Acta Veterinaria Hungarica 51 (3), pp. 305–319 (2003)

INFLUENCE OF FEEDING INTENSITY ON THE GROWTH, BODY COMPOSITION AND SEXUAL MATURITY OF MALE NEW ZEALAND WHITE RABBITS

Kinga FODOR[1*], L. ZÖLDÁG[1], S. Gy. FEKETE[1], A. BERSÉNYI[1], A. GÁSPÁRDY[1], Emese ANDRÁSOFSZKY[1], Margit KULCSÁR[2], F. ESZES[1] and M. SHANI[1]

[1]Institute on Animal Breeding, Nutrition and Laboratory Animal Science and
[2]Department of Obstetrics and Reproduction, Faculty of Veterinary Science,
Szent István University, H-1400 Budapest, P.O. Box 2, Hungary

(Received November 8, 2002; accepted April 1, 2003)

An experiment was carried out with young male New Zealand White (NZW) rabbits to establish live body weight changes, body measurements, body composition and sexual maturity as a function of feeding intensity. Animals in Group 1 ('AL', n = 10) were fed *ad libitum*, while those in Group 2 ('RS', n = 10) received restricted feeding corresponding to 70% of the *ad libitum* level. The starting liveweights were practically the same (0.907 ± 0.146 and 0.911 ± 0.147 kg in Group AL and Group RS, respectively). The feeding trial lasted from 6 to 22 weeks of age. The average body weight was significantly higher in Group AL from 7 to 22 weeks of age. At 22 weeks of age the body weight of RS rabbits was 85.64% of the weight of AL animals (3.22 ± 0.52 kg and 3.76 ± 0.33 kg, respectively). Average body weights of RS males at 8, 9, 11, 19 and 21 weeks of age were similar to those of *ad libitum* fed (AL) animals at 7, 8, 10, 15 and 16 weeks of age, respectively. The growth of bucks fed restricted tended to be allometric. The most significant difference was found at 16 and 18 weeks of age, while the lowest difference occurred at 6, 12, 15 and 19 weeks of age. It can be stated that low-intensity feeding up to slaughtering weight causes backwardness in rear cannon length and this backwardness remains also after the 15th week, which is well over the optimal slaughtering age. Based on the present data, the 70% restricted feeding cannot be recommended either for the future breeding bucks or for broiler males reared for slaughter. To determine the major chemical components of the body, rabbits were euthanised. Original dry matter and crude fat content of the body significantly ($P < 0.05$) decreased under restricted feeding (41.42%; 32.48% and 16.73%; 7.35%) while the percentage of protein within the dry matter increased (49.6%; 65.0%) and fat decreased (40.17%; 22.1%) significantly. Libido unambiguously decreases as a consequence of feed deprivation. The most conspicuous difference was found in the level of blood testosterone. Although a few RS bucks produced semen but only much later than the rabbits fed *ad libitum*. On the other hand, there was no difference in the motility of spermatozoa and ejaculate volume in comparison with AL animals. There was no re-

*Corresponding author: Dr. Kinga Fodor; E-mail: kfodor@univet.hu; Fax: +36 (1) 478-4128

lationship between the body fat content and the reproductive status of bucks in the present trial.

Key words: Restricted feeding, growing rabbit, New Zealand White, male, body measures, chemical composition, sexual maturity

In rabbit nutrition, *ad libitum* feeding has become the general practice. However, on the basis of favourable effects observed in other species of animals, more and more scientists propose the introduction of restricted feeding for growing breeding animals also in rabbits (Maertens, 1998). One of the most important objectives of the prospective development is to achieve sexual maturity at an optimum age. The growth of organs at a different rate that depends on feeding (nutritional allometry) is currently known in heifers, dogs and cats (Rivers and Burger, 1989) and in different rabbit breeds such as the 'Pannon' White, Danish White and crossbred varieties (Kenessey et al., 1998) as well as the New Zealand White and Hungarian Giant female rabbits (Fodor et al., 2000, 2001*b*).

