0.031	0.303	0.005	0.016
Meadow hay	(1.5 kg)	16.92	59.55	358.39	1.125	0.385	0.280	0.079	0.285
Feed mixture BAK	(0.30 kg)	2.11	10.58	22.86	0.372	0.063	0.028	0.017	0.033
Drinking water		0	1.20	0.25	0	0	0	0	0
Total		448.03	195.67	1358.1	1.601	0.479	0.611	0.101	0.334



1. Copper distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	488.118	28.478	8.624	3.331	4.722	0.913	2.744	2.951	0.932
SD	165.611	46.116	17.885	3.214	4.877	1.503	3.41	3.645	1.291
GB x	561.918	12.534	3.382	4.494	5.35	4.485	5.073	3.086	4.079
SD	194.903	7.658	1.255	Jan.66	1.852	6.469	2.502	1.609	3.562

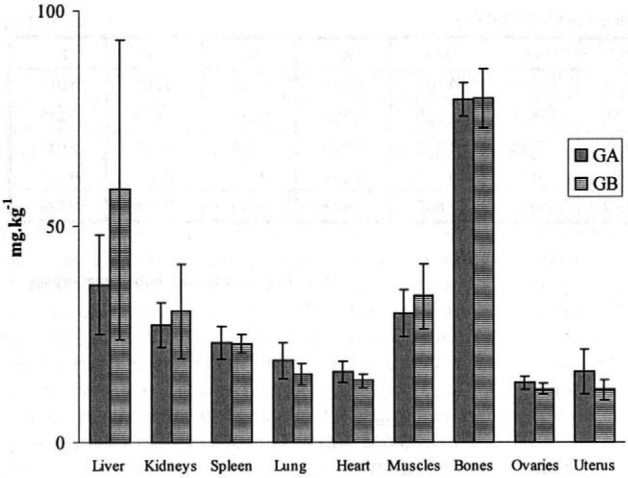
found to be higher in group A than in group B. The accumulation level of Cu in other organs, lung, heart, muscles, bones, ovaries and uterus, was higher in group B than in group A. There was no statistically significant difference found in the concentration of Cu among the analysed organs.

The highest amount of Zn was accumulated in the bones of ewes from group B and group A (79.654 ± 6.711 mg.kg^{-1} and 79.374 ± 3.839 mg.kg^{-1}, respectively, Fig. 2). The lowest concentration of Zn was found in ovaries of ewes from group A. There was a higher Zn concentration in liver in ewes from group B than in group A (58.628 ± 34.639 mg.kg^{-1} and 36.542 ± 11.576 mg.kg^{-1}, respectively). It was also found that the level of Zn in kidneys and muscles was much higher in group B than in group A. On the other hand a higher concentration of Zn was found in spleen, lung, heart and uterus of the ewes from group A than in the same organs of ewes from group B. There was no statistically significant difference in the concentration of Zn among the analysed organs.

Although the concentration of Fe was higher in all organs of ewes from group B than of those from group A (Fig. 3), it was significantly higher only in bones and uterus ($P < 0.05$). The highest concentration was found in the spleen of ewes from group B compared with the other analysed organs and the lowest concentration was found in bones of ewes from group A.

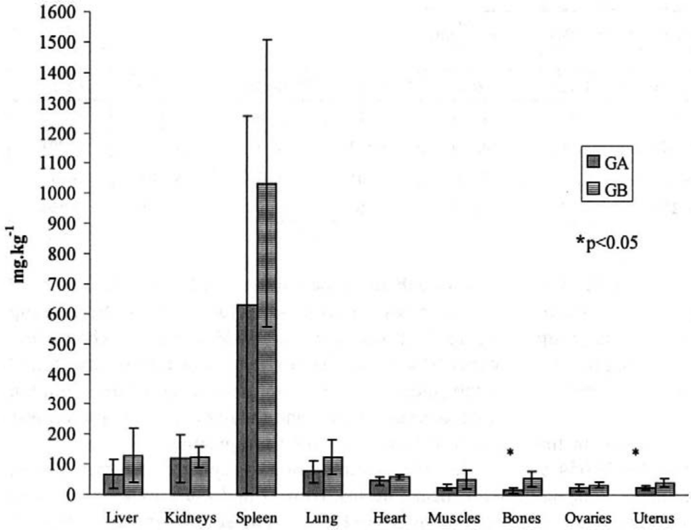
The Mo accumulation in spleen, kidneys, bones, liver, heart, uterus, ovaries and muscles was higher in ewes from group B than in those from group A (Fig. 4). The concentration of Mo was significantly higher in the kidneys ($P < 0.05$) and bones ($P < 0.01$) in ewes from group A. The concentration of Mo in the lungs was also higher in ewes from group A than in those from group B.

Distribution of Se in organs was higher in kidneys of ewes from group B than in those from group A (0.141 ± 0.061 mg.kg^{-1} and 0.111 ± 0.05 mg.kg^{-1}, respectively, Fig. 5) while Se was highly accumulated in the other analysed organs of ewes from group A compared with group B. The highest accumulation of Se was found in muscles of ewes from



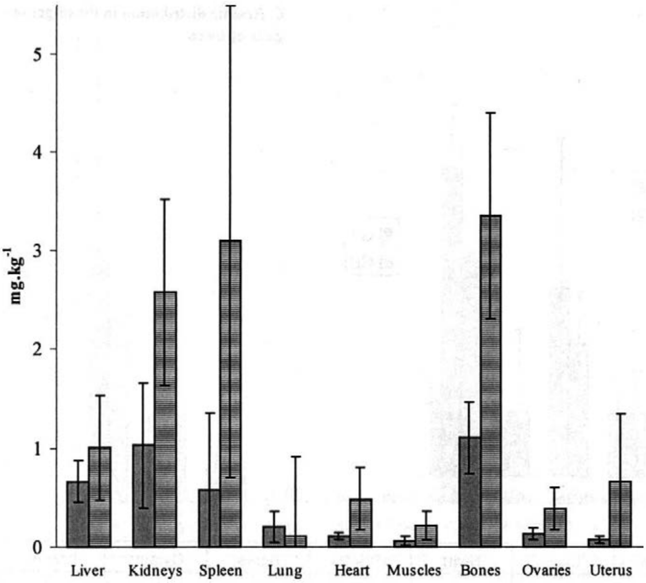
2. Zinc distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	36.542	27.192	23.198	18.99	16.408	29.89	79.374	13.78	16.246
SD	11.576	5.244	3.786	4.24	2.47	5.359	3.839	1.468	5.108
GB x	58.628	30.472	22.792	15.73	14.318	33.876	79.654	12.344	12.1
SD	34.639	10.828	2.137	2.527	1.55	7.547	6.711	1.230	2.359



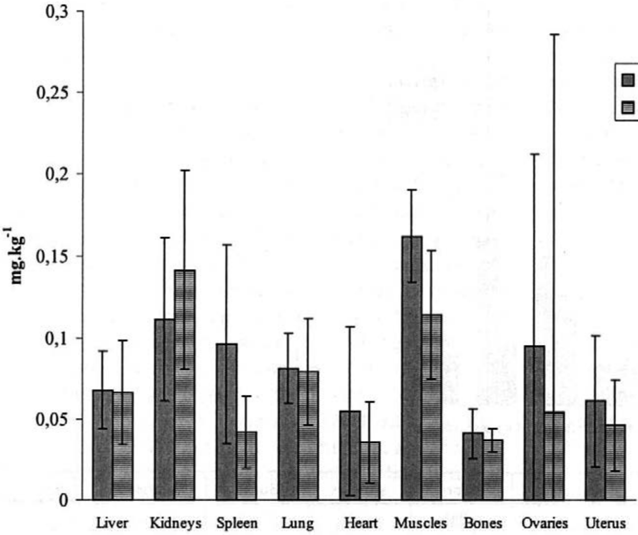
3. Iron distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	66.816	118.292	630.95	76.268	45.026	23.776	14.238	23.246	22.656
SD	47.504	77.751	626.056	37.444	12.184	9.427	9.365	9.950	7.901
GB x	129.458	124.21	1031.64	123.57	56.884	50.196	53.678	31.206	40.34
SD	92.469	35.52	475.542	59.476	6.887	31.718	25.321	9.404	12.540



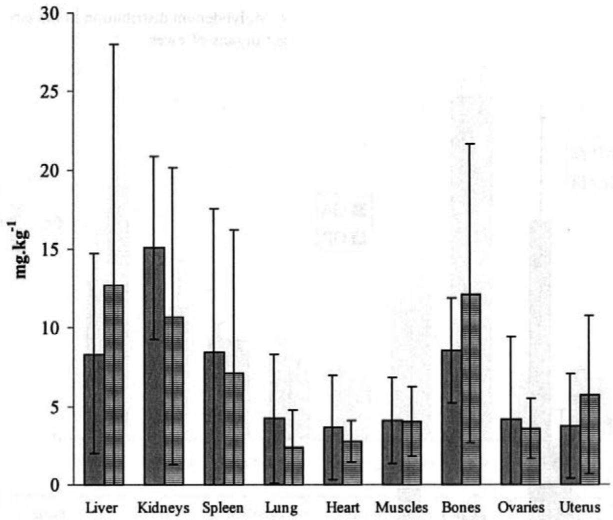
4. Molybdenum distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	0.665	1.028	0.576	0.202	0.107	0.061	1.103	0.132	0.07
SD	0.208	0.633	0.785	0.155	0.035	0.046	0.363	0.061	0.036
GB x	1.006	2.578	3.099	0.109	0.485	0.214	3.354	0.385	0.665
SD	0.529	0.941	2.389	0.801	0.319	0.146	1.044	0.215	0.683



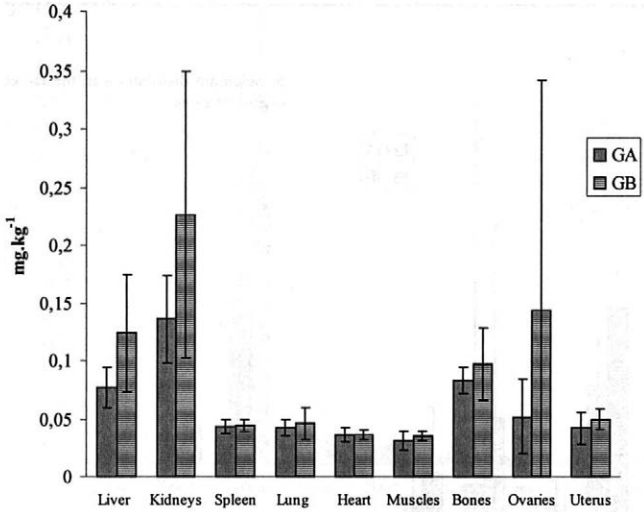
5. Selenium distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	0.068	0.111	0.096	0.081	0.055	0.162	0.041	0.095	0.061
SD	0.024	0.05	0.061	0.0214	0.052	0.028	0.015	0.117	0.04
GB x	0.066	0.141	0.042	0.079	0.035	0.114	0.037	0.054	0.046
SD	0.032	0.061	0.022	0.033	0.025	0.039	0.007	0.232	0.028



6. Arsenic distribution in the target organs of ewes

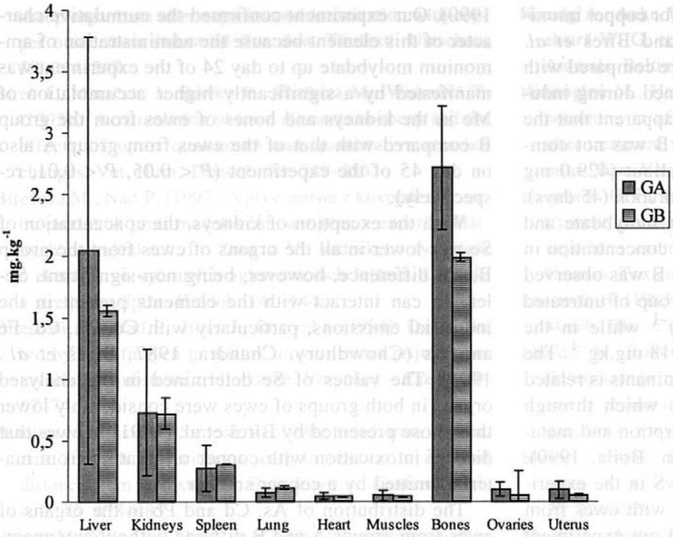
Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	8.352	15.066	8.445	4.224	3.626	4.070	8.52	4.136	3.700
SD	6.337	5.772	9.108	4.118	3.324	2.736	3.356	5.263	3.358
GB x	12.677	10.695	7.139	2.391	2.749	4.034	12.124	3.578	5.712
SD	15.34	9.397	9.025	2.356	1.311	2.232	9.477	1.911	5.058



7. Cadmium distribution in the target organs of ewes

Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	0.077	0.136	0.043	0.042	0.036	0.031	0.083	0.052	0.042
SD	0.017	0.038	0.006	0.007	0.006	0.008	0.011	0.032	0.014
GB x	0.124	0.226	0.044	0.046	0.036	0.035	0.097	0.143	0.05
SD	0.051	0.124	0.005	0.014	0.004	0.004	0.031	0.198	0.009

8. Lead distribution in the target organs of ewes



Animals	Liver	Kidneys	Spleen	Lung	Heart	Muscles	Bones	Ovaries	Uterus
GA x	2.045	0.728	0.275	0.078	0.049	0.054	2.716	0.102	0.1
SD	1.736	0.511	0.189	0.036	0.027	0.041	0.502	0.059	0.072
GB x	1.553	0.719	0.304	0.114	0.043	0.046	1.989	0.058	0.057
SD	0.621	0.546	0.286	0.133	0.011	0.02	1.782	0.019	0.02

group A, while the lowest level of Se was found in bones and heart of ewes from group B. There were no statistically significant differences among the results for organs analysed.

Distribution of As in the organs was different from other investigated elements. We found higher amounts of As in the liver, bones and uterus of ewes from group B than in ewes from group A (12.677 ± 15.34 mg.kg^{-1} and 8.352 ± 6.337 mg.kg^{-1}; 12.124 ± 9.477 mg.kg^{-1} and 8.52 ± 3.356 mg.kg^{-1}; 5.712 ± 5.058 mg.kg^{-1} and 3.700 ± 3.358 mg.kg^{-1}, Fig. 6). However, in kidneys, spleen, lung, heart, muscles and ovaries, the accumulation was higher in group A than in group B while no statistical differences among organs were found.

High Cd content was observed in all organs of ewes from group B compared with group A (Fig. 7). The concentration was higher in the kidneys of ewes from group B more than in group A (0.226 ± 0.124 mg.kg^{-1} and 0.136 ± 0.038 mg.kg^{-1}, respectively), and the lowest level of Cd was found in muscles. There were no significant differences in statistical results.

The accumulation of Pb was higher in liver, bones, ovaries and uterus of ewes in group A than in group B (Fig. 8). The concentration of Pb was higher in bones of ewes from group A than in group B (2.716 ± 0.502 mg.kg^{-1} and 1.98 ± 91.782 mg.kg^{-1}, respectively). In spleen and lungs, however, the accumulation of Pb was higher in group B than in group A. There was no significant difference between these organs.

DISCUSSION

Diagnostics of copper intoxication of sheep are based on the concentration of Cu in parenchymatous organs, particularly in liver and kidneys (Gummow *et al.*, 1991; Bíreš *et al.*, 1995a).

Metallothionein in liver and kidneys is responsible for the accumulation of copper and other toxic elements. The activity of metallothionein with regard to copper during copper intoxication depends on the dose of Cu, presence of other elements affecting the resorption, intermediary metabolism and elimination of Cu (Lloyd *et al.*, 1993; Pauwels *et al.*, 1994). In such a case interactions of Cu with other elements occur not only in liver and kidneys but also in other organs, particularly during the resorption resulting from industrial copper intoxication after exposure to fallout produced by smelters processing heavy metal ores (Bíreš *et al.*, 1991, 1995a).

In our experiment with industrial copper intoxication of ewes given the fallout from a copper smelter, we took into account the number of analysed elements and organs. At the same time, within the analysed elements and organs, we considered the interactions of Cu with ammonium molybdate and sodium sulphate applied or, if there were any, with other heavy metals present in the fallout material.

The concentrations of Cu determined in the liver of ewes from groups A and B were in an agreement with the levels considered as characteristic for copper intoxication by Hidiroglou *et al.* (1984) and Bíreš *et al.* (1991). However, when our results were compared with those of Bíreš *et al.* (1995a, b), obtained during industrial intoxication of ewes, it became apparent that the accumulation of Cu in groups A and B was not comparable with the dose of Cu in the fallout (429.0 mg Cu/ewes/day) and the period of administration (45 days).

Similarly, no effect of ammonium molybdate and sodium sulphate administration on Cu concentration in the liver of dead ewes from the group B was observed because the Cu concentration in the group of untreated ewes (group A) was 488.118 $mg.kg^{-1}$ while in the treated animals (group B) it was 561.918 $mg.kg^{-1}$. The interaction of Mo and S with Cu in ruminants is related to the production of thiomolybdates which through binding the present Cu reduce its absorption and metabolic activity (Mason, 1981; Golfman, Boila, 1990). The low effect of the applied Mo and S in the experimental ewes from group B compared with ewes from group A on the accumulation of Cu in our experiment can be explained by the duration of administration of Mo and S (24 days), the presence of other risk elements in the fallout (As, Cd, Pb, Zn) and the character of the biological material used (all the ewes were reared for 5 years in the area close to the industrial plant which created conditions for accumulation of Cu in the organism of animals at the beginning of the experiment).

The distribution of Zn in the analysed organs corresponded to the biological function of this element (Laurie, 1983). The statistically non-significant differences in the levels of Zn between groups A and B were in the reference range (Underwood, 1977). From the viewpoint of the effectiveness of the applied ammonium molybdate and sodium sulphate it can be stated that similarly to the situation with Cu the antidote had a minimum effect on the concentration of Zn as well in the organs examined.

The highest amount of Fe in the spleen of ewes of both groups was in an agreement with its metabolic activity and corresponded to the observations of Bíreš *et al.* (1991) who also recorded the highest levels of Fe in the spleen of ewes which died of industrial copper intoxication under experimental conditions. The administration of ammonium molybdate and sodium sulphate was associated in ewes of the group B with higher accumulation of Fe in all the organs analysed, the differences from the group A being significant ($P < 0.05$) in bones and the uterus. The higher accumulation of Fe in ewes from the group B which were given the antidote mentioned above was probably related to the effect on the metabolism of Cu, during which interactions between Cu and Fe occurred, on the level of resorption, intermediary metabolism and excretion (Schonewille *et al.*, 1995).

The distribution of Mo in the organs of ewes of the group B reflected the supplementation with ammonium molybdate and sodium sulphate and were related with the metabolic function of Mo in ruminants (Mason, 1990). Our experiment confirmed the cumulative character of this element because the administration of ammonium molybdate up to day 24 of the experiment was manifested by a significantly higher accumulation of Mo in the kidneys and bones of ewes from the group B compared with that of the ewes from group A also on day 45 of the experiment ($P < 0.05$, $P < 0.01$, respectively).

With the exception of kidneys, the concentration of Se was lower in all the organs of ewes from the group B, the difference, however, being non-significant. Selenium can interact with the elements present in the industrial emissions, particularly with Cu, Zn, Cd, Fe and As (Chowdhury, Chandra, 1987; Bíreš *et al.*, 1991). The values of Se determined in the analysed organs in both groups of ewes were considerably lower than those presented by Bíreš et al. (1991) in ewes that died of intoxication with copper originating from material emitted by a copper smelter.

The distribution of As, Cd and Pb in the organs of ewes from groups A and B differed without any unambiguous dependence on the administration of ammonium molybdate and sodium sulphate. The accumulation of As, Cd and Pb in the biological material from ewes reflected the uptake of the elements mentioned from the industrial fallout not only during the 45-days of experimental administration but also during the 5-years exposure to risk elements when reared in the area of industrial deposition. The differences in the concentration of individual elements in the organs examined also pointed at the complexity of interactions of toxic elements during industrial intoxication as they were described in ewes under experimental conditions and in those reared in the area close to the copper and zinc producing plant by Bíreš *et al.* (1992, 1995b) and Elgerwi *et al.* (1998). The levels of As, Cd and Pb in the examined biological material taken from dead and slaughtered ewes after 45-days administration of industrial fallout from the copper smelter agreed with those determined in the area close to the same industrial plant by Bíreš *et al.* (1995a).

REFERENCES

Baranski B. (1987): Effect of Cd on prenatal development and on tissue Cd, Cu and Zn concentrations in rats. Envir. Res., *42*: 54–62.

Bíreš J., Vrzgula L., Juhásová Z. (1991): Distribution of harmful metals in sheep organisms after experimental industrial contaminant intake. Vet. Med. (Praha), *36*: 361–371.