Fekete and Gippert (1981) studied the effects of different levels of feed restriction in broiler rabbits. They found that a 15% and 25% reduction of the daily feed intake resulted in a 19% and 35% decrease in the body weight gain, respectively; on the other hand, the digestibility of nutrients improved. Fodor et al. (2000, 2001*a*, 2001*b*) studied the effect of feeding intensity in female New Zealand White rabbits of early sexual maturity and Hungarian Giant rabbits of late sexual maturity. In female New Zealand White rabbits subjected to restricted feeding, the growth of the head was less intensive as compared to that of the body at a constant body weight; in addition, the body had grown wider by the time of reaching sexual maturity. In the Hungarian Giant rabbits the trunk and the head had grown longer, while growth of the hind legs had slowed down as a consequence of restricted feeding. The body weight of feed-restricted 18-week-old female New Zealand White rabbits of early maturity was 84.4% and their average body weight gain was 80.9% as compared to rabbits fed *ad libitum*. In the late-maturing 24-week-old Hungarian Giant rabbits the corresponding figures were 89.7% for body weight and 87.5% for average body weight gain. In the New Zealand White breed, restricted feeding delayed sexual maturity with later starting ovarian activity, weaker ovarian responsiveness, and a smaller number of tertiary follicles on the ovarian surface (Fodor et al., 2001*a*). This shows that the degree of optimal feed restriction considerably depends on the genotype in female rabbits. Szendrő et al. (2002) came to the same conclusion in the course of experiments with the Pannon White breed.

Wang and Zheng (1993) examined the possibility of selection based on body size in Angora rabbits. They found that the heart girth was in negative correlation with the fleece output, which is very significant in this variety. Ayyat et

al. (1995) called attention that the body weight/thigh length index could be used very well in the marketing of rabbit meat.

Kenessey et al. (1998) examined the effects of genotype, age and body weight on the slaughter value of growing rabbits between the ages of 6 and 16 weeks on a total of 537 animals. They found that the weight of all body parts increased with age but the rate of growth was unequal. The dressing percentage increased by 8% in average with the advancement of age, despite the fact that the rate of growth slowed down. This indicates that by 16 weeks of age rabbits do not yet reach the body proportions typical of full maturity. The weight of the head grew continuously with age in all genotypes, while its ratio to the slaughter weight decreased. The size and proportions of the internal organs (kidney, heart and lungs) were much more constant (i.e. less dependent on the genotype) than those of the external body parts. No significant differences were found in the size of the fat depots between genotypes (Chirecato et al., 1996; Lambertini et al., 1996). Rabbits with above-average body weight had significantly larger fat depots than those weighing less than average. In this regard the body weight had a stronger effect than the age or the genotype.

Stimulation of sexual maturation and shortening the time of mating are clearly consistent with the financial interests of farmers, as they contribute to decreasing the costs of production. A scarce feed supply in the rearing period delays sexual maturity in female domestic animals. Such periodicity cannot be observed in the sexual life of bucks. The sexual functions of bucks are not so unique than those of female rabbits and show no fundamental difference from those of other male animals. Berger et al. (1982) found that spermatogenesis started at the age of 40–50 days. Zahraan and Pingel (1981) have reported that the first ejaculate appears at the age of 135 days in summer and at the age of 119 days in winter. In the New Zealand White breed the earliest appearance of spermatozoa was observed at 112 days of age. Rabbits belonging to breeds of medium body size (New Zealand White, Californian) can be considered completely mature for breeding from the age of 4.5–5 months, while rabbits of larger body size (Hungarian Giant, German Giant Butterfly and Buscat White) as well as Angora rabbits become mature at the age of 5–6 months. The testicles of healthy, well kept, sexually mature bucks produce semen throughout the year. Such bucks are willing to mate at all times and immediately start pursuing the female. Mating normally takes place within one or two minutes from putting the animals into the cage. The normal semen is greyish-white and slightly translucent. One of its most important quality characteristics is the motility of spermatozoa. One ejaculate corresponds to 0.70 (0.30–1.20) ml of semen, and one ml of semen contains 250,000 spermatozoa on the average. Normally the volume and sperm concentration of semen will decrease only if the buck is mated or semen is taken too frequently (Tacke, 1995).