Bíreš J., Kovarová E., Juhásová Z. (1992): Harmful element accumulation in the liver and kidneys of sheep in dependence on the breed. Živoč. Výr., *37*: 403–408.

Bíreš J., Vrzgula L., Konrád V. (1993): Spontane und experimentelle Kupfer-intoxikation bei Schafen: Klinik und Pathologie. Tierärztl. Umschau, *48*: 661–669.

Bíreš J., Vrzgula L., Weissová T., Vrzgulová M., Baldovič R. (1995a): Distribution of Cu, Fe, Zn, As, Cd and Pb in sheep organisms after experimental intoxication with copper oxide from industrial flue dust. Tierärztl. Umschau, *50*: 364–367.

Bíreš J., Maraček, J., Bartko P., Bírešová M., Weissová T. (1995b): Accumulation of trace elements in sheep and the effects of upon qualitative and quantitative ovarian changes. Vet. Hum. Toxicol., *73*: 349–356.

Bírešová M., Naď P. (1997): Vplyv emisie z kovohút na tvorbu protilátok proti modelovému antigénu v experimentálnych podmienkach. In: Zbor. z VI. vedeckého sympózia o ekológii vo vybraných aglomeráciach Jelšava, Lubeník a stredného Spiša. Hrádok: 141–144.

Bírešová, M., Naď P., Bíreš J., Rosival I. (1994): Dynamika tvorby špecifických protilátok u oviec počas príjmu priemyselného substrátu z hlinikárne. Vet. Med.– Czech, *39*: 67–74.

Blanusa M., Ivisis N., Simeon V. (1990): Lead, iron, copper, zinc and ash in deciduous teeth in relation to age and distance from lead smelter. Bull. Environ. Contam. Toxicol., *45*: 478–485.

Buratti M., Xaiz D., Valia C. et al. (1992): Inaccuracy quality control in the monitoring of trace metal concentration in biological fluids. Sci. Total. Environ., *120*: 81–83.

Chowdhury B. A., Chandra R. K. (1987): Biological and health implications of toxic heavy metal and essential trace element interactions. Progr. Ed. Nutr. Sci., *11*: 55–113.

Elgerwi A., Bíreš J., Jesenská M., Hiščáková M. (1998): Distribution of minerals in organs of sheep after intoxication with copper from industrial emission. In: Proc. Hygienic and Ecological Problems in Relation to Veterinary Medicine, ÚVL, Košice, Slovak Republic: 177–182.

Freundt K. J., Ibrahim H. A. (1991): Influence of Pb, Cd, Zn, Mn, Cu, Hg or Be salts on the glutathione S-transferases of the rat liver. Bull. Environ. Contam. Toxicol., *46*: 618–624.

Froslie A., Norheim G., Rambaek J. P. et al. (1984): Levels of trace elements in liver from Norwegian moose, rein deer and red deer in relation to atomospheric deposition. Acta. Vet. Scand., *25*: 333–345.

Golfman L. S., Boila R. J. (1990): Effects of molybdenum and sulfur on minerals on the digestive tract of steers. Can. J. Anim. Sci., *70*: 905–920.

Gummow B., Botha C. J., Basson A. T., Bastianello S. S. (1991): Copper toxicity in ruminants: air pollutions as a possible cause onderstepoort J. Vet. Res., *58*: 33–39.

Hennig A., Anke M., Groppel B., Ludke H. (1974): In: Hoekstra W. G. et al. (eds.): Trace Element Metabolism in Animals. Baltimore, Maryland, Univ. Park Press, *2*: 726.

Hidiroglou M., Heaney D. P., Hartin K. E. (1984): Copper poisoning in af lock of sheep copper excretion patterns after treatment with molybdenum and sulfur or penicillamine. Can. Vet. J., *25*: 377–382.

Kessels B. G. F., Wensing T. H., Wentink G. H. et al. (1990): Clinical, chemical and haematological parameters in cattle kept in a cadmium–contaminated area. Bull. Environ. Contam. Toxicol., *44*: 339–344.

Laurie S. H. (1983): Trasport and storage of metals. J. Inher. Metab. Dis., *6* (Suppl. 1): 9–14.

Lloyd J. W., Rook J. S., Braselton W. E., Shea M. E. (1993): Relationships between liver element concentrations and age in perinatal lambs dying of natural causes in Michigan, USA. Prev. Vet. Med., *17*: 175–181.

Mason J. (1981): Molybdenum copper antagonism in ruminants: A review of the biochemical basis. Irish. Vet. J., *35*: 221–229.

Mason J. (1990): The biochemical pathogenesis of molybdenum-induced copper deficiency syndromes in ruminants: Towards the final chapter. Irish Vet. J., *43*: 18–81.

Pauwels M., Weyenbergh J. V., Soumillion A., Prost P., Deley M. (1994): Induction by zinc of specific metallothionein isoforms in human monocytes. Eur. J. Biochem., *220*: 105–110.

Schonewille J. Th., Yu S., Beynen A. C. (1995): High iron intake depresses hepatic copper content in goats. Vet. Quart., *17*: 14–17.

Steinbach O. M., Wolterbeek H. T. H. (1992): Effects of cadmium, copper and metallothionein synthesis inhibiting and stimulating compounds on zinc uptake and accumulation in rat hepatoma HTC cells. Chem.-Biol. Interact., *84*: 199–220.

Underwood E. J. (1977): Trace elements in human and animal nutrition. New York, San Francisco, London, Academic Press. 545 p.

Vrzgula L., Bíreš J., Konrád V. (1986): Prvý výskyt intoxikácie meďou pri ovciach – klinika, patológia. Živoč. Výr., *31*, 1986: 463–468.

Received for publication on March 1, 1999
Accepted for publication on June 22, 1999

Contact Address:

Prof. MVDr. Jozef Bíreš, DrSc., Univerzita veterinárskeho lekárstva, Komenského 73, 041 81 Košice, Slovenská republika, tel.: 095/633 21 11-15, fax: 095/632 36 66, e-mail: Bires@UVM.SK

Oznamujeme čtenářům a autorům našeho časopisu,

že v návaznosti na časopis Scientia agriculturae bohemoslovaca, který až do roku 1992 vycházel v Ústavu vědeckotechnických informací Praha, vydává od roku 1994

Česká zemědělská univerzita v Praze

časopis

SCIENTIA AGRICULTURAE BOHEMICA

Časopis si zachovává původní koncepci reprezentace naší vědy (zemědělství, lesnictví, potravinářství) v zahraničí a jeho obsahem jsou původní vědecké práce uveřejňované v angličtině s rozšířenými souhrny v češtině.

Časopis je otevřen nejširší vědecké veřejnosti a redakční rada nabízí možnost publikace pracovníkům vysokých škol, výzkumných ústavů a dalších institucí vědecké základny.

Příspěvky do časopisu (v angličtině, popř. v češtině či slovenštině) posílejte na adresu:

Česká zemědělská univerzita v Praze
Redakce časopisu Scientia agriculturae bohemica
165 21 Praha 6-Suchdol

CONTENT OF SOME PLASMA METABOLITES AND LIPID COMPOSITION OF PANCREAS IN EARLY POST-NATAL GROWTH OF LAMBS – EFFECT OF AGE AND LINOLEIC ACID

OBSAH NĚKTERÝCH METABOLITŮ V KREVNÍ PLAZMĚ A SLOŽENÍ LIPIDŮ PANKREASU BĚHEM ČASNÉHO POSTNATÁLNÍHO RŮSTU JEHŇAT – VLIV VĚKU A KYSELINY LINOLOVÉ

A. Angelov, V. Banskalieva

Institute of Animal Science, Kostinbrod, Bulgaria

ABSTRACT: The results show that neither age nor linoleic acid intake change plasma glucose content. Increased contents of free fatty acids (FFA), β-hydroxybutyrate (BHB) and insulin in 30-day animals – compared to 10 days old ones – correspond to some extent to changes in the physiological condition of lambs during the first month of their growth. Linoleic acid intake induces depressing growth of animals in that period, decrease of FFA and BHB, accompanied by characteristic changes in fatty acid composition of plasma FFA and pancreatic phosphatidylcholine and phosphatidylethanolamine. Increased incorporation of linoleic acid in the composition of studied lipids corresponds to its high content in diet. Changed fatty acid composition of pancreatic phospholipids is probably connected with increased insulin secretion in those animals.

Keywords: lambs; sunflower oil; linoleic acid; fatty acids; phospholipids; β-hydroxybutyrate; glucose; insulin

ABSTRAKT: Výsledky naznačují, že se obsah glukózy v krevní plazmě nemění ani vlivem věku, ani vlivem příjmu kyseliny linolové. Vyšší obsah volných mastných kyselin (VMK), β-hydroxymáselnanu (BHM) a inzulinu u zvířat ve věku 30 dní – ve srovnání s jedinci ve věku 10 dnů – do určité míry odpovídá změnám fyziologického stavu jehňat v prvním měsíci jejich růstu. Příjem kyseliny linolové způsobuje depresi růstu zvířat v daném období a pokles VMK i BHM, doprovázený charakteristickými změny ve složení mastných kyselin VMK v krevním séru a fosfatidylcholinu a fosfatidyletanolaminu v pankreasu. Zvýšený podíl kyseliny linolové ve složení sledovaných lipidů odpovídá jejímu vysokému obsahu v krmivu. Změněné složení mastných kyselin fosfolipidů pankreasu pravděpodobně souvisí se zvýšenou sekrecí inzulinu u těchto zvířat.

Klíčová slova: jehňata; slunečnicový olej; kyselina linolová; mastné kyseliny; fosfolipidy; β-hydroxymáselnan; glukóza; inzulin

INTRODUCTION

The liver in man and monogastric animals is known to be the basic source of β-hydroxybutyrate (BHB) and a direct relationship exists between plasma glucose and insulin contents. And vice versa, in polygastric animals, over 90% of ketone bodies are formed in the rumen wall. Insulin level depends on volatile fatty acids produced in rumen, and adipose tissue is of determinant significance for forming the plasma free fatty acids (FFA).

Intake of polyunsaturated fatty acids in monogastric animals as well as in ruminants induces changes in lipid and energy metabolism and insulin secretion (Bang *et al.*, 1976; Wright *et al.*, 1977; Gear *et al.*, 1980; Hood *et al.*, 1980; Palmquist, Mozer, 1981; Lardinois *et al.*, 1987; Clarke *et al.*, 1990; Opara *et al.*, 1990).

Few investigations are available studying the changes of some plasma metabolites, insulin secretion and pancreas composition in a preruminal phase, i.e. passing of monogastric animals into ruminant, as well as the effect of polyunsaturated fatty acids in that period, this directing us to the present study.

The aim of the experiment was to study relationships between the content and composition of some plasma metabolites, age and linoleic acid intake during the first month of post-natal growth of lambs.

MATERIAL AND METHODS

The experiment was carried out on male cross lambs (Finewooled x Friesian) at the Institute of Animal Science, Kostinbrod. The third day after birth the lambs were separated from their dams and fed (calf self-feeder) up to 10 days a certain amount of sheep's milk, milked from their mothers.

At the age of 10 days five animals were slaughtered, and the remaining ten were divided into two groups of five animals in each. From 11th to 30th day, animals of the control group received sheep's milk, and those of the other (experimental) group received skim milk powder with sunflower oil supplement. Diets of both groups also contained a supplement of microelement mixture and vitamin premix for such a class of animals. Chemical composition of diet is presented in Table I, and fatty acid composition in Table II showing the energy contribution of linoleic acid (18:2n-6) intake. At the end of experiment (30 days of age) animals of both groups were slaughtered 4 hours after the last feeding.

The objects of investigation in this study were blood plasma and pancreas. In the blood plasma were determined glucose, insulin, BHB content, level and fatty acid composition of free fatty acids (FFA) and in pancreas fatty acid composition of phosphatidylcholine and phosphatydylethanolamine.

Total lipids of plasma and pancreas were extracted according to the method of Bligh and Dyer (1959). Separation of individual lipid fractions was made by means of thin-layer chromatography and fatty acid composition of plasma free fatty acids (FFA) and pancreatic phospholipids were determined by gas-chromatography, for determining the FFA content internal standard of arachidic acid was used. Plasma insulin content was determined according to a modified method by Milanov *et al.* (1985), glucose concentration according to Schmidt (1961) and for quantitative measuring of BHB an enzyme method of Williamson and Mellanby (1974) was used.

Student's *t*-criterion was used for statistical assessment of data.

RESULTS AND DISCUSSION

Results presented in Table III show that compared to 10 days old animals, in control 30 days old lambs BHB, FFA and insulin contents are increased. Data by Lindsay and Leat (1975) for lambs show small changes in plasma FFA content between birth and 100 days of age, those by Rajion *et al.* (1985) – a certain increase between 10 and 30 days after birth.

Regardless of growing BHB value, its content keeps far lower than that of older ruminants (Banskalieva *et al.*, 1987; Dimov *et al.*, 1989). It is presumable that the higher value of this metabolite – compared to 10 days old animal – is connected with increased capacities of liver and also most likely with progressive rumen growth. It is known that the rumen development starts early after birth and towards the third week the rumen is able to digest varied foodstuffs (Poes *et al.*, 1971). The basic factor stimulating functional development of

I. Diet composition (%)

Groups	Parameters				
	fats	protein	carbohydrate	ash	consumed energy*
Control	32.9	29.7	32.2	5.2	2.58
Experimental	31.2	26.8	35.7	6.2	2.51

* Consumed energy – MJ/l diet

II. Fatty acid composition (M%) of diets

Groups	Fatty acids											
	C4:0	C6:0	C8:0	C10:0	C12:0	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:2*
Control group	8.3	2.8	5.5	15.2	6.1	8.0	19.8	2.3	4.1	26.6	1.3	0.66
Experimental group	–	–	–	–	–	–	7.6	–	4.3	28.7	59.5	27.7

* C18:2 – % of total energy in consumed feed

III. Content of plasma glucose, insulin, β-hydroxybutyrate (BHB) and free fatty acids (FFA) in lambs

Parameters	Groups		
	10 days old lambs	control	experimental
Glucose (mM/l)	8.1 ± 0.2	7.7 ± 0.4	8.6 ± 0.6
Insulin (nM/ml)	12.2 ± 7.6	23.1 ± 6.7	46.0 ± 20.1
BHB (nM/l)	139.5 ± 16.0^a	187.7 ± 14.4^a	71.0 ± 5.5^b
FFA (nM/ml)	214.9 ± 32.6^a	259.4 ± 30.0^a	124.0 ± 11.5^b

$^{a, b}$ – Values with common superscripts are not significant at $P < 0.05$

IV. Fatty acid composition (M%) of plasma free fatty acids in lambs

Fatty acids	Groups		
	10 days old lambs	control	experimental
14:0	4.0 ± 0.9	4.3 ± 0.5	2.7 ± 0.5
16:0	27.9 ± 2.6[a]	29.1 ± 1.8[a]	17.7 ± 1.4[b]
16:1	1.7. ± 0.2	2.2 ± 0.2	2.0 ± 0.2
18:0	20.8 ± 1.8[a]	19.6 ± 1.7[a]	11.6. ± 0.7[b]
18:1	40.6 ± 2.1[a]	36.4 ± 2.2[a]	24.2 ± 0.9[b]
18:2	5.0 ± 0.5[a]	8.4 ± 1.7[a]	41.9 ± 1.7[b]
UFA/SFA*	0.88 ± 0.01[a]	0.90 ± 0.06[a]	2.17 ± 0.21[b]
PUFA/SFA**	0.09 ± 0.03[a]	0.16 ± 0.01[a]	1.34 ± 0.14[b]
DBI***	0.50 ± 0.05[a]	0.53 ± 0.06[a]	1.08 ± 0.04[b]

[a, b] – Values with common superscript are not significantly different at $P < 0.05$

* UFA/SFA – Unsaturated fatty acids/Saturated fatty acids ratio

** PUFA/SFA – Polyunsaturated fatty acids/Saturated fatty acids ratio

*** DBI – Double bonds index = (M% unsaturated fatty acids x double bonds number)/100

V. Live weight and daily gain of lambs

Groups	Live weight at the beginning of experiment (kg)	Daily weight gain (g/d)
Control	7.05 ± 0.15	170 ± 21
Experimental	6.55 ± 0.40	150 ± 16

rumen is production of volatile fatty acids which starts in the first week after birth (Tamate *et al.*, 1961). Of all three volatile fatty acids – acetate, propionate and butyrate, the last most strongly stimulates rumen growth (Sander *et al.*, 1959).

It is also presumable that rumen growth – parallelly with volatile fatty acid production – has a certain effect on insulin plasma level (Table III). Data by Bassett (1974) also show an increase of plasma insulin during the suckling period of lambs.

Age advancing, however, is not accompanied by essential changes in glucose content (Table III) and fatty acid composition of plasma FFA (Table IV). In 10 days and in 30 days old animals fed sheep's milk, C16:0, C18:0 and C18:1 fatty acids prevail in plasma FFA composition.

Except for communication by Christie and Moore (1974) about sheep's pancreas (fatty acid composition of triacylglycerols), we did not find any data about lipid composition of lamb pancreas in early post-natal period. Table VI presents fatty acid composition of predominant phospholipids in pancreas – phosphatidylcholine (PC) and phosphatidylethanolamine (PE). PC is characterized by high C16:0 content, exceeding twice that of C18:1 and C18:2, while in PE – relative parts of C16:0, C18:0 and C18:2 move in close limits. Differences in fatty acid composition of PC and PE also determine different values of unsaturated fatty acids/saturated fatty acids (UFA/SFA), polyunsaturated fatty acids/saturated fatty acids (PUFA/SFA) ratios and double bonds index (DBI). With age advancing, fatty acid profile of both phospholipids keeps unchanged.

Sunflower oil intake (rich in linoleic acid) induces essential changes in the weight growth of lambs. The gain of experimental animals is lower (Table V), being analogic to the communication by Wright *et al.* (1977) for lambs fed high amounts of sunflower oil. Their results make it possible to suppose that at equal energy value of consumed feed, its qualitative characteristics is of significance for development of animals, in this case – its fatty acid composition (Table II).

Significantly lower values in plasma FFA and BHB of animals of the experimental group, compared with 10-day and 30-day control animals, were established.

Fatty acid spectrum of plasma FFA is strongly influenced by the composition of lipids consumed with diet (Table II). Higher relative part of C18:2n-6 (almost 5 times) in FFA of experimental lambs, in comparison with control group, corresponds to its increased content in diet. Relative content of other fatty acids decreases at the rate of about 40%. Changes in fatty acid composition of plasma FFA are similar to some extent to those established for FFA in the liver of experimental animals, but differ essentially from the changes in the composition of adipose tissue FFA and triacylglycerols (Angelov, Dimov, 1990). Wright *et al.* (1977) established up to 40% linoleic acid incorporation in lipids of muscles and adipose tissue of lambs fed sunflower oils.

Quantitative and qualitative analysis of plasma FFA makes it possible to suppose that under the conditions of this experiment (intensive growth, positive energy balance – incorporation of large quantities of exogenous lipids) an essential effect in formation of plasma FFA is exerted by the composition of lipids consumed with diet. Adipose tissue in young suckling lambs weighing up to 25 kg is known to be poorly developed and exerts unessential effect on plasma lipids (Thorton, Tune, 1987). Reduced FFA level (Table III), their specific fatty acid profile (Table IV), are probably a result of changes in both synthesis and secretion of fatty acids from liver. Data by Hood *et al.* (1980) show that linoleate induces significant inhibition of fatty acid synthesis in the liver as well as in adipose tissue. The use of saffrol oil also induces reduced lipogenesis in lambs during the first month of their growth (Vernon, 1975). Intake of polyunsaturated fatty acids is connected with reduced activity of the number of enzymes having a relation to fatty acid synthesis (Clarke *et al.*, 1990).

On the other hand, a higher plasma insulin level (Table III), in the experimental group, probably through influence on the lipid metabolism in adipose tissue, decreases fatty acid releasing in the plasma. This fact corresponds to the lower value of plasma FFA (Table III) as well as of adipose tissue FFA (Angelov, Dimov, 1990) in animals of that group.