To date, only few researchers have dealt with the correlations of nutrition with sexual maturity and semen production in male rabbits. As a consequence of various feeding deficiencies (e.g. energy supply disturbances) the number of abnormal spermatozoa increases and the motility and fertilising capacity of spermatozoa decrease. Therefore, Maertens (1995) suggested that young bucks under 18 weeks of age should be fed *ad libitum,* and restricted feeding (35 g complete feed/kg liveweight) should be used only in older animals. As opposed to feed restriction, *ad libitum* feeding significantly increases the libido of bucks as well as the volume and sperm concentration of the ejaculate, while it does not affect the other quality characteristics of semen.

The objective of this experiment was to determine changes in body weight, body measurements, body composition and sexual maturity as a function of feeding intensity in male New Zealand White rabbits as a continuation of similar studies performed on New Zealand White does previously (Fodor et al., 2001*a*).

Materials and methods

Housing

The experiment was carried out at the animal facilities of the Institute of Animal Breeding, Nutrition and Laboratory Animal Science, Faculty of Veterinary Science Budapest, Szent István University. The animals were kept in wire mesh cages individually. The ambient temperature was 20 ± 2 °C and the relative humidity approx. 65%. To avoid the effect of photoperiod (Adam and Robinson, 1994), controlled daily lighting periods were applied (16:8 h light to dark). The rabbits were allowed to drink tap water *ad libitum*.

Animals and experimental design

Twenty 5-week-old male New Zealand White rabbits, originating from the outbreed stock of LAB-NYÚL Ltd. (Gödöllő), were used. The animals were divided into two groups: a control group fed *ad libitum* (AL; n = 10) and a group given restricted feeding corresponding to 70% of the *ad libitum* intake (RS; n = 10), and their feed intake was recorded daily. Based on the individual body weight at starting age the siblings were randomly distributed into groups to obtain identical average body weights and to minimise variance.

Nutrition

The rabbits were fed a commercial diet (Table 1) containing 15.2% crude protein, 14.1% crude fibre and 11.5 MJ DE/kg (Bácska Ltd). The diet was distributed once a day (at 8:00 a.m.). The trial lasted from 6 to 22 weeks of age.

Table 1

Natural composition and analysed nutritive value of the diet

Ingredients	%
Barley	38.0
Wheat	10.0
Maize	15.3
Wheat bran	6.0
Sunflower meal	16.5
Alfalfa meal	11.7
Lysine	0.2
Limestone	1.5
Salt (NaCl)	0.3
Vitamin-mineral premix	0.5
Total	100.0

Major nutrients	%
Dry matter	91.9
Ash	7.0
Crude protein	15.2
Crude fibre	14.1
Ether extract	1.8
N-free extract	53.8
DE, MJ/kg	11.5

Body composition

To determine the major chemical components in the body, 10 and 20 rabbits were euthanised by i.p. pentobarbital (Nembutal inj. A.U.V., Phylaxia-Sanofi, Budapest) overdose at 5 and 22 weeks of age, respectively. For details of methodology see Fekete and Brown (1993).

Live body measurements

The body indices were calculated from the body measurements taken during the experiment. Most of the body indices used in this investigation are widely applied in other domestic species (Jakubec et al., 1985; Gáspárdy et al., 2001; Püski et al., 2001) in the same or in a modified form. Some of the indices (index of head capacity, index of ear surface) have been created by us in order to evaluate the body development of the rabbit.

The following measures of the live animals were recorded weekly: body weight (BW); body length (BL), from nose to base of tail; trunk length (TL),

from base of tail to the tuber scapulae; head length (HL), from nose to nape (1st cervical vertebra); head height (HH), between the top of head and the lower jaw; head width (HW), between the left and right margo infraorbitalis; ear length (EL); ear width (EW), in case of both ears between the margins at the widest points; heart girth (HG), thoracic circumference behind the shoulder-blade; rump width (RW), between the left and right tuber coxae; fore cannon (antebrachium) length (FCL), in case of both arms from elbow to wrist; rear cannon (crus) length (RCL), in case of both legs from knee to ankle.

From the given data, the following indices were calculated:

Index 1: head capacity = $[(HW \times HH)/2 \times \pi] \times HL$;
Index 2: ear surface = $(EL \times EW)/2$;
Index 3: fore cannon-rear cannon ratio = $FCL/RCL \times 100$;
Index 4: fore cannon-body weight ratio = $FCL/BW \times 10$;
Index 5: body capacity = $(TL \times \pi)/3 \times (R^2 + R \times r + r^2)$,
$R = 1/2 \times HG/\pi$,
$r = 1/2 \times RW$;
Index 6: head capacity-body capacity ratio = (index 1/index 5) × 100;
Index 7: body weight-heart girth ratio = $(BW/HG) \times 1000$;
Index 8: trunk length-rump width ratio = $(TL/RW) \times 10$;
Index 9: extremities-trunk ratio = $(FCL + RCL)/TL \times 100$

Checking of the sexual maturity

In order to follow testicular, Leydig cell (LH receptors) and pituitary activities (LH responsiveness) the following hormonal treatments were used in both groups: hCG treatment (Choriogonin inj. 1500 IU, Gedeon Richter Chemical Works, Budapest, 50 IU/buck, i.m.; n = 5) and GnRH treatment (Receptal inj. A.U.V., Hoechst Vet. GmbH, Munich, 0.8 g/buck, s.c.; n = 5). Age at the hormone treatments was 8, 16 and 20 weeks. Plasma testosterone levels were determined from samples collected at 0, 3 and 6 hours following hormone treatment, after acepromazine anaesthesia (Vetranquil 1% inj., Phylaxia-Sanofi, Budapest, 0.1–0.2 ml/buck), from the ear vein according to Nagy et al. (1998). This assay system is based on the use of 1,2,6,7-^{3}H-testosterone (TRK 402; Radiochemical Centre, Amersham, UK) and a highly specific polyclonal antibody raised against testosterone-3-CMO-BSA in rabbit [provided by V. Csernus, Medical University of Pécs, Hungary (Csernus, 1982); cross-reactivity: 5α-dihydro-testosterone: 45.0%, 5β-dihydro-testosterone: 9.3%, androstenedione: 2.2%, 17α-methyl-testosterone: 0.72%, 25 other steroids: < 0.10%]. Animals were allowed to mount female rabbits once a week in order to examine their libido and to collect semen. The volume of the ejaculate, the number and motility of spermatozoa, the ratio of live/dead spermatozoa and sperm anomalies were determined. At the end of the trial the testicles were weighed and submitted for histological examination.

Ethical issues, statistical analysis

The experiment was approved by the Animal Use and Care Administrative Advisory Committee of the Faculty of Veterinary Science Budapest. Student's *t*-test and one-way analysis of variance according to the procedure of SPSS (Nouris, 1988) were used for the statistical evaluation of data.

Results and discussion

Liveweight

At the beginning of the experiment the liveweights were practically the same in the two groups (0.91 ± 0.15 kg vs. 0.91 ± 0.15 kg). The liveweight of animals fed *ad libitum* was significantly higher ($P < 0.05$) than that of feed-restricted rabbits already from the 7th week of life (1.49 ± 0.13 kg and 1.30 ± 0.08 kg, respectively), and this fact was valid throughout the trial. At the end of the experiment the liveweight of 22-week-old rabbits in Group RS was 85.64% compared to that of rabbits in group AL (3.22 ± 0.52 kg and 3.76 ± 0.33 kg for RS and AL, respectively; Table 2, Fig. 1). During the trial the average body weight gain of restricted fed animals was 87.5% in comparison with the *ad libitum* fed rabbits (0.14 ± 0.1 kg and 0.16 ± 0.08 kg, respectively).