Changes of BHB content in animals of experimental group correspond to those of plasma FFA. Changes in

VI. Fatty acid composition (M%) of phosphatidylcholine and phosphatidylethanolamine in pancreas of lambs

Fatty acids	Groups		
	10 days old lambs	control	experimental
Phosphatidylcholine			
C16:0	44.4 ± 1.4	47.2 ± 1.6	41.9 ± 2.3
C18:0	6.0 ± 0.3	7.4 ± 1.8	8.6 ± 1.4
C18:1	20.8 ± 1.9[a]	19.1 ± 2.3[a]	6.9 ± 1.7[b]
C18:2	16.9 ± 1.2[a]	16.4 ± 0.7[a]	40.1 ± 2.6[b]
C20:3	0.7 ± 0.3	0.2 ± 0.1	–
C20:4	9.5 ± 0.8[a]	9.1 ± 0.4[a]	2.4 ± 1.6[b]
C20:5	1.6 ± 0.2	0.6 ± 0.2	–
UFA/SFA*	1.16 ± 0.10[a]	0.82 ± 0.06[a]	0.98 ± 0.8[b]
PUFA/SFA**	0.62 ± 0.07[a]	0.48 ± 0.07[a]	0.84 ± 0.11[b]
DBI***	1.03 ± 0.09	0.92 ± 0.07	0.97 ± 0.13
Phosphatidylethanolamine			
C16:0	19.8 ± 1.7[a]	20.7 ± 1.0[a]	12.6 ± 2.1[b]
C18:0	20.0 ± 1.1[a]	17.0 ± 0.5[a]	28.7 ± 1.7[b]
C18:1	24.8 ± 1.0[a]	26.4 ± 0.9[a]	9.1 ± 2.3[b]
C18:2	10.7 ± 0.5[a]	10.6 ± 0.7[a]	42.7 ± 2.7[b]
C20:3	1.7 ± 0.7	0.6 ± 0.2	–
C20:4	20.1 ± 1.4[a]	22.5 ± 1.2[a]	7.0 ± 0.7[b]
C20:5	3.5 ± 0.9	2.2 ± 0.3	–
UFA/SFA*	1.45 ± 0.14[a]	1.65 ± 0.10[a]	1.42 ± 0.08[b]
PUFA/SFA**	0.84 ± 0.11	0.95 ± 0.09	1.21 ± 0.10
DBI***	1.49 ± 0.1	1.50 ± 0.12	1.21 ± 0.11

[a, b] – Values with common superscript are not significantly different at $P < 0.05$

* UFA/SFA – Unsaturated fatty acids/Saturated fatty acids ratio

** PUFA/SFA – Polyunsaturated fatty acids/Saturated fatty acids ratio

*** DBI – Double bonds index = (M% unsaturated fatty acids x double bonds number)/100

plasma level of FFA probably influence their concentration uptake by the liver for oxidation. Presumably, under feeding conditions of animals of the experimental group (limiting rumen growth) basic ketogenesis takes place in the liver. Reduced forming of BHB is probably a result of difficult β-oxidation, or of a specific effect of linoleic acid intake on some key-enzymes in ketone body synthesis. According to data of Bang *et al.* (1976) Gear *et al.* (1980) and Palmquist, Mozer (1981) blood glucose level changes when feeding polyunsaturated fatty acids. Their results however show that in the period of post-natal growth of lambs – studied by us – glucose level keeps constant, regardless of the age and feed. Plasma insulin level (Table III) increases (although insignificantly, because of large individual variations) in animals in the experimental group. Its increased value does not correspond to constancy of plasma glucose nor to the physiological condition of animals (with not yet working rumen). This fact supposes that probable causes for increased insulin secretion in animals consuming sunflower oil would be related to changes in pancreas function. Our previous investigations show that linoleic acid intake induces significant changes in total phospholipid content as well as in phospholipid spectrum of pancreas (Angelov, Dimov, 1990). Data presented in Table VI show that in contrast to control animals - fatty acid composition of pancreatic PC and PE in lambs of the experimental group changes significantly. In PC the relative amounts of C18:1 and C20:4 fatty acids decrease significantly (2.5 and 4 times, respectively), C16:0 – insignificantly, and that of linoleic acid increases more than twice. Similar changes were observed in PE fatty acid composition. The higher incorporation degree of C18:2n-6 in PE composition is accompanied by considerable changes in the levels of other fatty acids. Regardless of the changes in fatty acid composition, the total degree of unsaturation of PC and PE keeps nearly constant, probably because of their role as plastic material. PUFA/SFA ratio, however, increases. Changed fatty acid profile of PC and PE probably induces structural changes in cellular membranes and β-cells of pancreas, resulting in changes of insulin secretion (Burr, Sharp, 1974; Lardinois, 1987). According to Opara *et al.* (1990) C18:2n-6 stimulates insulin releasing, but the mechanisms of that stimulation have not been explained yet.

Alterations in FFA, BHB and insulin contents reflect to some extent the changes in the physiological condition of lambs in the first month of their post-natal growth. Concerning the age effect, however, no changes were observed in glucose content, fatty acid profile of plasma FFA, and pancreatic phosphatidylcholine and phosphatidylethanolamine.

Linoleic acid intake in that period induces changes in the growth of animals and in some features of lipid and energy metabolism and connected hormonal regulation. Mechanisms regulating relationships between the studied plasma and pancreatic parameters, however, remain unexplained. Data on increased incorporation of linoleic acid in lipids of experimental animals could serve as a basis for further investigations into therapeutical effects of essential fatty acids in some diseases.

REFERENCES

Angelov A., Dimov V. (1990): Alterations in triacylglycerols and free fatty acids of plasma and adipose tissue of lambs dispensed with various essential fatty acids. Anim. Sci. (Sofia), *8*: 81–88.

Bang H., Dyeberg J., Hjorne N. (1976): The composition of food consumed by Greenland Eskimos. Acta Med. Scand., *200*: 69–73.

Banskalieva V., Bojkovski S., Dimov V. (1987): Effect of feeding level on free fatty acid and β-hydroxybutyrate concentration in gravid ewe blood plasma. Anim. Sci. (Sofia), *2*: 62–67.

Bassett J. (1974): Early changes in plasma insulin and growth hormone levels after feeding in lambs and adult sheep. Austr. J. Biol., *27*: 157–166.

Bligh E., Dyer W. (1959): A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol., *37*: 911–917.

Burr M., Sharp R. (1974): Effect of prostaglandin E1 and epinephrine on the dynamics of insulin release *in vitro*. Endocrinology, *94*: 835–840.

Christie W., Moore J. (1974): Structures of triglycerides isolated from various sheep tissues. J. Sci. Food Agric., *22*: 120–124.

Clarke S., Armstrong M., Jump D. (1990): Dietary polyunsaturated fats uniquely suppress rat liver fatty acid synthase and S14 mRNA content. J. Nutr., *120*: 225–231.

Dimov V., Banskalieva V., Koparanova O. (1989): Biosynthesis of volatile fatty acids in the rumen and plasma content of β-hydroxybutyrate and insulin in lambs. Comt. Rend. Acad. Bulg. Sci., *10*: 107–110.

Gear J., Mann J., Carter R., Jelfs R. (1980): Biochemical and hematological variables in vegetarians. Brit. Med. J., *1*: 1415–1420.

Hood R., Cook L., Mills S., Scott T. (1980): Effect of feeding protected lipids on fatty acid synthesis in ovine tissues. Lipids, *15*: 644–650.

Lardinois C., Starich G., Mazzaferri E., Delett A. (1987): Polyunsaturated fatty acids augment insulin secretion. J. Amer. Coll. Nutr., *6*: 507–515.

Lindsay D., Leat F. (1975): Carbohydrate and lipid metabolism. In: Blunt M. H. (ed.): The Blood of Sheep. Berlin, Springer-Verlag: 45–62.

Milanov S., Tarkolev H., Koparanova O., Milkov V., Guginska E. (1985): Bulgarian radioimmunological kits for determine insulin and growth hormone in serum. Roentgenol. Radiobiol. (Sofia), *24*: 52–56.

Opara E., Burch W., Hibbard V., Akwari O. (1990): Enhancement of endocrine pancreatic secretions by essential fatty acids. J. Surg. Res., *48*: 329–332.

Palmquist D., Mozer E. (1981): Dietary fat effects on blood insulin, glucose utilization, and milk protein content of lactating cows. J. Dairy Sci., *64*: 1664–1670.

Poes D., Mitchell G., Glimp A., Deweese P. (1971): Rumen development in lambs. II. Rumen metabolite changes. J. Anim. Sci., *32*: 989–993.

Rajion M., McLean J., Cahill R. (1985): Essential fatty acids in the fetal and newborn lambs. Austr. J. Biol. Sci., *38*: 33–40.

Sander F., Warner G., Harrison H., Loosli J. (1959): The stimulatory effect of sodium butyrate and sodium propionate on the development of rumen mucosa in the young calf. J. Dairy Sci., *42*: 1600–1605.

Schmidt F. H. (1961): Hexokinase-Methode zur Bestimmung von Glucose mit Enteiweissung. Klin. Wschr., *39*: 1244.

Tamate H., McGillard D., Jackobson N., Getty R. (1962): Effect of various dietaries on the anatomical development of stomach of the calf. J. Dairy Sci., *45*: 408–420.

Thornton R., Tune R. (1987): Factors controlling fat deposition in ruminants. In: Ferrell D. J. (ed.): Recent Advances in Animal Nutrition in Australia. Armidale, Australia, University of New England Printery, *3*: 28–48.

Vernon R. (1975): Effect of safflower oil upon lipogenesis in neonatal lamb. Lipids, *10*: 284–288.

Williamson D., Mellanby J. (1974): Determination of hydroxybutyrate. In: Bergmyer H. U. (ed.): Methods of Enzymatic Analysis. New York, Academic Press: 1831–1835.

Wright D., Payne E., Pyle C., Aitken W., Kirton A. (1977): Polyunsaturated fat in young ruminants. Anim. Food Sci., Technol., *2*: 93–100.

Received for publication on July 13, 1998
Accepted for publication on June 22, 1999

Contact Address:

Dr. Angel Angelov, Institute of Animal Science, Department of Biochemistry, 2232 Kostinbrod, Bulgaria, fax: 0721 24 31, e-mail: vbanskalieva@hotmail.com

Nejčerstvější informace o časopiseckých článcích poskytuje automatizovaný systém

Current Contents

na disketách

Ústřední zemědělská a lesnická knihovna odebírá časopis **„Current Contents"** řadu **„Agriculture, Biology and Environmental Sciences"** a řadu **„Life Sciences"** na disketách. Řada „Agriculture, Biology and Environmental Sciences" je od roku 1994 k dispozici i s abstrakty. Obě tyto řady vycházejí 52krát ročně a zahrnují všechny významné časopisy a pokračovací sborníky z uvedených oborů.

Uložení informací z Current Contents na disketách umožňuje nejrozmanitější referenční služby z prakticky nejčerstvějších literárních pramenů, neboť báze dat je **doplňována každý týden** a neprodleně expedována odběratelům. V systému si lze nejen prohlížet jednotlivá čísla Current Contents, ale po přesném nadefinování sledovaného profilu je možné adresně vyhledávat informace, tisknout je nebo kopírovat na disketu s možností dalšího zpracování na vlastním počítači. Systém umožňuje i tisk žádanek o separát apod. Kumulované vyhledávání v šesti číslech Current Contents najednou velice urychluje rešeršní práci.

Přístup k informacím Current Contents je umožněn dvojím způsobem:

1) **Zakázkový přístup** – po vyplnění příslušného zakázkového listu (objednávky) je vhodný především pro mimopražské zájemce.
Finanční podmínky:
- použití PC – 15 Kč za každou započatou půlhodinu
- odborná obsluha – 10 Kč za 10 minut práce
- vytištění rešerše – 1,50 Kč za 1 stranu A4
- žádanky o separát – 1 Kč za 1 kus
- poštovné + režijní poplatek 15 %

2) **„Self-service"** – samoobslužná práce na osobním počítači v ÚZLK.
Finanční podmínky jsou obdobné. Vzhledem k tomu, že si uživatel zpracovává rešerši sám, je to maximálně úsporné. (Do kalkulace cen nezapočítáváme cenu programu a databáze Current Contents.)

V případě Vašeho zájmu o tyto služby se obraťte na adresu:

Ústřední zemědělská a lesnická knihovna
Dr. Bartošová
Slezská 7
120 56 Praha 2
Tel.: 02/24 25 79 39, l. 520, fax: 02/24 25 39 38

Na této adrese obdržíte bližší informace a získáte formuláře pro objednávku zakázkové služby. V případě „self-servisu" je vhodné se předem telefonicky objednat. V případě zájmu je možné si objednat i průběžné sledování profilu (cena se podle složitosti zadání pohybuje čtvrtletně kolem 100 až 150 Kč).

PELLETED FEED FOR ARCTIC FOX

POUŽITÍ GRANULOVANÝCH KRMIV U ROSTOUCÍCH POLÁRNÍCH LIŠEK

M. O. Lorek[1], A. Gugolek[1], T. Rotkiewicz[2], M. Podbielski[2]

Warmia and Masuria University in Olsztyn, [1]Department of Breeding Fur-bearing Animals, [2]Department of Pathological Anatomy, Poland

ABSTRACT: The use of pellets for feeding growing arctic foxes was investigated using 80 young foxes from weaning to slaughter. The animals were divided into two groups, taking into consideration their sex and origin. The experimental group was given pelleted feed. The pellets contained meat meal, fish meal, soybean meal, maize meal and rape seed oil. The control group received traditional moist feed. Both groups were fed and watered *ad libitum*. Body weight gains were researched throughout experiment. After slaughter, postmortem and histopathological examinations of their internal organs and alimentary tract were conducted. Pelt evaluation and classification was also carried out at that time. Feeding arctic foxes on pelleted feed caused a decrease in their final body weight and pelt size but it improved the quality of their hair cost. The postmortem and histopathological examinations did not indicate any adverse effect of pellets on health of the animals.

Keywords: fox; pellets; feeding; growth; pelt; health

ABSTRAKT: Použití granulovaných krmiv při krmení rostoucích polárních lišek bylo zkoumáno na 80 mladých liškách. Zvířata byla rozdělena do dvou skupin s ohledem na pohlaví a původ. Pokusná skupina dostávala granulované krmivo obsahující masovou a rybí moučku, sójovou mouku, kukuřičnou mouku a řepkový olej. Kontrolní zvířata dostávala tradiční zvlhčené krmivo. Obě skupiny byly krmeny a napájeny *ad libitum*. Přírůstky hmotnosti byly kontrolovány průběžně. Po zabití byly morfologicky a histopatologicky vyšetřeny vnitřní orgány a zažívací ústrojí. Zároveň bylo provedeno hodnocení a klasifikace kožek. Krmení lišek granulovanými krmivy způsobilo snížení hmotnosti při zabití a velikosti kožek, ale zlepšilo kvalitu srsti. Na základě morfologického a histopatologického vyšetření nebyl zjištěn negativní vliv granulí na zdraví zvířat.

Klíčová slova: liška; granulované krmivo; krmení; kožka; zdraví

INTRODUCTION

Pellets are commonly used in feeding farm animals including herbivorous fur-bearing animals, such as rabbits or chinchillas. However, they are only infrequently used in feeding other fur-bearing animals, although in some countries (e.g. the USA or Denmark), fox and mink feeding is based on dried roughage (Allain *et al.*, 1980; Skrede, Gulbramdsen 1986; Weiss, 1987).

Pellets have a longer shelf life than other feeds, because of smaller total volume of particles and the nutrients contained in them lose their value much slower. Pellets contain minimal amounts of water, so – contrary to traditional feeds – they do not require isothermal conditions when stored. Another advantage of pelleting feed carried out at a high temperature is a reduction or even complete elimination of harmful microorganisms, including salmonella.

Scientists work on selecting the proper feed components and improving the technology of pellet production because the nutritive value of pellets depends on their physical structure (thickness and hardness) and taste. The present state of research on pelleted feeds for carnivorous fur-bearing animals indicates that expanders should be used for their production, just like in the case of pellets for dogs and cats. The process of expanding allows to agglomerate mixtures containing up to 20% of liquid raw materials (molasses, oils), which is not possible in other agglomerating processes. It is especially useful due to the possibility of increasing, the amount of energy from fat.

However, feeding based on pellets has also some negative sides and may cause certain difficulties in rearing young animals. The production results achieved by animals fed on pellets are similar to those obtained in the case of traditional wet feeds (Allain *et al.*, 1980; Weiss, 1987). However, complications with such feeds appear when young animals start to receive solid food. Wet feed contains approximately 70% of water. This content of moisture is very difficult to obtain, even in dissolved dried roughage. It is recommended to change from wet to dry feed gradually, so that weaned animals could eventually receive only pellets. Weiss (1987) emphasizes the fact that animals given pellets grow slower than those receiving wet feed, which is explained by water deficiency in the organism. It was found that animals given pellets need 2.5 to 3 times more water than those receiving wet feed. Therefore, they should have guaranteed access to water all the time. Dried roughage causes changes in the water metabolism of animals, excretion of water with feces increases and excrements are 'soft', not 'formed'. The research on foxes given dried roughage shows that their pelts are a little shorter, than from foxes given wet feed but of satisfactory quality (Sławoń, 1981; Weiss, 1987). On the other hand, response of mink to pellets was more positive (Allain *et al.*, 1980). No adverse effect of dried feed on mating and fertility of animals was observed (Allain *et al.*, 1980; Weiss, 1987). Moreover, Allain *et al.* (1980) found that minks fed on pellets consumed by 10–20% less feed (converted to dry matter) than those receiving traditional feed. Their daily body weight gains were similar to or higher than those noted for the control groups.

Feeding animals on pellets improves the financial position of farms: prices of pelleted commercial mixtures are only seemingly higher than those of wet feed. Converted to dry matter, pellets are cheaper than wet mixtures. Moreover, the use of pelleted feed saves expenses on refrigeration, storage, transport and labour connected with daily preparation of feed.

In Poland, the problem of feeding carnivorous fur-bearing animals on dried feed and pellets is still at the stage of preliminary tests (Sławoń, 1981). The aim of this paper was to study the possibilities of feeding arctic foxes on pelleted feed and to determine its effect on their growth, pelt quality and health.

MATERIAL AND METHODS

Data were obtained on 80 young blue arctic foxes, from weaning to slaughter. The animals, selected at random, were divided into two groups. Each group included 40 animals (20 males and 20 females), from different litters but born at a similar time. They were put into standard cages for foxes, 4 animals of the same sex per cage. The experimental factor was differential feeding. The controls received wet feed, normally given to all animals on the farm. The foxes from the experimental group were fed on specially prepared pellets the composition and nutritive value of which are given in Table I. The pellets measured 5–10 mm in length and 4 mm in diameter.

I. Composition and nutritive value (tabular) of the rations

Specification	Control group		Experimental group	
	growing period (July–September)	period of hair coat development (October–November)	growing period (July–September)	period of hair coat development (October–November)
1. Kind of feed (%)				
– meat offal	6	–	–	–
– hard poultry offal	40	40	–	–
– soft poultry offal	20	15	–	–
– mackerel offal	14	10	–	–
– extruded cereals (barley + oats)	20	15	–	–
– steamed potatoes	–	20	–	–
– meat meal	–	–	20	20
– fish meal	–	–	20	18
– soybean meal	–	–	15	7
– extruded maize meal	–	–	33	40
– rape seed oil	–	–	12	15
	100	100	100	100
2. Nutritive value				
a. Dry matter (%)	37.94	34.47	88.08	87.81
b. Digestible components (%)				
– protein	12.1	9.9	30.5	25.6
– fat	7.5	6.0	14.9	17.8
– carbohydrates	8.3	9.0	14.5	19.7
c. Metabolizable energy (MJ/100 g of feed)	0.619	0.539	1.449	1.513
d. Protein–energy ratio (g/MJ)	20	18	21	17
e. Energy (%)				
– protein	34	32	39	32
– fat	44	40	40	46
– carbohydrates	22	28	21	22

The experiment was divided into two periods during which the nutritive value of rations was adjusted to the needs of growing animals (Table I). The animals were fed and watered *ad libitum*. Automatic discharge feeders were installed in the cages for experimental foxes and were topped up when necessary.

Body weight and pelt quality of the animals were assessed, and pathological examinations of internal organs were carried out. Body weight was determined by weighing (accurate to 0.1 kg) each animal every 14 days, at the same time before feeding. The numerical data obtained were subjected to an analysis of variance for one-factor orthogonal designs (Ruszczyc, 1981).

The animals were slaughtered when their fur was fully developed. The pelts were evaluated and classified. The mean values were then compared. After slaughter, the carcasses of 5 males and 5 females selected at random from each of the groups were subjected to postmortem examinations. Specimens of liver, pancreas, stomach, duodenum, jejunum, colon, kidneys and heart muscle were taken for histopathological examinations. The specimens were fixed in a 10% neutralized formalin (pH 7.4) and were embedded in paraffin. The microtome sections obtained were stained in hematoxylin, eosin (HE) and PAS, according to the McManus method. The results are presented in Table IV.