Table 2

Body weight (kg) of rabbits in the *ad libitum* and restricted-fed groups (mean ± SD)

Weeks	Body weight		P
	Ad libitum	Restricted	
7	1.49 ± 0.13	1.30 ± 0.08	0.001
8	1.74 ± 0.18	1.50 ± 0.12	0.001
9	1.99 ± 0.16	1.72 ± 0.13	0.002
10	2.17 ± 0.18	1.93 ± 0.12	0.002
11	2.42 ± 0.18	2.14 ± 0.11	0.001
12	2.63 ± 0.21	2.35 ± 0.15	0.002
13	2.83 ± 0.23	2.42 ± 0.16	0.000
15	3.13 ± 0.27	2.78 ± 0.19	0.003
16	3.26 ± 0.28	2.88 ± 0.20	0.003
17	3.35 ± 0.30	2.96 ± 0.20	0.004
18	3.45 ± 0.30	3.06 ± 0.23	0.005
19	3.54 ± 0.32	3.16 ± 0.24	0.009
20	3.63 ± 0.32	3.17 ± 0.24	0.002
21	3.71 ± 0.33	3.27 ± 0.21	0.003
22	3.76 ± 0.33	3.22 ± 0.52	0.010

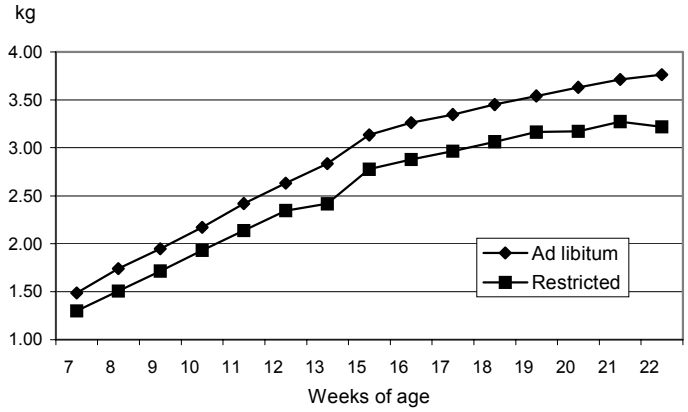

Fig. 1. Change of liveweight as a function of age

Animals given restricted feeding reached a body weight of 2300 g, regarded as the mean slaughtering limit (Csíkváry et al., 1985), by the end of the 12th week, while rabbits fed *ad libitum* reached it by the beginning of the 11th week.

Body measurements

Average body weights of RS males at 8, 9, 11, 19 and 21 weeks of age corresponded to those of *ad libitum* fed (AL) animals at 7, 8, 10, 15 and 16 weeks of age, respectively. Therefore, the comparison of live body measurements and indices was also based on these ages (Table 3).

When the RS bucks reached the body weight of *ad libitum* fed animals at an older age, they showed significant differences in their following body measurements: rear cannon length was in the same size or shorter, capacity of head remained smaller and a retardation was found in heart girth. The comparison of body measurements at specific ages (Tables 4 and 5) demonstrates that the effect of restricted feeding manifests itself first in a decrease of body weight gain, length of head and trunk, rump width and head capacity, as well as in a change of the fore cannon to body weight and body weight to heart girth ratio. Finally the width of head and the trunk length to rump width ratio will change.

Restricted breeding has negligible or no effect on head capacity to body capacity ratio and fore cannon to rear cannon length ratio in animals of the same age. The highest number of significant differences was found at the age of 16 and 18 weeks, and the fewest differences occurred at 6, 12, 15 and 19 weeks of age.

Table 3

Body measurements of male New Zealand White rabbits at the same body weight but at different ages