RESULTS AND DISCUSSION

Table I shows the composition and nutritive value of the rations given to the foxes from the control and experimental groups. The component selection in the traditional ration is typical for the domestic feed market. The composition of pellet was based on animal and plant friable feeds. They were supplemented with energy in the form of rape seed oil. The nutrient and metabolizable energy content of the two types of feed was different due to the a different dry matter content of wet feed and pellets. However, the standards concerning the nutritive value of the two types of ration, such as the energy-protein ratio and percentage of energy derived from protein, fat and carbohydrates, was comparable. The standards discussed were similar for both rations and were consistent with those in the Feeding Standards for Fur-bearing Animals (1994).

Table II shows an analysis of body weight of foxes in individual weeks. Statistical differences between experimental and control animals were observed from the 12th week. The foxes from the control group were characterized by statistically higher body weight than those from the experimental group. The differences remained similar until the end of the experiment. The final body weight of the foxes given on pellets was 1.08 kg lower than that for the control group. Weiss (1987) claimed that animals receiving pellets achieved lower body weight gains. It was probably caused by certain disturbances in the water balance or by wastage of feed as the pellets can fall through the wire netting.

The tendency towards lower body weight of animals fed pellets was not confirmed by Allain *et al.* (1980). In their research on standard and pastel minks given pellets they noted higher body weight gains and larger pelt sizes than those for animals fed dried roughage.

Table III presents the results of pelt evaluation conducted on the basis of pelt size and fur coat. The ani-

II. Body weight of foxes (kg)

Age (weeks)	Statistical measures	Group	
		control	experimental
8	n	40	40
	$\bar{x}$	1.07	1.08
	v	14.95	21.23
10	$\bar{x}$	1.88	1.86
	v	11.58	12.84
12	$\bar{x}$	2.66^A	2.27^B
	v	12.00	12.86
14	$\bar{x}$	3.63^A	3.05^B
	v	7.80	11.41
16	$\bar{x}$	4.25^A	3.80^B
	v	9.90	11.64
18	$\bar{x}$	5.13^A	4.12^B
	v	9.17	18.39
20	$\bar{x}$	5.65^A	5.10^B
	v	9.29	9.75
22	$\bar{x}$	6.25^A	5.57^B
	v	9.33	10.72
24	$\bar{x}$	7.07^A	5.81^B
	v	11.42	11.69
26	$\bar{x}$	7.34^A	6.26^B
	v	11.28	11.11

A, B – $\alpha = 0.01$; a, b – $\alpha = 0.05$

III. Pelt evaluation

Traits	Group	
	control	experimental
Size (cm)		
0 > 97	6	2
1 > 88	29	7
2 > 79	5	31
n	40	40
$\bar{x}$	0.97^B	1.72^A
v	54.41	32.12
Hair coat category		
1	20	29
2	17	10
3	3	1
n	40	40
$\bar{x}$	1.57^A	1.25^B
v	40.38	35.08

A, B – $\alpha = 0.01$; a, b – $\alpha = 0.05$

IV. Quantitative analysis of histopathological changes

Organ	Kind of change	Number of changes	
		control group	experimental group
Stomach	mucosa inflammation	4	2
	mucosa congestion	5	4
	increased mucus excretion	5	4
Duodenum, jejunum	catarrhal inflammation	5	4
	excessive epithelium exfoliation	7	4
	proliferation of lymphatic cells	6	5
Colon	mucosa inflammation	3	3
	increased mucus excretion	5	2
Liver	degeneration of liver cells	4	5
	haemostasis	7	9
	foci of coagulative necrosis	3	1
Pancreas	extravasation, cell necrosis	3	2
	congestion	4	5
Kidney	parenchymatous degeneration of the epithelial cells of convoluted tubules	3	3
	focal necrosis of the epithelial cells of convoluted tubules	4	3
	haemostatic congestion in the medullar part	5	4
	mesangial glomerulonephritis	2	0
Heart	no changes	0	0

mals from the control group had longer pelts, due to their higher final body weight. On the other hand, foxes from the experimental group averaged a higher pelt quality (hair coat category), a probable result of receiving balanced feed with unchanged composition for a long period of time. The composition and nutritive value of wet feeds always vary, due to the availability of feed components. Other authors who studied the problem of feeding fur-bearing animals on pellets did also not observe a negative effect of such feed on the quality of fur cover (Allain *et al.*, 1980; Weiss, 1987).

The results of postmortem and histopathological examinations of the alimentary tract are presented in Table IV. All the animals had well-developed internal organs. Regular amounts of feed were found in the alimentary tracts of the foxes from both groups. Small amounts of excrements were noted in their large intestines. The gastric mucosa and duodenal mucosa were red, soft and covered by large amounts of stretchy mucus.

The following changes were noted in the histological preparations made of stomachs: catarrhal inflammation of the mucous membrane, congestion of the mucous and submucous membranes and excessive amounts of mucus produced by goblet cells. The morphological changes were more frequent in group I (standard feed). In the experimental group, catarrhal inflammation of the gastric mucosa occurred in only 2 animals.

Well-developed villi were observed in the duodenum and jejunum. Infiltration by numerous lymphoid cells was noted in the duodenum, which caused villus deformation. Excessive exfoliation of villus epithelial cells was also observed. Necrosis of the top parts of the villi occurred in the case of a few animals. The symptoms of catarrhal inflammations were found in the intestines of foxes from both groups.

The large intestine had a regular structure; catarrhal inflammation and excessive amounts of mucus were noted in only some of its parts.

Liver cells in the foxes from group I were characterized by parenchymatous and vacuolar degeneration. Small foci of coagulative necrosis were observed in the liver cells of 3 foxes. The livers of the animals from group II showed congestion of intralobular capillary vessels and interlobular vessels. Numerous liver cells exhibited parenchymatous or vacuolar degeneration. Moreover, small foci of coagulative necrosis were observed in liver cells of one fox. Lymphoid cell infiltration was found around blood vessels.

The pancreas tissue was characterized by extensive extravasation. Some foci of necrosis were noted in the extra-secretary cells. Small foci of lymphoid cell infiltration were present in connective tissue around leading out ducts and blood vessels. The changes described occurred in the animals of both groups.

The following changes were noted in the kidneys: parenchymatous degeneration of the epithelial cells of convoluted tubules, focal necrosis of those cells and haemostatic congestion in the medullar part of the kidneys. The intensity of the above changes was similar in both groups of animals. Mesangial glomerulonephritis was found in 2 foxes of group I.

Heart muscles of the animals from both groups did not show any morphological changes.

CONCLUSIONS

1. Feeding pelleted feed to arctic foxes resulted in a decrease in their final body weight and pelt size, but improved the quality of hair coat.

2. Postmortem and histopathological examinations of the internal organs and alimentary tract of foxes did not indicate any effect of pellets on health of the animals.

REFERENCES

Allain D., Rougeot J., Charlet-Lery G., Sabaut J. J. (1980): Technique of feeding pellets to minks. Scientifur, *4*: 47–50.

Normy żywienia mięsożernych i roślinożernych zwierząt futerkowych (1994). Jablonna.

Ruszczyc Z. (1981): Metodyka doświadczeń zootechnicznych. Warszawa, PWRi.,

Skrede A., Gulbramdsen K. E. (1986): Fat sources in pelleted dry diets for minks and foxes. Scientifur (1): 81.

Slawon J. (1981): Badanie nad opracowaniem skladu suchych mieszanek pelnoskladnikowych dla lisów polarnych. Zesz. Nauk. Post. Nauk Roln., *259*: 23–29.

Weiss V. (1987): Trockenfutter? Dtsch. Pelztierzüchter, *7*: 98.

Received for publication on March 8, 1999
Accepted for publication on June 22, 1999

Contact Address:

Prof. dr. hab. Manfred O. L o r e k , Uniwersytet Warmińsko-Mazurski w Olsztynie, Wydzial Bioinżynierii Zwierząt, Katedra Hodowli Zwierząt Futerkowych, 10-718 Olsztyn, Polska, tel.: 0-89/523 32 85, fax: 0-89/523 35 19

Upozornění pro autory vědeckých časopisů

Z důvodu rychlejšího a kvalitnějšího zpracování grafických příloh (grafů, schémat apod.) příspěvků zasílaných do redakce Vás žádáme o jejich dodání kromě tištěné formy i na disketách.

Pérovky mohou být zpracovány jako předloha pro skenování nebo mohou být dodány též jako bitmapa ve formátu ***.TIF** (600 DPI). Pro skenování by grafy neměly obsahovat šedivé plochy. Místo šedi se mohou použít různé typy černobílého šrafování.

Jestliže jsou **grafy vytvořeny v programu EXCEL**, je potřeba je dodat uložené v tomto programu (nestačí grafy naimportované do programu WORD).

Obrázky **nezasílejte** ve formátu **Harvard Graphics**, nýbrž vyexportované do některého z výše uvedených formátů.

TRACE ELEMENTS IN THE WOOL OF POLISH MERINO SHEEP GRAZED IN POLLUTED AND UNPOLLUTED ENVIRONMENT

VÝSKYT STOPOVÝCH PRVKŮ V ROUNU OVCÍ PLEMENE POLSKÉ MERINO PASOUCÍCH SE VE ZNEČIŠTĚNÉM, RESP. NEZNEČIŠTĚNÉM PROSTŘEDÍ

R. Kołacz[1], E. Bodak[1], Z. Dobrzański[1], B. Patkowska-Sokoła[2]

Agricultural University of Wroclaw, [1]Department of Animal Hygiene and Livestock Environment, [2]Department of Sheep and Fur Animals Breeding, Wroclaw, Poland

ABSTRACT: The study was aimed to compare concentrations of trace elements in the wool of Merino ewes grazing on the pastures polluted and unpolluted with industrial emissions. As, Ba, Cd, Cu, Co, Cr, Fe, Mn, Mo, Pb, Si, Sr, Ti and Zn were examined. ICP technique was applied with the use of Philips Sc model PU-7000 controlled by IBM P-3202. CETAC-5000 AT nebulizer and microwave station MD-2000 CEM were used for mineralization of samples. Significant differences concerned 11 elements: As, Ba, Cd, Co, Fe, Mn, Mo, Pb, Si, Ti and Zn. Manganese in polluted and unpolluted environment amounted respectively to: 3.682 and 0.059 $mg.kg^{-1}$ dry matter; Pb 6.937 and 0.495; Fe 21.661 and 2.563; Cd 0.543 and 0.074; Co 0.186 and 0.046; Ti 2.353 and 0.640; Mo 0.125 and 0.048; Si 111.30 and 55.86. As 0.047 and 0.029, Zn 224.73 and 140.21 and Ba 4.687 and 2.996; Cu 7.23 and 4.33, Sr 9.303 and 8.179, Cr 0.047 and 0.046. According to a descending order of the values in both groups Zn and Si occupied the same first and second position and As the 14th one.

Keywords: sheep; wool; trace elements; heavy metals; environment

ABSTRAKT: Sledování jsme zaměřili na porovnání koncentrací stopových prvků v rounu ovcí plemene merino pasoucích se na pastvinách znečištěných, resp. neznečištěných průmyslovými emisemi. Sledovali jsme obsahy těchto prvků: As, Ba, Cd, Cu, Co, Cr, Fe, Mn, Mo, Pb, Si, Sr, Ti a Zn. Ke stanovení obsahů jsme použili metodu ICP na přístroji Philips Sc typu PU-7000 řízeném počítačem IBM P-3202. K mineralizaci vzorků jsme použili rozprašovač CETAC-5000 AT a mikrovlnnou stanici MD-2000 CEM. Významné rozdíly jsme zjistili u 11 prvků: As, Ba, Cd, Co, Fe, Mn, Mo, Pb, Si, Ti a Zn. Koncentrace hořčíku ve znečištěném, resp. neznečištěném prostředí činila 3,682, resp. 0,059 mg/kg sušiny; Pb 6,937, resp. 0,495; Fe 21,661, resp. 2,563; Cd 0,543, resp. 0,074; Co 0,186, resp. 0,046; Ti 2,353, resp. 0,640; Mo 0,125, resp. 0,048; Si 111,30, resp. 55,86; As 0,047, resp. 0,029; Zn 224,73, resp. 140,21; Ba 4,687, resp. 2,996; Cu 7.23, resp. 4,33; Sr 9,303, resp. 8,179; Cr 0,047, resp. 0,046. Podle sestupného pořadí hodnot prvků v obou skupinách se prvky Zn a Si nacházely shodně na prvním a na druhém místě a prvek As byl na 14. místě.

Klíčová slova: ovce; rouno; stopové prvky; těžké kovy; prostředí

INTRODUCTION

Monitoring of elements in human and animal hair provides valuable diagnostic procedure, optional to the blood and urine analysis; therefore it is applied with the increasing frequency to animal science, environmental physiology and toxicology. Deposit of elements into livestock hair depends on their frequency in the environment, the system of housing, species, breed, way of absorption, dietary factors, type of interaction between elements, sex, age, body location and hair colour (Pais, 1990).

Elements incorporated in hair follicles are chemically or physically associated with cortical cells of hair shaft and reflect mineral status at the time when hair filament was synthesized. Significant quantities are also absorbed to hair surface via contact with secretions from sebaceous, apocrine and eccrine glands (Combs *et al.*, 1983). The endogenous element is not always homogeneously spread across the whole section of hair. Iron and lead seem to be packed on the periphery of hair by natural means, while sulphur, zinc and copper are distributed across the hair diameter (Bos *et al.*, 1985).

Sheep grazing in the areas polluted with emissions originating from industrial works, city agglomerations and motorways enhance both dietary and not-dietary absorption of heavy metals (Kolacz *et al.*, 1994; Ward, Savage, 1994). Industrially or naturally evoked deficiency/excess of elements, as it is found in some ecosystems, increases the risk of development of toxaemia or endemic diseases. Moreover, endo- and exogenous mineral unbalance affects the fleece characteristics leading to its lesser usefulness for further processing (Wojciechowska *et al.*, 1991).

The aim of the study was to compare the concentrations of trace elements in the wool of Merino sheep grazing on pastures located within the area of copper mining and works (polluted environment) and in the mountains (unpolluted environment).

MATERIALS AND METHODS

Experimental material consisted of 20 wool samples taken from 3 years old dry Merino ewes grazing on two locations from May to September, 10 samples from each location. The following locations served as the basis of an examination:

- unpolluted area of the National Park of Bieszczady Mountain (South-East Poland), sparsely populated, protected from industrial influences by the governmental law (G-UnPol);
- polluted area of copper mining and metallurgical works (South West Poland), densely populated and urbanized (G-Pol). Pasture was located at the distance of 5–7 km far from the center of the works (Legnica-Glogow Copper Region).

Wool samples each of 15-20 g were collected by clipping the wool from the shoulder on the final day of grazing season. Laboratory procedure included manual removal of mechanical particles from the wool, washing with the use of detergent at 50 °C, multiple rinse with distilled water and extracting with methylene chloride in Soxhlet apparatus. Elemental values were determined by inductively coupled plasma mass spectrometry (ICP) with the use of spectrometer Philips PU-7000 (Cambridge, GB) controlled by IBM P-3202 (Boss, Fredeen, 1989; Górecka, 1995). Mineralization of samples was done by microwave technique with the use of MD-2000 CEM station and ultrasonic nebulizer CETAC U-5000 AT (USA). The solvent was spectrally pure HNO_3 (MERCK). The following 14 elements were determined at the detection limit from 0.07 to 3 $ng.cm^{-3}$, depending on the element: As, Ba, Cd, Co, Cr, Cu, Fe, Mn, Mo, Pb, Si, Sr, Ti, Zn. Statistical analysis was based on Statgraph. ver. 5.1.

RESULTS

The concentrations all 14 elements were higher in the wool from the copper mining area, if compared to the respective values of mountainous environment (Table I). Significant differences concerned 11 elements: As, Ba, Cd, Co, Fe, Mn, Mo, Pb, Si, Ti Zn.

In the wool from the polluted environment, concentration of Pb was higher 14 times; Fe – 8.4; Cd – 7.3; Co – 4; Ti – 3.7; Mo – 2.6; Si – 2, As and Zn – 1.6 ($P < 0.01$). Ba was higher 1.6 times ($P < 0.05$), similarly like Cu, yet the latter difference was not significant. Sr and Cr values were approximately the same in both groups. Profound difference concerned Mn (3.682 vs 0.059 $mg.kg^{-1}$).

The concentrations of elements in the wool according to a descending order of the values are presented in Table II. Characteristic of both groups were the same positions of Zn, Si and As which occupied the 1st and 2nd and 14th place. Sr took a high position as the 3rd (G-UnPol) and 4th (G-Pol). In polluted environment the 3rd element incorporated into the hair was Fe. Remaining elements occupied similar positions with a shift in the order about 1 or 2 places.

DISCUSSION

Elements enter the tissues by alimentary, pulmonary and integument routes. Heavy metals of industrial ori-

I. The concentration of trace elements in the wool of Polish Merino sheep ($mg.kg^{-1}$)

Element	Statistical parameters	Environment	
		unpolluted	polluted
As	$\bar{x}$	0.029	0.047**
	s	0.0141	0.022
Ba	$\bar{x}$	2.996	4.687*
	s	0.8621	1.838
Cd	$\bar{x}$	0.074	0.543**
	s	0.0329	0.4029
Co	$\bar{x}$	0.046	0.186**
	s	0.021	0.048
Cr	$\bar{x}$	0.046	0.047
	s	0.029	0.036
Cu	$\bar{x}$	4.335	7.230
	s	1.276	4.354
Fe	$\bar{x}$	2.563	21.661*
	s	0.561	9.305
Mn	$\bar{x}$	0.059	3.682**
	s	0.036	1.144
Mo	$\bar{x}$	0.048	0.125**
	s	0.029	0.031
Pb	$\bar{x}$	0.495	6.937**
	s	0.177	2.955
Si	$\bar{x}$	55.86	111.30**
	s	11.19	30.88
Sr	$\bar{x}$	8.179	9.303
	s	1.783	2.244
Ti	$\bar{x}$	0.640	2.353**
	s	0.161	0.679
Zn	$\bar{x}$	140.21	224.73**
	s	35.53	75.29

** $P < 0.01$; * $P < 0.05$

II. The concentration of trace elements in the wool of Polish Merino sheep in a descending order of the values

Environment	Element													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Unpolluted	**Zn >**	**Si >**	**Sr >**	**Cu >**	**Ba >**	**Fe >**	**Ti >**	**Pb >**	**Cd >**	**Mn >**	**Mo >**	**Cr =**	**Co >**	**As**
Polluted	**Zn >**	**Si >**	**Fe >**	**Sr >**	**Cu >**	**Pb >**	**Ba >**	**Mn >**	**Ti >**	**Cd >**	**Co >**	**Mo >**	**Cr =**	**As**

gin are toxic, especially if entered by the pulmonary tract, since elements diffuse immediately into blood with negligence of the liver filter. Previous studies conducted in the same area of copper mining and works (Kolacz *et al.*, 1994) revealed the increase of Cu, Pb, Zn, As and Si in the lungs of dairy cows which could be the cause of pathomorphological changes in that organ. It was proved that elevated concentrations of Cu, Cd and Pb in sheep blood induce hematological and immunological dysfunctions (Kolacz *et al.*, 1995; Bíreš, 1989). However, alimentary exposure may be less deleterious as metabolic mechanisms control the absorption-excretion balance. In the study by Baars *et al.* (1988) heavy metals apparently did not impair the health of locally grazing sheep in the Netherlands. This might be due to the selective consumption behavior, stabling during the winter, limited biological availability of the elements and management of sheep adapted to the local circumstances. It is not possible to omit the role of interactions between elements of antagonistic or synergistic type, finally regulating the mineral state of organism.

The concentrations of elements in hair reflect endo- and exogenous loads. Particular elements, however, have different indicative meaning for the monitoring of deficiency/excess states.

Arsenic occurs in animal tissues in the range from 0.05 to 1.5 ppm (Kabata-Pendias, Pendias, 1993). Hair makes a good indicator of poisoning with As and reflects the scale of environmental pollution, however, the load must be high indeed to induce a toxic risk. Toxicity related to hair is manifested by its being prone to breaking and colour changes. Gebel *et al.* (1996) stated that As in the wool of sheep bred in an urban area was approximately 10 times higher (0.57 ppm) than in those bred on the grounds formerly influenced by mercury mining (0.051 ppm), so contaminated with As, Hg and Sb. It suggests that air pollution (dust-fall, aerosols) influences As accumulation to a higher degree than dietary intake. In our study the concentrations of arsenic in the wool from both polluted and unpolluted environments, were lower than those cited above.

Barium occurs in animal tissues in the range of 0.1–30 ppm. Indicative tissues are skin, lungs, bones and teeth. The atmospheric Ba may reach even 100 ng/m^3 near city agglomerations, mainly due to its high concentration in vehicle fumes. In the soil barium is immobilized by its binding to loam minerals, Fe-Mn-P concretions and S-compounds, which in turn decreases its availability (Kabata-Pendias, Pendias, 1993). Therefore grazing sheep may be exposed to Ba rather by respiratory and integument tracts than by the alimentary one. Our results document the effect of environmental load with barium on its concentration in the wool.

Hair was found to be a worse indicator for **cadmium** than kidneys and liver. However, to some extent, hair does reflect environmental pollution (Kollmer, 1991). Cadmium together with As and Hg are involved in the disturbance of hair cycle shown by the presence of dystrophic hair and intensity of defects is proportional to toxic values detected in blood and urine (Pierard, 1979). Enne *et al.* (1989) determined Cd in the wool of ewes living in the coal-mining region (Italy) as reaching 0.8 ppm. Hair of sheep, horses and alpacas exposed to vehicle fumes alongside the London Orbital motorway had significantly elevated Cd in hair tips, as well as Br, Cr, Cu, Ni, Pb, V and Zn (Ward, Savage, 1994). In our study cadmium in the wool from polluted environment proves an exposure of sheep to the same type of pollution.

Trace amount of Cd present in the wool from unpolluted sheep might be also of industrial origin (acid rains, dust migration). Not even a considerable distance from the source of emissions protects from contamination. Rumen, kidneys, liver and covering hair of wild ruminants grazing in the Hartz Mountains (Germany) contained more cadmium than domestic sheep. Secondary cadmium-induced Cu-, Mn- and Zn-deficiency caused limb defects in mouflons (Anke *et al.*, 1979). In the case of environmental Cd pollution parallel overload with Zn appears to be advantageous in view of antagonistic action between these elements (Anke, Groppel, 1985). It is worth mentioning that high Zn concentration (also S and Mo) was found in soil and fodder plants in the copper mining and works area (Dobrzański *et al.*, 1994), which in turn could influence retention of cadmium in the sheep body.

Cobalt in animal tissues ranges from 0.005 to 0.5 ppm. Hair makes the material rarely used as an indicator for that element. Clinical tests include indirect measurements in tissues via the level of vitamin B_{12} and in urine via the concentration of methylomalonic acid (Jaśkowski *et al.*, 1993). Ruminants belong to the species of high needs for cobalt, because of its poor utilization for cyanocobalamin synthesis. Cobalt deficiency is characteristic of peat, sandy and Mo-abundant soils. Cobalt in contaminated soil may increase from 8 ppm of natural background up to 120–140 ppm (Kabata-Pendias, Pendias, 1993). In our study the wool of polluted sheep incorporated cobalt at a significantly higher amount, if compared to the wool from the mountainous area.

Chromium in animal tissues varies from 0.02–0.1 (soft tissues) to 0.2–1.0 ppm (hair, skin). There are noticeable regional differences in the concentration of this element related to species and feeding factors. Hair makes a good indicator for environmental Cr, since it is easily deposited in cells and remains there for a relatively long period (Matsubara, Machida, 1985).

Numerous papers have been published concerning Cr in human hair depending on age, nutritional habits, stress, diseases and exposure to pollution. Less numerous pieces of information are available about animal cover. In opossum correlations were found for Cr – Pb and Cr – Cd (Burger *et al.*, 1994). Chromium in the hair of Karakul (Namibia) varied from 0.3 to 1.7 ppm and was negatively correlated with texture and positively with silky, elastic fibers (Matter, 1991). In the present study the contents of chromium in the wool from both environments were similar and several times lower than the bottom limit referred by Matter (1991).

Copper in animal tissues occurs in the range of 1–30 ppm. This element is of special need for hair growth and its development and also by taking part in collagen hardening and synthesis of keratin and melanin. Wójcikowska-Soroczyńska and Kopczyńska (1991) stated that the wool of Polish sheep breeds contains Cu in the wide range 4–36, and yellowish 3–5 ppm. Curious correlation was found for eumelanine, Cu and wool colour. Black hair of domestic breed Wrzosówka contained 62 ppm Cu; dark-grey – 43; sky blue – 33; light grey – 22 (Krośnicka-Bombala, 1996).

Elemental interactions of antagonistic (Cu – Zn, Cu – Mo, Cu – S) or synergistic type (Cu – Fe) are of high importance. According to Frank (1988), moose living in the region affected by acid rain (Sweden) suffer from secondary Cu deficiency and molybdenosis related to pH increase in soil and water, which changed mineral uptake by plants. Alopecia and poor pigmentation were the consequences of depression of Cu-dependent tyrosinase activity. Secondary Cu-deficiency may occur in ruminants kept in the regions contaminated with Cu and S. Anke and Groppel (1985) reported that Cu – S interaction was manifested by a decreased level of Cu in the sheep hair by 37% and in cow by 83% when compared to the control values. In some regions polluted with Cu the wool of sheep accumulated 83 ppm (22 of the control value). Copper content in the wool of sheep from a coal mining area (Italy) amounted to 1.8 ppm (Enne *et al.*, 1989). In our study the wool of sheep grazing in polluted environment incorporated a higher content of copper than that from the mountainous area, but the difference was not significant. Because of the fact that the region of copper industry was found to be abundant in antagonistically acting zinc, molybdenum and sulphur, lower accumulation of copper in tissues of the sheep grazing there could be expected.

Iron in the wool of Polish sheep breeds varies from 37 to 75 ppm (Wójcikowska-Soroczyńska, Kopczyńska, 1991). Iron appears to be strongly related to hair colour. The wool of Wrzosówka breed contained the following values of Fe (ppm): black – 41; dark-grey – 22; sky blue – 38; light grey – 24 (Krośnicka-Bombala, 1996). Merino wool before extraction with methylene chloride contained 20–26 mg Fe/100 g d.m. and after extraction 1–10 (Wojciechowska *et al.*, 1991). In our study the wool from polluted area incorporated iron easily (21.66 vs 2.56 $mg.kg^{-1}$d. m.), which is reflected in the frequent occurrence of Fe-compounds in that environment.

Hair is a good indicator of **manganese**. Isotopic ^{52}Mn was incorporated in hair after 48 h. Injection of ^{52}Mn made isotope detectable after 1 h. Manganese in hair depends on the species. It amounts in mouflon 73 $\mu mol.kg^{-1}$ d.m., aurochs – 55; moose and horse – 18; red deer – 13; dairy cow – 9–11; mink – 3.6; rhesus and man – 2.4 (Kośla *et al.*, 1989). The wool of Polish sheep breeds contains manganese in the range from 0.05 to 20 ppm (Wójcikowska-Soroczyńska, Kopczyńska, 1991). Varied manganese contents in Wrzosówka wool depended on the color as follows (ppm): black – 16; dark grey – 13; sky blue – 12; light grey – 9. Polish Merino wool contained manganese at the concentration 0.14–8.45 ppm, which was dependent on pasture location, hair section and season of the year (Krośnicka-Bombala, 1996). Manganese is not toxic, yet, antagonistically affects copper and iron management in the organism. The sheen of Karakul wool was positively correlated with Cu and negatively with Mn (Matter, 1991). In our study the wool of polluted environment contained manganese within the range reported for Polish Merino breed. On the other hand, the sheep from the mountainous environment incorporated manganese to the hair at an extremely low amount. It could result from low availability of manganese caused by antagonism among some main elements (Ca, Mg, P, K) or improper Fe/Mn proportion in the diet.

Indicative tissues for **molybdenum** are spleen, liver, kidneys and hair. A normal concentration of Mo in human and animal hair varies from 0.02 to 1 ppm (Kabata-Pendias, Pendias, 1993). Deficiency does not occur in natural environment. Excess may appear in the provinces geologically rich in antagonistic elements (Co, Cu, Mn, Ca, S). The symptoms of molybdenum poisoning are poor growth, diarrhea, anemia, achromotrichia, degeneration of central nervous system and the loss of crimp (Pitt, 1976). Cattle is more sensitive to molybdenosis than sheep, mouflons and goats (Anke, Groppel, 1985). In our study sheep from both, polluted and unpolluted areas incorporated molybdenum in hair in the range reported as a norm.

Lead is a toxic element directly related to industrial and traffic emissions. This element enters easily into tissues and undergoes accumulation, mainly in bones (4–25 ppm). Deleterious effects concern the nervous system, marrow, erythrocyte functions and bone structure. There exist antagonistic interactions between Pb and Cu, Zn, Se, Ca and P.

Lead in hair precisely reflects total body load independently of age. Correlation coefficients proved a strong dependence between Pb content in hair and blood (Paulsen *et al.*, 1996). The wool of sheep grazing in a coal mining region (Italy) cumulated on average 20.1 ppm Pb (Enne *et al.*, 1989). The bottom section of hair cumulated less Pb (1–13 mg.100 g^{-1} d. m.) than the tip (8–68) (Wojciechowska *et al.*, 1991). Our results prove significant influence of environmental pollution on wool contamination with Pb.

Silicon in animal tissues ranges from 1–10 (blood and parenchyma organs) up to 100–500 ppm (bone, tendon, skin, lung). Biological role of silicon was reviewed by Bodak *et al.* (1997). This element is essential and not toxic. There is an evident effect of silicon on bone formation as well as cartilage, connective tissue, collagen, keratin, hair and feather. In the present study Si was the 2nd element regarding the content incorporated into the wool of both groups, which may indicate its unique role in the building of hair structure.

Strontium in animal tissues varies from 0.1–1 (muscle) to 30–100 ppm (bone). Biological role of this element was determined in relation to calcification processes. Indicative tissues are bone, aorta, testes and prostate. There are interactions among Sr and Ca, P, Cu, Co. In the present study strontium concentration was similar in both groups of sheep. It can be reported that this element was incorporated in hair and its values reached high positions, the 3rd (unpolluted environment) and 4th (polluted).

Titanium in animal tissues occurs in the range 0.5–2 ppm. Indicative organs are lungs and skin. Atmospheric concentration varies from 15–25 (unpolluted regions) to 700 ng.m^{-3} (polluted). Titan enters into tissues mainly with respired dust. Dietary intake is limited due to low Ti accumulation in plant tissues. However, tissues of plants with high ability to absorb Si from the environment absorb elevated amounts of Ti. In water and soil Ti shows low mobility (Pais, 1990). Our results related to the sheep from the copper mining area indicate responses to the exposure to industrial pollution.

Zinc is strongly related to the growth of wool. Deficiency causes poor growth and improper fiber keratinization. Follicles contain a high proportion of apoptotic bodies (White *et al.*, 1994). In the case of alopecia the value of Zn may be in the normal range but Cu level is elevated (Morgan *et al.*, 1986). In the wool of Polish sheep breeds Zn varies from 87 to 113 ppm (Wójcikowska-Soroczyńska, Kopczyńska, 1991). The wool of Wrzosówka breed contained zinc as follows (ppm): black – 115, dark-grey – 118, sky blue – 135, light gray – 122 (Krośnicka-Bombala, 1996). In our study the wool of mountain sheep incorporated zinc in the range reported as a norm, whereas zinc of the wool from polluted area notably exceed the referred value. Increased zinc uptake by sheep exposed to pollution could be advantageous for metabolic reactions as it counteracts accumulation of cadmium.

Concluding, results of the present study indicate that the wool of Merino ewes grazing in the area of copper mining and metallurgical works incorporated significantly higher amounts of As, Ba, Cd, Co, Fe, Mn, Mo, Pb, Si, Ti and Zn, if compared to the mountainous environment. More studies are needed to determine the routes of absorption of these elements from the environment and metabolic mechanisms responsible for incorporation of elements into sheep hair.

REFERENCES

Anke M., Gropplel B. (1985): Possibilities to reduce the toxic effect of sulfur, cadmium, molybdenum, zinc and nickel in useful animals. PAAE Krakow, Poland: 41–63.

Anke M., Grun M., Briedermann L. (1979): The supply of wild ruminants with major and trace elements. 1. The cadmium content of winter grazing and the cadmium status of red deer, roes and mouflons. Arch. Thierernähr., *12: 829–844.*

Baars A., Van Beek H., Spierenburg T., Beeftink W., Nieuwenhuize J., Pekelder J., Boom J. (1988): Environmental contamination by heavy metals and fluoride in the Saeftinge salt marsh (The Netherlands) and its effect on sheep. Vet. Q., *2*: 90–98.

Bíreš J. (1989): Interactive relations between copper, iron, zinc, arsenic, cadmium and lead in the liver in sheep after experimental poisoning with copper oxide. Veter. Med. (Praha), *34*: 665–674.

Bodak E., Dobrzański Z., Trziszka T. (1997): Biofunkcje krzemu – znaczenie w produkcji zwierzcej. Med. Wet., *53*: 316–322.

Bos A., Van Der Stap C., Valkovic V. (1985): Incorporation routes of elements into human hair; implications for hair analysis used for monitoring. Sci. Total Environ., *42*: 157–169.

Boss C., Fredeen K. (1989): Concepts of instrumentation and techniques in inductively coupled plasma atomic emission spectrometry. New York, Perkin Elmer.

Burger J., Marquez M., Gochfeld M. (1994): Heavy metals in the hair of opossum from Paolo Verde, Costa Rica. Arch. Environ. Contam. Toxicol., *27*: 472–476.

Combs D. K., Goodrich R., Meiske J. C. (1983): Influence of dietary zinc or cadmium on hair and tissue mineral concentration in rats and goats. J. Anim. Sci., *56*: 184–193.

Dobrzański Z., Górecka H., Kolacz R., Górecki H. A. (1994): Effect of pollution from copper mining and metallurgy works on heavy metals concentration in green forage, blood serum of dairy cows and milk. In: Proc. VIII Int. Congr. Anim. Hyg., St. Paul, MI, USA: 29–31.

Enne G., Leita L., Giardini I., Sequi P. (1989): Relationship between the level of environmental contamination with heavy metals and accumulation in sheep tissues. Med. Wet., *9–10*: 565–568.

Frank A. (1988): Mysterious moose disease in Sweden. Sci. Total Environ., *209*: 17–23.

Gebel T., Kevekordes S., Schaefer J., Von Platen H., Dunkelberg H. (1996): Assessment of a possible genotoxic environmental risk in sheep breed on grounds with strongly elevated contents of mercury, arsenic and antimony. Mutat. Res., *368*: 267–274.

Górecka H. (1995): Wykorzystanie spektrometrii plazmowej w badaniach ekotoksykologicznych. Ekol. Techn., 2: 11–13.

Jaśkowski J., Lachowski A., Gehrke M. (1993): O diagnozowaniu i ocenie niedoborów miedzi, selenu, kobaltu i manganu u bydla i owiec. Med. Wet., *49*: 306–308.

Kabata-Pendias A., Pendias H. (1993): Biogeochemia pierwiastków śladowych. Warszawa, PWN.

Kollmer W. E. (1991): Cadmium in induced hair of the rat and its relation to the level in the diet and in the major organs during long term exposure to cadmium in the subtoxic and toxic range. J. Trace Elem. Electrol. Health Dis., *5*: 165–171.

Kołacz R., Dobrzański Z., Nowakowska A. (1995): The concentration of Zn, Cu, Pb and Cd in blood of sheep and cattle and the effect on some hematological and biochemical indices. Mat. Miedzyn. Sesji Nauk. Higienizacja wsi, Lublin: 63–69.

Kołacz R., Houszka M., Dobrzański Z., Górecka H. (1994): Effect of increased concentration of air dust in copper industry region on pathomorphologic changes in lung of dairy cows. Med. Wet., *50*: 488–491.

Kośla T, Rokicki E., Roga-Franc M. (1989): Sierść jako wskaźnik oceny zawartości manganu w organizmie zwierzęcym. Med. Wet., *45*: 166–168.

Krośnicka-Bombala R. (1996): Wplyw pory roku i umaszczenia na zawartość pigmentu oraz mikroelementów w okrywie owiec i kóz o różnym umaszczeniu. Zesz. Nauk. Przeg. Hod., PTZ, *23*: 117–132.

Matsubara J., Machida K. (1985): Significance of elemental analysis of hair as a means of detecting environmental pollution. Environ. Res., *38*: 225–238.

Matter H. (1991): Does mineral content in Karalul fibres affect hair quality? Karakul Yearbook. Karakul Breed. Soc., South. Africa, *33*: 63–72.

Morgan K. L., Brown P., Wright A., Steele F., Baker A. (1986): An investigation into the aethiology of 'wool slip': alopecia in ewes which are housed and shorn in winter. Vet. Rec., *20*, 1986: 621–625.

Pais I. (ed.) (1990): The problems of essentiality and beneficiality of trace elements. Univ. Horticult. Food Indust., Budapest: 191–204.

Paulsen F., Mai S., Zellmer U., Alsen-Hinrichs C. (1996): Blood and hair arsenic, lead and cadmium analysis of adults and correlation analysis with special reference to eating habits and other behavioral influence. Gesundheitswesen, *58*: 459–464.

Pierard G. (1979): Toxic effects of metals from the environment on hair growth and structure. J. Cutan. Pathol., *6*: 237–242.

Pitt M. (1976): Molybdenum toxicity: interactions between copper, molybdenum and sulphate. Agents Actions, *6*: 758–769.

Ward N., Savage J. (1994): Elemental status of grazing animals located adjacent to the London Orbital (M25) motorway. Sci. Total Environ., *23*: 185–189.

White C., Martin G., Hynd P., Chapman R. (1994): The effect of zinc deficiency on wool growth and skin follicle histology of male Merino lambs. Brit. J. Nutr., *71*: 425–435.

Wojciechowska E., Pielesz A., Wlochowicz A. (1991): Wplyw sladowych ilości wybranych pierwiastków na zólkniecie welny owiec merynosowych i dlugowelnistych. In: Proc. Conf. Metlan 91, Gdansk, Poland: 71–76.

Wójcikowska-Soroczyńska M., Kopczyńska B. (1991): Badania nad wybranymi pierwiastkami śladowymi w welnach owiec Polskich. In: Proc. Conf. Metlan 91, Gdansk, Poland: 173-178.

Received for publication on December 9, 1998
Accepted for publication on June 22, 1999

Contact Address:

Prof. dr. hab. Roman Kołacz, Agricultural University, Faculty of Biology and Animal Production, Department of Animal Hygiene and Livestock Environment, Dicksteina 3, 51-617 Wroclaw, Poland, tel./fax: 071/348 41 42

NÁLEZ PRIRODZENÉHO HYBRIDA *CARASSIUS GIBELIO* (BLOCH, 1782) x *CYPRINUS CARPIO* (LINNAEUS, 1758)

THE FIND OF A NATURAL HYBRID OF *CARASSIUS GIBELIO* (BLOCH, 1782) x *CYPRINUS CARPIO* (LINNAEUS, 1758)

I. Stráňai

Slovak University of Agriculture, Faculty of Agronomy, Nitra, Slovak Republic

ABSTRACT: The presence of an interspecific hybrid *Carassius gibelio* x *Cyprinus carpio* that has not been known in the territory of Slovakia until now is described in this paper. A hybrid that was caught was a male with body length 276.2 mm, weight 755 g and age 3+. This individual resembles the species *Carassius gibelio* by its body shape and color, and by dark pigmented peritoneum, but the lower pair of barbs indicates the affinity with *Cyprinus carpio*. It is possible to state on the basis of a comparison of meristic traits of the hybrid with these traits in parental species that it inclines to the species *Carassius gibelio* by the number of scales along the lateral line, number of branchial spines and the number of branched rays in the dorsal fin. The compared plastic traits body length, V–A and P–A distances, minimum body depth, depth of caudal peduncle and fin length indicate that it inclines to the species *Cyprinus carpio*. The length of head and anal fin of the hybrid is of intermediary character. It approaches the species *Carassius gibelio* by the traits preventral distance, depth of dorsal fin, body width, preorbital distance and upper jaw length. Taking into account the effect of matrocliny, it is to conclude that the individual is a hybrid between *Carassius gibelio* (female) x *Cyprinus carpio* (male).

Keywords: *Carassius gibelio* x *Cyprinus carpio* hybrid; presence; Slovakia

ABSTRAKT: V práci je opísaný výskyt medzidruhového hybrida *Carassius gibelio* x *Cyprinus carpio*, ktorý doteraz nebol známy z územia Slovenska. Ulovený hybrid je samec s dĺžkou tela 276,2 mm, hmotnosťou 755 g a veku 3+. Tvarom tela a sfarbením, ako aj tmavo pigmentovaným peritoneom, pripomína tento jedinec druh *Carassius gibelio*, ale na súvislosť s druhom *Cyprinus carpio* poukazuje prítomnosť dolného páru fúzov. Pri porovnaní meristických znakov hybrida s týmito znakmi pri rodičovských druhov možno konštatovať, že v počte šupín v bočnej čiare, počte žiabrových paličiek a v počte rozvetvených lúčov v chrbtovej plutve inklinuje k druhu *Carassius gibelio*. Z porovnávaných plastických znakov hybrid inklinuje k druhu *Cyprinus carpio* výškou tela, vzdialenosťou V–A a P–A, najmenšou výškou tela, výškou chvostového stebla a dĺžkou plutiev. Dĺžka hlavy a análnej plutvy hybrida má intermediárny charakter. V znakoch predventrálna vzdialenosť, výška chrbtovej plutvy, šírka tela, predočná vzdialenosť a dĺžka hornej čeľuste má hybrid bližšie k druhu *Carassius gibelio*. Po zohľadnení vplyvu matroklinity vyplýva, že jedinec je hybridom *Carassius gibelio* (samica) x *Cyprinus caprio* (samec).