Body measurements	*Ad libitum*		Restricted		P
	mean	± SD	mean	± SD	
	1.5 kg (7 and 8 weeks of age)				
Body weight, kg	1.49	0.13	1.50	0.12	0.7
Trunk length, cm	26.16	1.18	29.45	1.01	0.000
Heart girth, cm	21.57	0.81	22.75	1.03	0.01
Fore cannon length, cm	6.38	0.17	6.6	0.2	0.021
Rear cannon length, cm	9.72	0.35	10.24	0.23	0.002
Index 5	689.16	65.3	823.38	70.05	0.000
Index 6	*25.79*	*2.39*	*22.42*	*2.59*	*0.007*
Index 8	56.61	1.55	64.36	3.22	0.000
Index 9	*61.65*	*1.73*	*57.22*	*1.74*	*0.000*
	1.73 kg (8 and 9 weeks of age)				
Body weight, kg	1.74	0.18	1.72	0.13	0.7
Trunk length, cm	28.71	1.82	30.18	0.92	0.035
Head length, cm	*12.64*	*0.44*	*11.97*	*0.48*	*0.004*
Head width, cm	*4.13*	*0.2*	*3.83*	*0.22*	*0.005*
Heart girth, cm	*23.8*	*1.2*	*22.38*	*1.35*	*0.023*
Rear cannon length, cm	*10.8*	*0.33*	*10.84*	*0.25*	*0.035*
Index 1	*198.05*	*18.88*	*177.3*	*9.96*	*0.007*
Index 3	*65.01*	*1.47*	*62.69*	*1.97*	*0.008*
Index 8	57.76	2.57	67.65	3.82	0.000
	2.15 kg (10 and 11 weeks of age)				
Body weight, kg	2.17	0.18	2.14	0.11	0.6
Heart girth, cm	*23.81*	*1.03*	*22.62*	*0.95*	*0.015*
Rear cannon length, cm	*11.44*	*0.39*	*11.79*	*0.24*	*0.03*
Index 1	216.51	13.83	231.93	12.21	0.02
Index 2	*46.26*	*4.98*	*38.58*	*3.53*	*0.000*
Index 6	21.2	2.61	23.93	1.53	0.01
	3.15 kg (15 and 19 weeks of age)				
Body weight, kg	3.14	0.24	3.16	0.24	0.8
Trunk length, cm	36.44	1.78	38.38	1.20	0.01
Fore cannon length, cm	8.53	0.23	8.83	0.22	0.01
Rear cannon length, cm	*13.23*	*0.3*	*13.62*	*0.26*	*0.04*
Index 1	308.74	23.81	336.94	28.31	0.027
	3.26 kg (16 and 21 weeks of age)				
Body weight, kg	3.26	0.28	3.27	0.21	0.93
Body length, cm	52.07	1.27	54.96	1.56	0.000
Trunk length, cm	36.73	1.12	39.2	1.42	0.000
Head height, cm	5.75	0.25	6.1	0.19	0.003
Head width, cm	4.66	0.08	4.92	0.13	0.000
Fore cannon length, cm	8.66	0.2	9.0	0.21	0.009
Rear cannon length, cm	*13.4*	*0.41*	*13.79*	*0.36*	*0.003*
Index 1	325.75	24.76	366.29	29.93	0.004
Index 9	*60.08*	*1.29*	*58.15*	*1.66*	*0.009*

Table 4

Level of significant differences in body measurements between *ad libitum* and restricted-fed male New Zealand White rabbits at 6 to 12 weeks of age

	Level of significance						
Age, weeks	6	7	8	9	10	11	12
Body weight, kg	0.034	0.001	0.000	0.001	0.002	0.000	0.002
BL, cm	0.037	0.006	*	0.029	0.044	0.013	*
TL, cm	*	*	*	0.002	0.041	*	*
HL, cm	0.002	0.02	0.044	0.000	0.006	*	*
HH, cm	*	*	*	*	0.043	*	*
HW, cm	*	*	*	*	0.023	*	*
HG, cm	*	*	*	0.000	0.002	0.000	0.003
RW, cm	0.01	0.045	0.000	0.000	*	*	*
FCL, cm	*	0.02	0.01	0.000	*	0.017	0.000
RCL, cm	*	*	0.02	0.006	*	0.006	0.006
Index 1	0.002	0.025	*	0.000	0.001	*	*
Index 2	*	0.004	0.02	*	*	0.01	0.05
Index 3	*	*	*	0.01	*	*	*
Index 4	0.007	0.001	0.000	0.04	0.003	0.000	0.005
Index 5	*	*	*	0.000	0.001	0.000	0.007
Index 6	*	*	*	*	*	0.01	*
Index 7	0.03	0.000	0.000	*	*	*	*
Index 8	*	*	0.000	0.003	*	*	*
Index 9	*	*	0.014	*	*	*	*