Kľúčové slová: hybrid *Carassius gibelio* x *Cyprinus carpio*; výskyt; Slovensko

ÚVOD

Počas výlovu hlavného rybníka v Malom Záluží pri Nitre s polykultúrnou obsádkou a generačnými dravými druhmi (šťuka, sumec, zubáč) a ich eventuálnou potravou – karasom striebristým, sme zaregistrovali hybrida *Carassius gibelio* x *Cyprinus carpio*. Vzhľadom na skutočnosť, že tento hybrid nie je známy z nášho územia, považujem za potrebné v nasledujúcom podrobnejšie uviesť opis tejto ryby, uloženej v ichtyologickej zbierke zoologického oddelenia Prírodovedného múzea SNM v Bratislave pod ev. č. Ry 6537.

MATERIÁL A METÓDA

Skúmaný jedinec pochádza z rybníka v Malom Záluží, ktorý sa lovil 7. 10. 1998.

Analýzou meristických a plastických znakov sme zistili, že tento jedinec je hybridom druhov *Carassius gibelio* x *Cyprinus carpio*. Porovnanie hybrida s rodičovskými druhmi sme urobili metódou výpočtu hybridných indexov (Hubbs, Kuronuma, 1942). Z obidvoch rodičovských druhov sme vybrali po 10 jedincoch s približnou veľkosťou skúmaného hybrida, pričom sa porovnávali tie znaky, ktorých rozdiel priemernej číselnej hodnoty medzi rodičovskými druhmi bol najmenej 2 %. Pohlavie sledovaných rýb sa určovalo anatomicky. Od všetkých skúmaných jedincov obidvoch rodičovských druhov, ako aj od hybrida sme odobrali šupiny z prvého radu nad bočnou čiarou nad bázou ventrálnej plutvy. Na nich sme sledovali počet radiálnych kanálikov, pomer dĺžky kaudálneho a laterálneho polomeru k orálnemu polomeru, ako aj tvar šupín.

Vzhľadom na to, že v prípade hybrida sa jedná len o jeden exemplár, všetky zistené hodnoty sledovaných parametrov sa udávajú len ako jednoduchý aritmetický priemer s príslušným empirickým rozpätím.

VÝSLEDKY

Vylovený hybrid *Carassius gibelio* x *Cyprinus carpio* je samec vo veku 3+ s dĺžkou tela 276,2 mm a s hmotnosťou 755 g (obr. 1).

Opis: D III 17, P I 17, V I 7, A III 6, lin. lat. 33, lin. transv. 6/6, počet žiabrových paličiek 38, pažerákové zuby jednoradové 4 – 4, pomer laterálneho a kaudálneho polomeru k orálnemu polomeru šupiny 0,8 a 0,9 : 1.

Meristické a plastické znaky hybrida, ako aj porovnávané rodičovské druhy sú uvedené v tab. I a II, hodnoty hybridných indexov v tab. III.

Nakoľko hybrid zaujíma rôzne postavenie k jednému či druhému rodičovskému druhu, ako aj rôzny stupeň dedenia meristických a plastických znakov, si v ďalšom bližšie všímame tie znaky, ktoré sú pre obidva rodičovské druhy výrazne odlišné. Z meristických znakov je to:

Počet šupín v bočnej čiare, tvar šupín a počet radiálnych kanálikov – pri *Carassius gibelio* sa zistil priemerný počet 30,4, pri *Cyprinus carpio* 37,8. Hybrid mal na bočnej čiare 33 šupín a v tomto znaku viac inklinuje k druhu *Carassius gibelio*.

Šupiny *Carassius gibelio* majú pre väčšinu *Cyprinidae* typický tvar: sú cykloidné, s dobre vyvinutými diagonálnymi lalokmi. Počet radiálnych kanálikov v orálnej časti je priemerne 5,2, v rozmedzí 4–7, v časti kaudálnej priemerne 3,6, v rozmedzí 2–6. Šupiny *Cyprinus carpio* sú pretiahleho tvaru s menej vysunutým diagonálnym lalokom. Počet radiálnych kanálikov v orálnej časti je priemerne 31, v rozmedzí 19–44, v kaudálnej časti 15,8, v rozmedzí 12–22. Šupiny hybrida tvarom a počtom radiálnych kanálikov v orálnej časti (5) sú podobné šupine *Carassius gibelio*, v kaudálnej časti je 8 radiálnych kanálikov. Počet všetkých radiálnych kanálikov na šupine hybrida je 15 (pri *Carassius gibelio* 8,8, pri *Cyprinus carpio* 46,8) (obr. 2).

Počet žiabrových paličiek (Sp.br.) – v tomto znaku sa hybrid približuje k druhu *Carassius gibelio* (hybrid 38, *Cyprinus carpio* 23, *Carassius gibelio* 48,6).

Počet rozvetvených lúčov (D) – podobne ako v predošlom prípade aj počet rozvetvených lúčov v chrbtovej plutve javí odklon na stranu *Carassius gibelio* (17,4). Hybrid má 17 lúčov a *Cyprinus carpio* 20 lúčov.

Počet a tvar pažerákových zubov – pri hybridovi sa zistila formula 4 – 4, pri *Carassius gibelio* zhodne 4 – 4. *Cyprinus carpio* má trojradové zuby (1.1.3 – 3.1.1). Zuby hybrida sú jednoradové, prvý a čiastočne aj štvrtý na konci vytvára rozšírenú žuvaciu plôšku, podobne ako u *Cyprinus*, ostatné sú štíhle a o polovicu užšie ako u *Carassius gibelio*.

Postavenie sledovaného hybrida z hľadiska porovnávaných plastických znakov, ktorými sa rodičovské druhy výrazne líšia, je takéto:

- **dĺžka hlavy** (lc) – jedná sa o intermediárny znak,
- **výška tela** (H) – znak približujúci sa ku *Cyprinus carpio*,
- **predventrálna vzdialenosť** (pV) - znak skoro zhodný s *Carassius gibelio*,
- **predpektorálna vzdialenosť** (pP) – skoro intermediárny znak s miernym príklonom k *Cyprinus carpio*,
- **vzdialenosť V–A, P–A**, najmenšia výška tela (h), **výška chvostového stebla** (hpc) a **dĺžka brušných plutiev** (dV) – vo všetkých týchto znakoch hybrid inklinuje k druhu *Cyprinus carpio*,
- **dĺžka análnej plutvy** (lA) – intermediárny znak,
- **výška chrbtovej plutvy** (hD), **šírka tela** (laco), **predočná vzdialenosť** (prO), **dĺžka hornej čeľuste** (lmx) – vo všetkých týchto znakoch inklinuje hybrid k druhu *Carassius gibelio*.

Z ostatných znakov zasluhuje pozornosť tmavopigmentované peritoneum (obr. 3), čo poukazuje na spoločný znak s *Carassius gibelio*. Naopak prítomnosť dolného páru fúzov, ktoré sú však kratšie než u druhu *Cyprinus carpio*, poukazuje na znak spoločný s týmto druhom.

1. Hybrid *Carassius gibelio* x *Cyprinus carpio* – *Carassius gibelio* x *Cyprinus carpio* hybrid

I. Meristické znaky rodičovských druhov *Carassius gibelio*, *Cyprinus carpio* a hybrida *Carassius gibelio* x *Cyprinus carpio* – Meristic traits of the parental species *Carassius gibelio*, *Cyprinus carpio* and of the hybrid *Carassius gibelio* x *Cyprinus carpio*

Druh	Species	*Carassius gibelio*			*Cyprinus carpio*			*Carassius gibelio* x *Cyprinus carpio*
Znak	trait	$\bar{x}$	min.	max.	$\bar{x}$	min.	max.	$\bar{x}$
Dĺžka tela v mm (Sl)	standard length in mm (Sl)	231,8	197,5	258,2	302,9	289	328,8	276,2
Hmotnosť v g	weight in g	576,6	298	683	891,4	762	1 175	755
Počet tvrdých lúčov v D (Du)	unbranched rays in D (Du)	4	4	4	3	3	3	3
Počet mäkkých lúčov v D (Db)	branched rays in D (Db)	17,4	16	18	20	18	21	17
Počet tvrdých lúčov v A (Au)	unbranched rays in A (Au)	3	3	3	3	3	3	3
Počet mäkkých lúčov v A (Au)	branched rays in A (Ab)	6	6	6	6	6	6	6
Počet tvrdých lúčov v P (Pu)	unbranched rays in P (Pu)	1	1	1	1	1	1	1
Počet mäkkých lúčov v P (Pu)	branched rays in P (Pb)	15,2	14	18	15,2	15	16	17
Počet tvrdých lúčov v V (Vu)	unbranched rays in V (Vu)	1	1	1	1	1	1	1
Počet mäkkých lúčov v V (Vu)	branched rays in V (Vb)	7,8	7	8	8	8	8	7
Počet tvrdých lúčov v C_1	unbranched rays in upper lobe C_1	7	7	7	6,6	6	7	6
Počet mäkkých lúčov v C_2	branched rays in median part C_2	16,6	16	17	17	17	17	16
Počet tvrdých lúčov v C_3	unbranched rays in lower lobe C_3	5,4	5	6	6	6	6	6
Počet šupín v bočnej čiare (l.l.)	lateral line (l.l,)	30,4	29	31	37,8	37	39	33
Počet radov nad bočnou čiarou (Squ.sup.)	escale rows above lateral line (Squ.sup.)	7	7	7	6	6	6	6
Počet radov pod bočnou čiarou (Squ.inf.)	scale rows below lateral line (Squ.inf.)	6	6	6	6	6	6	6
Žiabrové paličky (Sp.br.)	branchial spines (Sp.br.)	48,6	47	50	23	22	25	38
Pažerákové zuby (D.ph.)	pharyngeal teeth (D.ph.)	4 – 4	4 – 4	4 – 4	1.1.3 – 3.1.1	1.1.3 – 3.1.1	1.1.3 – 3.1.1	4 – 4

II. Plastické znaky rodičovských druhov *Carassius gibelio*, *Cyprinus carpio* a hybrida *Carassius gibelio* x *Cyprinus carpio* – Plastic traits of the parental species *Carassius gibelio*, *Cyprinus carpio* and of the hybrid *Carassius gibelio* x *Cyprinus carpio*

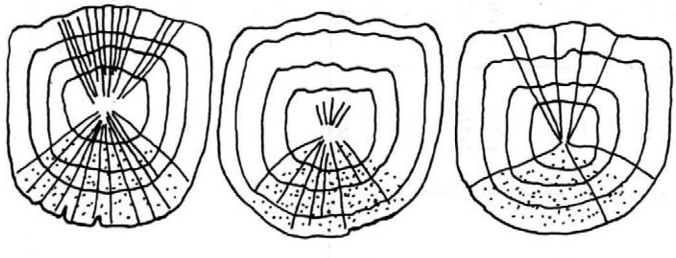
Druh	Species	*Carassius gibelio*			*Cyprinus carpio*			*Carassius gibelio* x *Cyprinus carpio*
Znak	trait	$\bar{x}$	min.	max.	$\bar{x}$	min.	max.	$\bar{x}$
V % dĺžky tela	**in % standard length**							
Dĺžka hlavy (lc)	length of heat (lc)	24,6	23,1	26,0	28,4	26,9	32,1	26,5
Výška hlavy (hc)	head depth (hc)	23,3	22,2	25,6	23,2	22,3	24,5	23,4
Výška tela (H)	body depth (H)	47,9	46,2	50,2	39,8	38,8	41,8	41,0
Predchrbtová vzdialenosť (pD)	predorsal distance (pD)	50,8	48,4	52,1	51,4	50,6	53,2	47,2
Predanálna vzdialenosť (pA)	preanal distance (pA)	77,8	75,4	78,9	76,9	76,0	77,7	70,0
Predventrálna vzdialenosť (pV)	preventral distance (pV)	47,8	47,7	50,3	51,2	50,4	52,8	48,3
Predpektorálna vzdialenosť (pP)	prepectoral distance (pP)	25,5	23,8	26,9	29,8	28,1	34,2	27,1
Vzdialenosť P–V (P–V)	distance btw. pectoral f.b. ventral f.b. (P–V)	25,1	23,9	27,2	23,2	18,5	25,7	22,7
Vzdialenosť V–A (V–A)	distance btw. ventral f.b. anal f.b. (V–A)	35,3	34,5	36,5	29,3	28,8	29,9	31,9
Vzdialenosť P–A (P–A)	distance btw. pectoral f.b. anal f.b. (P–A)	57,0	55,9	58,6	51,6	49,4	52,9	51,2
Dĺžka chvostového stebla (lpc)	length of caudal peduncle (lpc)	15,6	13,9	17,9	16,3	15,8	16,6	20,2
Najmenšia výška tela (h)	minimum body depth (h)	17,6	16,7	19,1	15,0	14,3	15,6	16,0
Výška chvostového stebla (hpc)	depth of caudal peduncle (hpc)	21,1	20,0	22,8	17,2	16,5	18,1	18,7
Dĺžka chrbtovej plutvy (lD)	length of dorsal fin (lD)	37,8	35,5	39,6	38,4	36,9	39,8	41,0
Dĺžka análnej plutvy (lA)	length of anal fin base (lA)	11,9	11,3	12,3	9,5	8,8	9,8	10,7
Výška chrbtovej plutvy (hD)	depth of dorsal fin (hD)	17,8	15,8	19,2	13,5	12,7	15,6	18,9
Výška análnej plutvy (hA)	depth of anal fin (hA)	15,2	14,0	17,7	13,6	12,0	14,8	18,1
Dĺžka prsných plutiev (lP)	length of pectoral fin (lP)	17,6	16,9	18,5	18,6	17,4	19,3	19,4
Dĺžka brušných plutiev (lV)	length of ventral fin (lV)	19,3	18,1	20,1	15,6	14,5	16,4	22,6
Šírka tela (laco)	body width (laco)	23,4	19,9	26,9	19,7	18,4	20,7	22,4
Šírka hlavy (lac)	head width (lac)	19,0	17,6	21,9	19,1	18,0	20,4	20,1
Predočná vzdialenosť (prO)	preorbital distance (prO)	6,8	6,1	8,1	10,9	10,4	12,1	7,7
Zadočná vzdialenosť (poO)	postorbital distance (poO)	12,4	11,3	13,3	13,4	12,2	15,6	13,2
Priemer oka (Oh)	horizontal diameter of eye (Oh)	5,9	5,7	6,6	5,4	5,0	5,9	4,9
Medziočná vzdialenosť (io)	interorbital distance (io)	10,0	9,6	10,7	10,5	9,8	11,6	10,7
Dĺžka hornej čeľuste (lmx)	upper jaw length (lmx)	6,1	5,5	6,8	8,4	7,6	9,6	6,4
Dĺžka spodnej čeľuste (lmd)	lower jaw length (lmd)	9,1	8,5	9,9	9,6	9,1	10,9	9,1
Dĺžka fúzov I (lbd)	leng of barbel I (lb)	–	–	–	1,8	1,6	2,5	–

Pokračování tab. II – Continuation of Table II

Druh	Species	*Carassius gibelio*			*Cyprinus carpio*			*Carassius gibelio* x *Cyprinus carpio*
Znak	trait	$\bar{x}$	min.	max.	$\bar{x}$	min.	max.	$\bar{x}$
Dĺžka fúzov II (lbd)	leng of barbel II (lb)	–	–	–	5,3	4,9	6,1	1,0
V % dĺžky hlavy	**in % length of head**							
Výška hlavy (hc)	head depth (hc)	94,8	90,8	98,4	81,9	75,4	86,9	88,4
Šírka hlavy (lac)	head width (lac)	77,1	72,0	83,9	67,3	62,9	69,5	75,8
Predočná vzdialenosť (prO)	preorbital distance (prO)	27,8	24,9	31,2	38,5	36,5	39,6	29,3
Zaočná vzdialenosť (poO)	postorbital distance (poO)	50,6	48,9	51,6	47,1	46,9	48,1	49,6
Priemer oka (Oh)	horizontal diameter of eye (Oh)	24,9	22,1	26,7	19,4	17,6	19,9	18,5
Medziočná vzdialenosť (io)	interorbital distance (io)	41,0	38,5	44,8	37,7	35,8	41,1	40,4
Dĺžka hornej čeľuste (lmx)	upper jaw length (lmx)	24,7	22,5	26,4	29,6	28,4	31,3	24,3
Dĺžka spodnej čeľuste (lmd)	lower jaw length (lmd)	37,2	35,7	40,3	33,9	32,4	35,7	34,5
Dĺžka fúzov I (lbd)	leng of barbel I (lb)	–	–	–	6,3	4,9	8,7	–
Dĺžka fúzov II (lbd)	leng of barbel II (lb)	–	–	–	18,8	18,2	19,8	3,8
V % dĺžky chvostového stebla	**in % length of caudal peduncle**							
Najmenšia výška tela (h)	minimum body depth (h)	113,6	101,3	126,5	92,4	87,1	99,1	79,4
Výška chvostového stebla (hpc)	depth of caudal peduncle (hpc)	137,0	127,8	143,4	105,3	100,0	109,5	92,8
V % vzdialenosti P–V	**in % distance P–V**							
Dĺžka P (lP)	length of pectoral fin (lP)	70,1	62,1	75,0	80,7	70,0	94,0	86,4
V % vzdialenosti V–A	**in % distance V–A**							
Dĺžka V (lV)	length ventral fin (lV)	54,6	49,6	58,3	53,2	48,3	56,5	70,9

III. Vzťah hybrida *Carassius gibelio* x *Cyprinus carpio* k rodičovským druhom, vyjadrený hybridným indexom (*Carassius gibelio* = 0, *Cyprinus carpio* = 100 %) – A relation of the hybrid *Carassius gibelio x Cyprinus carpio* to the parental species, expressed by a hybrid index (*Carassius gibelio* = 0, *Cyprinus carpio* = 100%)

Znak	Trait	*Carassius gibelio* x *Cyprinus carpio*
Počet šupín v bočnej čiare (l.l.)	lateral line (l.l.)	35,10
Žiabrové paličky (Sp.br)	branchial spines (Sp.br)	41,40
Počet mäkkých lúčov v D (Db)	branched rays in D (Db)	–15,30
Dĺžka hlavy (lc)	length of head (lc)	50,00
Výška hlavy (H)	body depth (H)	85,10
Predventrálna vzdialenosť (pV)	preventral distance (pV)	14,70
Predpektorálna vzdialenosť (pP)	prepectoral distance (pP)	51,10
Vzdialenosť V–A	distance V–A	56,70
Vzdialenosť P–A	distance P–A	107,40
Najmenšia výška tela (h)	minimum body depth (h)	61,50
Výška chvostového stebla (hpc)	depth of caudal peduncle (hpc)	61,50
Dĺžka análnej plutvy (lA)	length of anal fin base (lA)	50,00
Výška chrbtovej plutvy (hD)	depth of dorsal fin (hD)	–25,60
Dĺžka brušných plutiev (lV)	length of ventral fin (lV)	–89,20
Šírka tela (laco)	body width (laco)	27,00
Predočná vzdialenosť (prO)	preorbital distance (prO)	21,90
Dĺžka hornej čeľuste (lmx)	upper jaw length (lmx)	13,10
Priemer (meristické znaky)	mean (meristic traits	7,20
Priemer (plastické znaky)	mean (plastic traits)	34,60
Celkový priemer	total mean	32,10



2. Porovnanie tvarov šupín hybrida s rodičovskými druhmi – Comparison of the scale shape of the hybrid with parental species

A – *Cyprinus carpio*, B – *Carassius gibelio* x *Cyprinus carpio* hybrid, C – *Carassius gibelio*

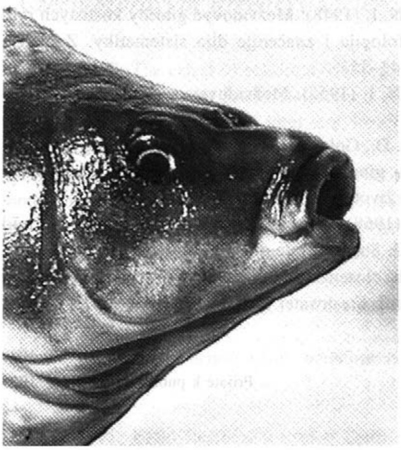
Sfarbenie pripomína pomery u *Carassius gibelio*: trup je striebristý, chrbtová a chvostová plutva sivé. Hlava (obr. 4) je tmavosivá, jej boky prechádzajú do svetlo žltej ako u *Cyprinus carpio*. Na základni chrbtovej plutvy je svetlý pás po obidvoch bokoch. Bledé pásy sú zreteľné aj na párnych plutvách.