*P > 0.05

Table 5

Level of significant differences in body measurements between *ad libitum* and restricted-fed male New Zealand White rabbits from 15 to 22 weeks of age

	Level of significance							
Age, weeks	15	16	17	18	19	20	21	22
Body weight, kg	0.003	0.003	0.004	0.005	0.009	0.002	0.003	0.01
BL, cm	*	0.013	*	0.029	*	*	*	0.03
TL, cm	*	*	*	*	*	*	*	*
HL, cm	*	0.023	*	*	*	*	*	*
HH, cm	*	*	0.015	0.048	*	*	0.02	0.03
HW, cm	*	0.004	0.002	0.000	0.000	0.000	0.000	*
HG, cm	0.002	0.004	0.001	0.054	0.000	0.000	0.009	0.01
RW, cm	*	0.032	0.03	0.017	0.007	0.023	0.021	*
FCL, cm	*	*	*	*	*	*	*	*
RCL, cm	0.01	0.022	0.004	*	*	*	*	*
Index 1	*	0.007	0.003	0.001	0.005	0.02	0.006	0.035
Index 2	*	0.04	*	*	*	*	*	*
Index 3	*	*	*	*	*	*	*	*
Index 4	0.002	0.003	0.003	0.003	0.004	0.000	0.000	0.03
Index 5	0.05	0.001	0.001	0.056	0.000	0.003	0.003	0.02
Index 6	*	*	*	*	*	*	*	*
Index 7	0.047	0.03	*	0.007	*	0.004	0.03	*
Index 8	*	*	*	0.03	*	*	*	*
Index 9	0.02	*	*	*	*	*	0.04	0.02

*P > 0.05

It can be established that restricted feeding causes retarded growth of the hind legs and trunk, i.e. body parts which have considerable slaughter value. This retardation is perceptible even after the age of 15 weeks which is well over the optimal slaughtering age. Allometric growth of rabbit organs and body components was described by Deltoro and López (1985) and Petersen et al. (1988). Based upon the results of the present study, restricted feeding at the level of 70% cannot be recommended for male New Zealand White rabbits intended either for slaughter or for breeding.

Body composition

Initial total content of dry matter and crude fat (ether extract) of the body significantly decreased after restricted feeding ($P < 0.05$), while the proportion of crude protein within dry matter increased and that of crude fat decreased significantly (Fig. 2). The difference in ash content between the two groups is not significant. Calculating the parameters of chemical maturity (Moulton, 1923), i.e. ash/fat free dry matter (FFDM) and CP/FFDM %, it can be stated that 6-week-old rabbits did not reach chemical maturity (Fekete et al., 1997), but bucks at the end of the trial did, like in the study of Coudert and Lebas (1985).

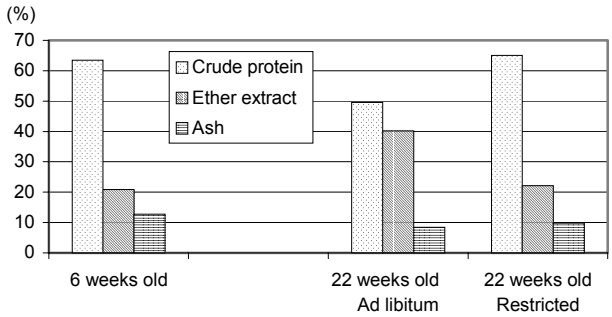

Fig. 2. Body composition in dry matter at an equal liveweight (kg) and at different ages

Reproductive status (Table 6)

Libido unambiguously decreases as a consequence of feed deprivation. Up to 22 weeks of age 30% of bucks receiving restricted feeding showed no willingness to mate, while all bucks fed *ad libitum* had covered the test female by the age of 16 weeks at the latest. Semen was successfully taken from all bucks of the *ad libitum* fed group in the 15th or 16th week, while in the feed-restricted group it was obtained from four bucks only by the end of the experimental period. Although in Group RS semen could be obtained from fewer bucks and much later, no appreciable differences were found in semen volume and sperm motility as compared with the *ad libitum* fed males.