Hybrida charakterizuje aj deväť znakov, ktorých parametre sú väčšie ako u obidvoch rodičovských druhov. Jedná sa o výšku hlavy (hc), dĺžku chvostového stebla (lpc), dĺžku chrbtovej plutvy (lD), výšku chrbtovej plutvy (hD), výšku análnej plutvy (hA), dĺžku prsných (lP) a brušných plutiev (lV), šírku hlavy (lac) a medziočnú vzdialenosť (io).

DISKUSIA

Hybridné indexy, ktoré určujú postavenie hybrida medzi obidvoma rodičovskými druhmi, udávajú pomerne blízku zhodu v znakoch meristických i plastických. Rozdiely v priemeroch sú veľmi malé, len slabo odchýlené na stranu predpokladaného materského druhu, t.j. *Carassius*. Táto, aj keď pomerne rovnaká hodnota signalizuje väčšiu afinitu k znakom tohoto druhu. Na základe doterajších znalostí o prirodzených a umelých hybridoch rýb možno konštatovať, že pomerná stabilita znakov, ako aj ich rovnaký odklon na stranu jedného z rodičov, sú zapríčinené väčšou stabilitou znakov vývojovo staršieho, konzervatívnejšieho druhu (Nikoľjukin, 1948; Holčík, Duyvené de Witt, 1962; Holčík, 1962). Tak napr. ak nastane hybridizácia medzi dvoma druhmi kaprovitých rýb, z ktorých jeden má dvojradové pažerákové zuby a druhý jednoradové pažerákové zuby, potomstvo má spravidla dvojradové pažerákové zuby na obidvoch stranách, alebo na jednej. Tento jav sme však v našom prípade nezaznamenali, i keď sa jednalo o trojradové a jednoradové zuby. Tak-

3. Pigmentované peritoneum a gonády hybrida – Pigmented peritoneum and gonads of the hybrid



4. Detail hlavy hybrida – Detail of the hybrids head

tiež je známe (Chu, 1935), že vývojovo staršie druhy kaprovitých majú na šupinách vyššie počty radiálnych kanálikov. Objavenie sa vyššieho počtu kanálikov u hybridov umožňuje predpokladať, že predok vývojovo staršieho druhu mal viac radiálnych kanálikov na šupinách ako druhy žijúce v súčasnosti (Holčík, 1962; Krupka *et al.*, 1985). *Cyprinus carpio* má väčší počet týchto kanálikov ako *Carassius gibelio*, čo svedčí o jeho starosti, avšak hybrid na šupinách ho počtom kanálikov neprevyšuje.

Existencia medzidruhových krížencov medzi *Carassius gibelio* a *Cyprinus carpio* je z literárnych údajov známa u bisexuálnych populácií karasa striebristého prevažne v podmienkach chovov. Na dosiahnutie hybridov Kiseľjev (1958) používa, a to výlučne umelým výterom, samca kapra a samicu karasa striebristého východoázijského (*Carassius auratus* L. 1758) označovaného ako čínsky zlatý karas. Podobne Kuzema a Tomilenko (1965) krížením samice toho istého karasa striebristého a samca kapra línie Ropšín, Masai a Sato (1969) alebo Suzuki (1968) získali hybridov, ktoré sa podobali na hybridov medzi karasom obyčajným a kaprom.

Porovnaním niektorých meristických znakov hybrida (samica *Carassius gibelio* x samec *Cyprinus carpio*), ktoré uvádza Kiseľjev (1958), s našimi údajmi nebadať rozdiely. Ide o nasledovné znaky (v zátvorkách je nami zistený údaj): počet šupín v bočnej čiare 31–36 (33), počet radov nad bočnou čiarou 5–6,5 (6), počet radov pod bočnou čiarou 5–6,5 (6), počet lúčov v chrbtovej plutve IV 16–19 (III 17), počet žiabrových paličiek 30–38 (38), dĺžka hlavy v percentách dĺžky tela 25–30 (26,5).

V areáli rozšírenia karasa striebristého na východ od Uralu v prirodzených populáciách prevládajú samice nad samcami. Taktiež v niektorých vodách Rumunska a západnej Európy, hlavne v Nemecku (Romašov, Golovinskaja, 1960), v menšom meritku existujú dvojpohlavné populácie. Tieto populácie použili k medzidruhovému kríženiu s kaprom Adumua-Bossman a Keiz (1971).

Mimo pôvodného areálu rozšírenia karasa striebristého v prirodzených populáciách je takmer úplne zastúpený monosexuálnymi populáciami, ktoré sa rozmnožujú gynogeneticky. V tomto prípade výskyt krížencov karasa striebristého vzhľadom na gynogenézu možno považovať za problematický, nakoľko spermia cudzieho druhu vnikne do vajíčka, aktivuje ho k brázdeniu a ďalšiemu vývoju, ale jadro spermie nesplýva s jadrom vajíčka. Na našom území, ako i vo väčšej časti Európy, žijú výlučne tieto populácie označované ako karas striebristý euroázijský – *Carassius gibelio* (BLOCH 1782).

Od roku 1992 sa objavujú na našom území v populácii z Dunaja aj samce karasa striebristého (roku 1994 zistený aj v dolnom toku Váhu a Nitry). Takto je postupne možné vytvorenie bisexuálnych populácií aj na našom území s následnou možnosťou prirodzenej medzidruhovej hybridizácie, ako na to upozorňuje Berg (1949), totiž že existujú u tohto druhu línie dávajúce normálnych krížencov pri krížení s divožijúcou formou kapra – sazanom.

V prípade, že samce karasa striebristého na našom území vytvoria bisexuálnu populáciu, t.j. tento karas sa bude rozmnožovať tak ako ostatné druhy rýb, je možnosť vzniku prirodzených recipročných medzidruhových hybridov samec karas striebristý x samica kapor.

Vychádzajúc z poznatkov, ktoré uvádza Nikoľjukin (1952), že väčšina znakov recipročných hybridov javí sklon k materinskému druhu, z nášho sledovania, po zohľadnení matroklinity, vyplýva, že preskúmaný jedinec je hybridom *Carassius gibelio* samica a *Cyprinus carpio* samec. V prípade samice karasa striebristého by sa preto malo jednať o populáciu s diploidným karyotypom a v budúcnosti je možné očakávať aj existenciu iných hybridov.

LITERATÚRA

Adumua-Bossmann, J. A., Keiz G. (1971): Vergleichende Untersuchungen über Wachstum und morfologische Eigenschaften von reinrassigen Karpfen (*Cyprinus carpio* L.) und Goldgiebeln (*Carassius auratus gibelio* /Bloch/) sowie ihrer aus reziproken Kreuzungen hervorgegangen Bastarde. Veröff. Zool. Statssamml. München, *15*: 205–207.

Berg L. S. (1949): Ryby presnych vod SSSR i sopredeľnych stran. II. Moskva Izd. AN SSSR: 470–925.

Holčík J. (1962): Nález nových prirodzených hybridov *Leuciscus leuciscus* x *Alburnus alburnus* a *Alburnus alburnus* x *Leuciscus leuciscus*. Práce Lab. Rybárstva a Hydrobiol., *1*: 63–77.

Holčík J., Duyvené de Witt J. J. (1962): Taxonomic studies in Acheilognathinae (Teleostei : Cyprinidae). 1. The taxonomic charakteristics both reciprocals of the hybrids between *Rhodeus ocellatus* and *Acheilognatus lanceolatus*. Copeia, *4*: 377–390.

Hubbs C. L., Kuronuma K. (1942): An analysis of hybridization in nature between two species of Japanese flounders. Pap. Mich. Acad. Sci., Arts and Letters, *27*: 267–306.

Chu Y. T. (1935): Comparative studies on the scales and on the pharyngeals and their teeth in Chinese Cyprinids, with particular reference to taxonomy and evolution. Biol. Bull. of St. John's Univ., 2: 1–225.

Kiseľjev I. V. (1958): Opyt razvedenija v prudach gibridov ryb iz semejstva karpovych. Moskva, Rybn. Chozj. 37 s.

Kiseľjev I. V. (1958): Gibridi stavkovich ryb z rodiny koropovich. Kiev, AN URSR. 63 s.

Krupka I., Sedlár J., Stráňai I. (1985): Nález prirodzeného hybrida *Rutilus rutilus* x *Chondrostoma nasus*. Práce Lab. Rybárstva a Hydrobiol., *5*: 217–229.

Kuzema A. I., Tomilenko V. G. (1965): Vyvedenie novych kaprovych ryb metodom otdalennoj gibridizacii. Rybnochozjaj. Resp. Mazhvedom. Temat. Nauk SR, *2*: 3–17.

Masai H., Sato Y. (1969): The brain patterns of hybrids produced by back-cross between the hybrid *Carassius* x *Cyprinus* and its parents. Jpn. J. Ichthyol., *16*: 219–231.

Nikoľjukin N. I. (1948): Mežvidovye gibridy kostistych ryb, ich morfologija i značenije dlja sistematiky. Zool. Ž., *XXVII*: 343–353.

Nikoľjukin N. I. (1952): Mežvidovaja gibridizacija ryb. Saratov.

Romašov D. D., Golovinskaja K. A. (1960): Ginogenez i otdalennaja gibridizacija u ryb. Otdalennaja gibridizacija rastenij i životnych. Moskva: 496–510.

Suzuki R. (1968): Hybridization experiments in cyprinid fishes. XI. Survival rate of F1 hybrids with special reference to the closeness of taxonomical position of combined fishes. Bull. Freshwater Fish. Res. Lab., *18*: 115–155.

Došlo 9. 3. 1999

Prijaté k publikovaniu 22. 6. 1999

Kontaktná adresa:

Doc. Ing. Ivan Stráňai, CSc., Slovenská poľnohospodárska univerzita, Tr. A. Hlinku 2, 949 76 Nitra, Slovenská republika, tel.: 087/60 17 00

SELECTION OF THE TERMINAL SIRE AND DAM BREEDS OF SHEEP AND ITS IMPACT IN COMMERCIAL CROSSBREEDING*

ŠLECHTĚNÍ VÝCHOZÍCH OTCOVSKÝCH A MATEŘSKÝCH PLEMEN OVCÍ A JEHO DOPAD V UŽITKOVÉM KŘÍŽENÍ

J. Přibyl[1], M. Milerski[1], J. Přibylová[1], V. Mareš[2], A. Pinďák[3]

[1]*Research Institute of Animal Production, Prague-Uhříněves, Czech Republic*
[2]*Sheep and Goat Breeders Association of the Czech Republic*
[3]*Czech Moravian Breeders Society, Czech Republic*

ABSTRACT: The effect of selection in sheep is modelled by using the deterministic approach of G-flow method totally for breeding and commercial flocks. Selection is aimed at the group of economically important traits: daily gain, carcass quality, fleece weight, conception rate, litter size, losses of lambs during a rearing period and number of lambings per ewe and year. Four variants of breeding are compared: 1) variant which considers only one meat breed (paternal) both in nucleus and commercial flocks, 2) only one prolific breed (maternal) both in nucleus and commercial flocks, 3) crossing of the sire (meat) and dam (prolific) breeds, 4) like variant 3, but with multiplicative flock for dam breed. The total net income per 1 ewe in the whole system was –352 Czech crowns (Kč) for variant 1, –67 Kč for variant 2, +44 Kč for variant 3, and +57 Kč for variant 4. Discounted economic values for traits in selection index and their realization range depend on the structure of flocks and position of the breed in crossbreeding system. The genetic gain is determined totally in monetary units and for individual traits. The effectiveness of nucleus flocks depends on a ratio of ewes in nucleus versus commercial flocks.

Keywords: sheep; selection effect; breeding; crossbreeding; economic values of traits; discounting

ABSTRAKT: Efekt šlechtění u ovcí je modelován pomocí metody toku genů souhrnně pro šlechtitelské a užitkové chovy zaměřené na produkci jatečných jehňat. Selekce je zaměřena na skupinu ekonomicky důležitých vlastností: denní přírůstek, složení jatečného trupu, stříž vlny, zabřezávání, velikost vrhu, ztráty jehňat během odchovu a počet obahnění do roka. Jsou porovnány čtyři základní způsoby použití plemen a z toho vyplývající efekty šlechtění při minimálním rozsahu šlechtitelských chovů v porovnání s chovy užitkovými: 1) Použití pouze masného (otcovského) plemene, a to jak ve šlechtitelských, tak v užitkových chovech. Ze šlechtitelských jsou do užitkových chovů přesouváni beránci. 2) Použití pouze plodného – kombinovaného (mateřského) plemene, a to jak ve šlechtitelských, tak v užitkových chovech. Ze šlechtitelských jsou do užitkových chovů přesouváni beránci. 3) V užitkových chovech křížení otcovského a mateřského plemene. Ze šlechtitelských chovů otcovského plemene jsou přesouváni do užitkových chovů beránci, ze šlechtitelských chovů mateřského plemene jehnice. 4) Jako v případě 3, ale s rozmnožovacími chovy mateřského plemene. Ze šlechtitelských do rozmnožovacích chovů jsou přesouváni beránci, z rozmnožovacích do užitkových chovů jehnice. Zisk na bahnici v rámci celého systému navazujících chovů byl –352 Kč pro způsob 1, –67 Kč pro způsob 2, +44 Kč pro způsob 3 a +57 Kč pro způsob 4. Odúrokované ekonomické hodnoty vlastností v selekčním indexu a rozsah projevu každé vlastnosti souvisí se způsobem použití plemene, čímž je současně ovlivněn i selekční cíl plemene. Genetický zisk je stanoven pro jednotlivé vlastnosti a souhrnně vyjádřen v penězích. Souhrnný projev genetického zisku v užitkových chovech je vyšší při užitkovém křížení než při čistokrevné plemenitbě. Efektivnost šlechtitelských chovů závisí na poměru mezi rozsahy šlechtitelských a užitkových chovů. Při širším poměru je efektivnost vyšší.

Klíčová slova: ovce; selekční efekt; šlechtění; křížení; ekonomické hodnoty vlastností; odúrokování

* Supported by the Ministry of Agriculture of CR (Project of the National Agency for Agricultural Research).

INTRODUCTION

Crossbreeding plays an important role in animal breeding, and improves the economy of husbandry in comparison with purebreeding, thanks mainly to position and heterosis effects. The size of the pure breeds basis could be restricted to relatively small populations. It depends on demands of commercial flocks for breed animals and requirements of purebred nucleus flocks for replacement and selection. The position in crossbreeding schema influences the goal of selection of breeds of base populations in the nucleus.

GOAL OF THE STUDY

The goal of the study is to compare the efficiency of the different systems of breeding (purebreeding or simple commercial crossbreeding) with orientation to lamb production and to judge of selection efficiency, with minimizing the nucleus flocks size.

LITERATURE REVIEW

Sheep husbandry in the Czech Republic is nowadays aimed mainly at lamb production. For this reason the selection and breeding direction to meat production with the possibility of evaluation of potential carcass quality on live animals is practised (Milerski, 1998).

Systems of commercial crossing were tested by Křížek, Jakubec (1984), and Jakubec, Křížek (1988), including estimation of crossbreed parameters (Křížek *et al.*, 1986, 1990, 1992). Optimization of hybridization schema was done by Savický and Nitter (1995). The schema of sheep selection in the Czech Republic was suggested by Přibyl *et al.* (1995), together with the review of selection programmes in selected countries.

Banks *et al.* (1998), Meszaros *et al.* (1998) and Lauridsen *et al.* (1997) were working with optimization of selection programme in sheep breeding. The construction of selection indexes for nucleus breeding, in the case of integrating it into the crossbreeding schema, was elaborated by Simm, Dingwall (1989) and Snowder (1997).

VARIANTS OF BREEDING

Four breeding systems are considered here.

1. Husbandry of only one meat (paternal) breed in nucleus, as well as in commercial flocks. Production recording, breeding value estimation and selection of animals are only in nucleus. The size of nucleus is minimized. From the nucleus to the commercial flocks are transferred only males. We expect the breeding

I. Characteristics for different systems of breeding

System of breeding		1	2	3	4
Paternal breed					
Proportion in total population	%	2.19	–	1.19	1.06
Whole reproduction rate of ♀	%	137	–	137	137
Rams to nucleus	%	1.46	–	1.46	1.46
Rams to commerc.	%	65.20	–	65.20	65.20
Ewes to nucleus	%	38.01	–	38.01	38.01
Maternal breed					
Proportion in total population	%	–	1.77	45.52	0.92
Whole reproduction rate of ♀	%	–	169	169	169
Rams to nucleus	%	–	1.18	1.18	1.18
Rams to multipl.	%	–	–	–	65.49
Rams to commerc.	%	–	65.49	–	–
Ewes to nucleus	%	–	30.72	30.72	30.72
Ewes to commerc.	%	–	–	35.95	–
Multiplicative flocks					
Proportion in total population	%	–	–	–	50.81
Whole reproduction rate of ♀	%	–	–	–	150
Ewes to multipl.	%	–	–	–	34.56
Ewes to commerc.	%	–	–	–	32.11
Commercial flocks					
Proportion in total population	%	97.81	98.23	53.29	47.21
Whole reproduction rate of ♀	%	120	150	150	150
Ewes to commerc.	%	43.44	35.56	–	–

value estimation with AM method with exploitation of information about all the relatives to the second generation of ancestors. Selection is provided only within young males and young females in the first year before including them into the nucleus. We consider the reproduction rate of 137% in the nucleus for adult females and year. In the commercial flocks, with a lower level of care 120%. For young females we consider as a model half of the reproduction rate. On one adult male we consider 40 females, on a young one 1/2 of this number. Turnover of the female flock is 26% and of the male flock 41% (young and two classes of adult rams – totally 3 age classes). 1/3 of lambs are regarded as not suitable for breeding and are sent to feeding, all other ram-lambs and majority of the ewe-lambs are included into breeding in the nucleus or commercial flocks. In the nucleus there is better care and production, but also higher costs, which are connected with the animal evidence, production recording and breeding work. Summary of characteristics of the breeding variants is in Table I.

2. Husbandry of only one combined – prolific (maternal) breed in nucleus, as well as in commercial flocks. Ways of breeding are similar to variant (1), but with higher reproduction rate – 169% in the nucleus and 150% in commercial flocks. (Summary characteristics are in Table I.)

3. Simple commercial crossbreeding. Young rams are transferred into commercial flocks from the nucleus of sire breed, young ewes are transferred there from the nucleus of dam breed.

4. Simple commercial crossbreeding with multiplicative flock for dam breed. Young rams are transferred into commercial flocks from the nucleus of sire breed like in variant (3). Ewe-lambs of the maternal breed for the purpose of commercial flock are produced in multiplicative flocks. To multiplicative flocks come the young rams from the nucleus of the maternal breed. Multiplicative flocks have the level of care similar to that of commercial flocks, without production recording and without selection. Multiplicative flocks could be a part of commercial flocks.

As Table I shows, there are differences in the proportions of each flocks in total population and differences in the transfer of young animals into different flocks. All lambs that are not included into breeding are sent to slaughter and conform the principal market product.

ECONOMY OF BREEDING

The production levels and market prices are different according to the breeds and type of flocks (Table II).

Meat (sire) breed has better growth rate, slaughter weight and market price. Crossbred animals manifested effects of crossbreeding.

Majority of the income (almost 85–90%) is from slaughtered lambs. Therefore we consider only this product, and we subtract incomes for adult animals and wool directly from the costs per ewe. The economy of each breeding system is presented in Table III.

The table shows that systems of breeding with simple commercial crossing (3) and (4) have better effectiveness. System (3) has the highest income, but also the highest costs. The breeding of the paternal breed only in the pure form without connection with commercial crossing is less effective.

II. Production of breeds and crossbreeds

Breed		Paternal	Maternal	Crossbreds
Gain of lamb	kg	0.25	0.23	0.25
Birth weight	kg	4.0	3.8	3.8
Slaughter weight	kg	39.0	36.0	38.8
Price of 1 kg	Kč	45	42	44
Costs of ewe/day	Kč	4.5	4.2	4.2
Costs of lamb/d	Kč	2.0	1.9	2.0
Costs of selection work on ewe	Kč	300	300	–

III. Economy of production according to the breeding system (average per 1 ewe in the total system of all connected flocks)

System of breeding		1	2	3	4
Slaughtered lambs	*N*	0.93	1.24	1.32	1.24
Incomes for lambs	Kč	1633.5	1872.1	2152.4	2007.8
Production costs	Kč	1978.7	1934.2	1968.3	1944.7
Costs of selection	Kč	6.6	5.3	140.2	5.9
Total costs	Kč	1985.3	1939.5	2108.5	1950.6
Gain	Kč	–351.8	–67.4	43.9	57.2

BASIC ECONOMIC VALUES OF PRODUCTION TRAITS

The basic economic values for the purpose of selection are determined by the use of the profit function of closed turnover of the flock. They are connected with the growth, carcass quality, fertility and fleece weight (Table IV) and with respect of the manifested average production level without consideration of specific value of breeds.

IV. Basic economic values of production traits

Trait	Unit	Economic value (Kč)
1. Daily gains	1 g	4.8
2. Dressing percentage	0.1%	4.1
3. Meat in carcass	1%	19.3
4. Conception rate	1%	11.8
5. Fertility/ewe	1%	10.0
6. Viability of lambs	1%	14.5
7. Fleece weight	1 kg	20.1

V. The average cumulative discounted expressions during the period, of the traits manifested on ewes (B) and on lambs (J), in dependence on the system of using the breed and length of the period

Breed	Paternal				Maternal					
System of breeding	1		3 and 4		2		3		4	
Traits	B	J	B	J	B	J	B	J	B	J
Length of the period (years)										
5	1.73	3.52	0.25	5.13	2.55	5.75	0.43	0.38	3.78	5.14
10	3.64	5.20	0.24	6.43	4.47	8.52	0.45	0.40	8.40	9.00
15	4.55	5.64	0.22	6.32	5.60	9.27	0.43	0.39	10.60	10.57
20	4.84	5.62	0.20	5.94	5.97	9.24	0.40	0.36	11.34	10.96
25	4.83	5.40	0.18	5.50	5.95	8.87	0.37	0.33	11.32	10.77
30	4.66	5.10	0.16	5.07	5.75	8.38	0.34	0.31	10.94	10.31
35	4.43	4.77	0.15	4.68	5.46	7.85	0.31	0.28	10.41	9.74
40	4.17	4.46	0.14	4.32	5.15	7.33	0.28	0.26	9.81	9.15
45	3.92	4.16	0.13	3.99	4.84	6.83	0.26	0.24	9.22	8.57
50	3.67	3.88	0.12	3.70	4.53	6.37	0.24	0.22	8.64	8.02

VI. Economic values of each trait for selection according to the use of breed

Breed		Paternal		Maternal		
System of breeding		1	3 and 4	2	3	4
Trait	1	25.92	26.40	42.58	1.58	51.70
	2	22.09	22.56	36.37	1.35	44.16
	3	104.22	106.15	171.19	6.37	207.86
	4	56.99	2.12	70.21	4.37	133.58
	5	48.30	1.80	59.50	3.70	113.20
	6	70.04	2.61	86.28	5.37	164.14
	7	97.08	3.62	119.60	7.44	227.53

DISCOUNTED EXPRESSIONS

Traits are manifested with the different time delay after selection and on the different number of units (animals). In Table V are presented the average cumulative discounted expressions for the given period, with interest rate 5%, in dependence on the length of period and on the position of breed in the production system. Values are calculated by matrix form of G-flow (rams 3 age categories, ewes 11 age categories) over the age classes and connected flocks.

The average discounted expressions change in dependence on the length of the period. Mostly they increase with the time and lately they decline. Maximum for trait manifested on the ewes (B) is usually lately than maximum for traits manifested on lambs (J). We have to decide for how long period we want the selection programme to run.

The way of using the breed is principal for the selection. The use of paternal breed in crossbreeding decreases the importance of traits (B) in selection approximately 25-30 times in comparison with mere purebreeding. For maternal breed, the crossbreeding increases the meaning of traits (B) approx. twice in comparison with purebreeding.

Comparing pure breeds (paternal and maternal ones), there are for maternal breed more important the traits on lambs (J), due to the higher fertility of this breed and manifestation of the lamb traits on higher number of animals. There are differences in discounted expressions for maternal breed between the systems of breeding (3) and (4). In case (3) there is a high proportion of nucleus herds in comparison with the commercial ones, which is influenced by the low discounted values.

DISCOUNTED ECONOMIC VALUES OF TRAITS

We consider the period of 25 years for the selection of breeds in nucleus flocks for the complex of traits. Discounted economic values for each system of breeding and breed are the combination of basic economic values with average cumulative discounted expression (Table VI).

POPULATION-GENETIC PARAMETERS

Population-genetic parameters are taken over from literature. Traits defined in the aggregate genotype are presented in Tables IV and VI. Selection on aggregate genotype is direct or indirect with the help of the other information in production recording. Information traits in selection index are in Table VIII. Population-genetic parameters for all traits are shown in Table VII.

RELIABILITY OF BREEDING VALUE ESTIMATION

Reliability of breeding value estimation for each independent trait depends on the genetic parameters (Table VII) and the amount of available information. We expect that 80% of records in nucleus are suitable

VII. Population-genetics parameters of traits in the index and aggregate genotype

Trait	s_g	$r_G \backslash h^2$								
		1	2	3	4	5	6	7	8	9
1. Daily gains	15	0.25								
2. Dressing percentage	16.43	–0.05	0.30							
3. Meat in carcass	1.41	0.20	0.30	0.32						
4. Conception rate	4.43	–	–0.02	0.05	0.10					
5. Fertility/ewe	7.91	–	–	–	–	0.10				
6. Viability of lambs	2.24	–	–	–	–	–	0.05			
7. Fleece weight	0.30	0.57	–	–	–	–	–	0.30		
8. Ultrasound area of back muscles	0.80	0.59	0.42	0.57	–	–	–	–	0.25	
9. Subjective classification of muscularity	0.39	0.33	0.33	0.37	–	–	–	–	0.70	0.15

VIII. Reliability of breeding value estimation (r^2) for each trait in index

Trait	Breed	
	paternal	maternal
1. Daily gains	0.44	0.45
4. Conception rate	0.20	0.21
5. Fertility/ewe	0.20	0.21
6. Viability of lambs	0.13	0.14
7. Fleece weight	0.34	0.35
8. Ultrasound area of back muscles	0.44	0.45
9. Subjective classification	0.34	0.36

IX. Intensity of selection in dependency on breed

		Breed	
		paternal	maternal
♂ Intensity of selection	%	2.19	1.77
Selection difference	d_s	2.31	2.47
♀ Intensity of selection	%	57.02	46.08
Selection difference	d_s	0.68	0.86

X. Expected genetic gain per year in the nucleus in dependence on the system of breeding and breed

Breed	Paternal		Maternal		
System of breeding	1	3 and 4	2	3	4
Trait					
1. Daily gains	4.46	5.00	5.21	4.69	4.78
2. *Dressing percentage	1.41	1.68	1.67	1.46	1.49
3. Meat in carcass	0.21	0.24	0.25	0.22	0.23
4. Conception rate	0.25	0.01	0.22	0.32	0.31
5. Fertility/ewe	0.68	0.03	0.60	0.89	0.85
6. Viability of lamb	0.05	0.00	0.05	0.07	0.06
7. Fleece weight	0.04	0.05	0.05	0.05	0.05
Total monetary Kč	223.96	196.22	387.05	16.25	520.23

*unit 0.1%

for evaluation. As selection is done (like model) only for young animals before introduction to breeding, available information is about growth, subjective classification of muscularity, and ultrasound area of back muscles for each animal. The same records are available for all relatives. As regards the traits realised on ewes, there is for young animals available only information from ancestors and collateral animals. Number of observations depends on the fertility of breed in nucleus. Reliability for all traits in the index is summarised in Table VIII.

INTENSITY OF SELECTION

We consider only natural service and minimal size of nucleus flocks. All ewes in nucleus produce progeny (rams and ewes) for breeding purposes. The best of ewes are used for replacement in the nucleus, the rest is sent to the commercial (multiplicative) flock, or eliminated. We expect that 1/3 of lambs are not suitable for breeding and they are not used for selection. Intensities of the selection are shown in Table IX. Higher intensity of selection was found in maternal breed because of higher fertility.

EXPECTED RESULTS OF SELECTION

Selection runs according to the indexes. An effect of selection in nucleus is predicted by the G-flow method for the average of 25 years. There are differences in dependence on the system of breeding (Table X). Genetic gains of traits are similar for all the systems of breeding of maternal breed and purebreeding of paternal breed. It is very different from the selection of paternal breed for crossbreeding, when there are much lower gains of traits manifested on ewes. Maternal breed (variants 2 and 4) has higher total monetary effect of selection than paternal breed, due to the higher intensities of selection. The lowest effect of selection was found in maternal breed in variant (3) because in this variant nucleus flocks are very extended (approx. 1/2) in comparison with the total number of animals in

XI. Expected manifestation of genetic gain in commercial flocks, in dependence on the system of breeding

Trait	System of breeding			
	1	2	3	4
1. Daily gains	4.46	5.21	4.85	4.89
2. *Dressing percentage	1.41	1.67	1.57	1.59
3. Meat in carcass	0.21	0.25	0.23	0.24
4. Conception rate	0.25	0.22	0.32	0.31
5. Fertility/ewe	0.68	0.60	0.89	0.85
6. Viability of lamb	0.05	0.05	0.07	0.06
7. Fleece weight	0.04	0.05	0.05	0.05

* unit 0.1%

the system. But this variant has the highest genetic gain of maternal traits.

Genetic gain is transferred to commercial flocks where the combination of original breeds and position effects plays the role. Manifestation of genetic gains in commercial flocks is presented in Table XI. In average, there are higher genetic gains in the case of crossbreeding, especially for traits of ewes, than in purebreeding.

CONCLUSIONS

1) The system of breeding strongly influences the economy of lamb production.
2) The position of the breed in dependence on the system of breeding influences principally the goals of selection.
3) The economic effect of nucleus depends on the proportion of nucleus in the whole population. In a small proportion the effect is higher.
4) In the case of "only" purebreeding in commercial flocks, the maternal breed is more intensively selected on traits of lambs than paternal breed. (Paternal breed more intensively on traits of ewes.)
5) Maternal breed has higher genetic gains due to the higher fertility and consequently higher intensity of selection.
6) Genetic gains manifested in commercial flocks are higher in the case of commercial crossbreeding than in the case of purebreeding, especially for traits of ewes.

REFERENCES

Banks K. G., Van der Werf J. H. J., Kinghorn B. P. (1998): Optimal use of young and old sires in sheep breeding. 6WCGALP, Armidale, Australia, 11–16 January.

Jakubec V., Křížek J. (1988): Breeding and exploitation of prolific breeds in Czechoslovakia. J. Agric. Sci. in Finland: 22–30.

Křížek J., Jakubec V. (1984): Comparison of performance of various types of crossbreeds between the Improvement Walachian breed and prolific breeds. In: 35th Ann. Meet. EAAP, The Hague, Netherlands, 6–9 August.

Křížek J., Jakubec V., Řeháček E. (1986): Estimates of crossbreeds parameters and their exploitation in forming of synthetic line of sheep. In: 37th Ann. Meet. EAAP, Budapest, Hungary, 1–4 September.

Křížek J., Wolf J., Jakubec V. (1990): Estimation and analysis of gene effects in sheep. Scientia Agric. Bohem., *22*: 277–286.

Křížek J., Wolf J., Říha M., Jakubec V. (1992): Estimation of genetic crossbred parameters for reproduction characters of sheep. In: 43rd Ann. Meet. EAAP, Madrid, Spain, 13–17 September.

Lauridsen J., Berg P., Jensen J. (1997): Comparison of alternative sheep breeding schemes using stochastic simulation. In: 48th Ann. Meet. EAAP, Vienna, Austria, 25–28 August.

Meszaros S. A., Banks R. G., Van der Werf J. H. J. (1998): Optimizing breeding structure in sheep flocks when inbreeding depresses genetic gain through effects on reproduction. 6WCGALP, Armidale, Australia, 11–16 January.

Milerski M. (1998): [Dissertation.] Czech University of Agriculture Prague.

Přibyl J., Křížek J., Milerski M., Přibylová J., Říha M., Slaná O., Šafus P., Večeřová D. (1995): Tvorba šlechtitelských programů pro malé přežvýkavce. [Research Report.] Prague-Uhříněves, Research Institute of Animal Production.

Savický J., Nitter G. (1995): CS – a computer simulation program for evaluating the efficiency of cross-breeding systems in animal production. In: 3rd Prague Workshop on Crossbreeding in Farm Animals, Prague, Czech Republic, 5–8 October.

Simm G., Dingwall W. S. (1989): Selection indices for lean meat production in sheep. Livest. Prod. Sci., *21*: 223–233.

Snowder G. D. (1997): Multitrait index selection of sheep. Sheep Symp.: Emerging Genetic Technology to Improve Sheep Production. J. Anim. Sci., *75*, Suppl. 1.

Received for publication on March 5, 1999

Accepted for publication on June 22, 1999

Contact Address:

Doc. Ing. Josef Přibyl, DrSc., Výzkumný ústav živočišné výroby, 104 00 Praha 10-Uhříněves, P.O.Box 1, Česká republika, tel.: 00420/2/67 71 17 47, e-mail:pribyl@vuzv.cz

INSTRUCTIONS FOR AUTHORS

Original scientific papers, short communications, and selectively reviews, that means papers based on the study of technical literature and reviewing recent knowledge in the given field, are published in this journal. Published papers are in Czech, Slovak or English. Each manuscript must contain a short and a longer summary (including key words).

The author is fully responsible for the originality of his paper, for its subject and formal correctness. The author shall make a written declaration that his paper has not been published in any other information source.

The board of editors of this journal will decide on paper publication, with respect to expert opinions, scientific importance, contribution and quality of the paper.

The paper extent shall not exceed 15 typescript pages, including tables, figures and graphs.

Manuscript layout: quarto, 30 lines per page, 60 strokes per line, double-spaced typescript. A PC diskette should be provided with the paper and graphical documentation. Tables, figures and photos shall be enclosed separately. The text must contain references to all these annexes.

If any abbreviation is used in the paper, it is necessary to mention its full form at least once to avoid misunderstanding. The abbreviations should not be used in the title of the paper nor in the summary.

The **title** of the paper shall not exceed 85 strokes. Subtitles of the papers are not allowed either.

Abstract is an information selection of the subject and conclusions of the paper, it is not a mere description of the paper. It must present all substantial information contained in the paper. It shall not exceed 170 words. It shall be written in full sentences, not in form of keynotes, and comprise basic numerical data including statistical data. It must contain key words. It should be submitted in English and if possible also in Czech or Slovak.

Introduction has to present the main reasons why the study was conducted, and the circumstances of the studied problems should be described in a very brief form.

Review of literature should be a short section, containing only literary citations with close relation to the treated problem.

Only original method shall be described, in other cases it is sufficient enough to cite the author of the used method and to mention modifications of this method. This section shall also contain a description of experimental material.

In the section **Results** figures and graphs should be used rather than tables for presentation of quantitative values. A statistical analysis of recorded values should be summarized in tables. This section should not contain either theoretical conclusions or deductions, but only factual data should be presented here.

Discussion contains an evaluation of the study, potential shortcomings are discussed, and the results of the study are confronted with previously published results (only those authors whose studies are in closer relation with the published paper should be cited). The sections Results and Discussion may be presented as one section only.

The section **References** should preferably contain reviewed periodicals. The citations are arranged alphabetically according to the surname of the first author. References in the text to these citations comprise the author's name and year of publication. Only the papers cited in the text of the study shall be included in the list of references. All citations shall be referred to in the text of the paper.

The author shall give his full name (and the names of other collaborators), academic, scientific and pedagogic titles, full address of his workplace and postal code, telephone and fax number or e-mail.

The manuscript will not be accepted to be filed by the editorial office if its formal layout does not comply with the instructions for authors.

POKYNY PRO AUTORY

Časopis uveřejňuje původní vědecké práce, krátká sdělení a výběrově i přehledné referáty, tzn. práce, jejichž podkladem je studium literatury a které shrnují nejnovější poznatky v dané oblasti. Práce jsou uveřejňovány v češtině, slovenštině nebo angličtině. Rukopisy musí být doplněny krátkým a rozšířeným souhrnem (včetně klíčových slov).

Autor je plně odpovědný za původnost práce a za její věcnou i formální správnost. K práci musí být přiloženo prohlášení autora o tom, že práce nebyla publikována jinde.

O uveřejnění práce rozhoduje redakční rada časopisu, a to se zřetelem k lektorským posudkům, vědeckému významu a přínosu a kvalitě práce.

Rozsah vědeckých prací nesmí přesáhnout 15 strojopisných stran včetně tabulek, obrázků a grafů. V práci je nutné používat jednotky odpovídající soustavě měrových jednotek SI (ČSN 01 1300).

Vlastní úprava rukopisu: formát A4, 30 řádek na stránku, 60 úhozů na řádku, mezi řádky dvojité mezery. K rukopisu je třeba přiložit disketu s prací pořízenou na PC a s grafickou dokumentací. Tabulky, grafy a fotografie se dodávají zvlášť, nepodlepují se. Na všechny přílohy musí být odkazy v textu.

Pokud autor používá v práci zkratek jakéhokoliv druhu, je nutné, aby byly alespoň jednou vysvětleny (vypsány), aby se předešlo omylům. V názvu práce a v souhrnu je vhodné zkratek nepoužívat.

Název práce (titul) nemá přesáhnout 85 úhozů. Jsou vyloučeny podtitulky článků.

Krátký souhrn (Abstrakt) je informačním výběrem obsahu a závěru článku, nikoliv však jeho pouhým popisem. Musí vyjádřit všechno podstatné, co je obsaženo ve vědecké práci, a má obsahovat základní číselné údaje včetně statistických hodnot. Musí obsahovat klíčová slova. Nemá překročit rozsah 170 slov. Je třeba, aby byl napsán celými větami, nikoliv heslovitě. Je uveřejňován a měl by být dodán ve stejném jazyce jako vědecká práce.

Rozšířený souhrn (Abstract) je uveřejňován v angličtině, měly by v něm být v rozsahu cca 1–2 strojopisných stran komentovány výsledky práce a uvedeny odkazy na tabulky a obrázky, popř. na nejdůležitější literární citace. Je vhodné jej (včetně názvu práce a klíčových slov) dodat v angličtině, popř. v češtině či slovenštině jako podklad pro překlad do angličtiny.

Úvod má obsahovat hlavní důvody, proč byla práce realizována, a velmi stručnou formou má být popsán stav studované otázky.

Literární přehled má být krátký, je třeba uvádět pouze citace mající úzký vztah k problému.

Metoda se popisuje pouze tehdy, je-li původní, jinak postačuje citovat autora metody a uvádět jen případné odchylky. Ve stejné kapitole se popisuje také pokusný materiál.

Výsledky – při jejich popisu se k vyjádření kvantitativních hodnot dává přednost grafům před tabulkami. V tabulkách je třeba shrnout statistické hodnocení naměřených hodnot. Tato část by neměla obsahovat teoretické závěry ani dedukce, ale pouze faktické nálezy.

Diskuse obsahuje zhodnocení práce, diskutuje se o možných nedostatcích a práce se konfrontuje s výsledky dříve publikovanými (požaduje se citovat jen ty autory, jejichž práce mají k publikované práci bližší vztah). Je přípustné spojení v jednu kapitolu spolu s výsledky.

Literatura by měla sestávat hlavně z lektorovaných periodik. Citace se řadí abecedně podle jména prvních autorů. Odkazy na literaturu v textu uvádějí jméno autora a rok vydání. Do seznamu se zařadí jen práce citované v textu. Na práce v seznamu literatury musí být odkaz v textu.

Na zvláštním listě uvádí autor plné jméno (i spoluautorů), akademické, vědecké a pedagogické tituly a podrobnou adresu pracoviště s PSČ, číslo telefonu a faxu, popř. e-mail.

Rukopis nebude redakcí přijat k evidenci, nebude-li po formální stránce odpovídat pokynům pro autory.

CZECH JOURNAL OF ANIMAL SCIENCE

Volume 44, No. 11 **November 1999**

CONTENTS

OBSAH

Vědecký časopis Czech Journal of Animal Science ● Vydává Česká akademie zemědělských věd – Ústav zemědělských a potravinářských informací ● Redakce: Slezská 7, 120 56 Praha 2, tel.: 02/24 25 34 89, fax: 02/24 25 39 38, e-mail: cerna@uzpi.cz ● Sazba: Studio DOMINO – Ing. Jakub Černý, Plzeňská 145, 266 01 Beroun, tel.: 0311/62 29 59 ● Tisk: ÚZPI Praha ●

Rozšiřuje Ústav zemědělských a potravinářských informací, referát odbytu, Slezská 7, 120 56 Praha 2