Table 6

Relationship between body fat content and reproductive parameters in New Zealand White bucks throughout the trial. *P > 0.05

Hormone	No. of animal	Ether extract (fat) %	Age in weeks at first		Level of testosterone in blood after hormone treatment at the age of									Semen features		Weigh of testicles absolute (g) relative (g)			
					8 weeks			16 weeks			20 weeks								
			jump-ing	semen collec-tion	0 hour	3rd hour	6th hour	0 hour	3rd hour	6th hour	0 hour	3rd hour	6th hour	Volume of semen, ml	Motility of sper-matozoa, %	left	right	left	right
Ad libitum feeding																			
GnRH	*1a*	36.3	11	15 (0.2 ml)	5.76	6.88	8.26	10.86	17.96	18.72	12.26	17.54	12.70	0.6	80	2.88	2.87	0.08	0.08
GnRH	*2a*	41.6	11	16 (0.5 ml)	0.72	6.34	5.15	2.62	16.32	17.27	2.21	14.66	15.86	0.9	80	4.24	3.49	0.11	0.09
hCG	*3a*	50.6	15*	16 (0.25 ml)	1.40	2.55	3.42	12.47	9.32	10.81	12.15	8.89	10.95	–	–	1.78	1.99	0.04	0.04
hCG	*4a*	37.2	11	15 (drops)	1.85	8.15	5.38	1.68	11.71	11.08	5.41	1.47	3.44	0.7	80	2.64	2.81	0.07	0.07
GnRH	*5a*	39.3	16	16 (0.25 ml)	–	4.92	2.60	3.25	13.88	13.85	2.06	11.41	10.97	0.8	80	3.45	3.17	0.1	0.09
hCG	*6a*	42.0	11	15 (0.5 ml)	1.08	7.31	7.14	4.27	20.22	10.95	4.15	4.43	8.44	1.0	60	2.66	2.43	0.07	0.07
GnRH	*7a*	37.3	11	16 (0.35 ml)	5.42	6.18	5.08	2.54	15.90	19.97	4.87	18.32	19.64	0.9	80	2.55	2.56	0.07	0.07
GnRH	*8a*	44.7	15	16 (0.35 ml)	2.14	5.48	3.98	1.77	13.98	15.84	2.26	14.43	16.37	0.4	80	3.34	2.98	0.08	0.07
hCG	*9a*	35.8	11	15 (0.3 ml)	5.27	7.14	8.42	2.62	13.28	14.14	1.97	8.65	13.7	1.0	80	2.13	2.06	0.06	0.06
hCG	*10a*	36.8	11	16 (0.25 ml)	1.27	6.07	6.14	1.28	15.48	18.25	1.29	1.79	11.58	0.7	80	3.55	2.88	0.09	0.07
Mean		*40.17*			*2.77*	*6.10*	*5.56*	*4.34*	*14.81*	*15.09*	*4.86*	*10.16*	*12.45*			*2.92*	*2.72*	*0.077*	*0.071*
SD		4.69			2.08	1.56	1.96	3.97	3.1	3.44	4.1	6.18	4.51	0.2	6.67	0.73	0.47	0.02	0.01
Restricted feeding																			
hCG	*1b*	14.5	11	18 (drops)	1.14	3.14	5.03	6.86	9.43	11.55	1.94	9.76	7.74	0.4	80	2.87	2.78	0.09	0.09
GnRH	*2b*	25.6	11	18 (0.4 ml)	2.30	4.30	2.81	2.20	9.67	8.24	3.89	11.35	10.96	0.7	80	2.67	2.75	0.07	0.07
hCG	*3b*	35.2	11	–	1.30	4.56	4.33	2.29	8.56	8.38	4.71	5.69	6.99	–	–	2.51	2.89	0.07	0.08
hCG	*4b*	22.7	16	–	0.84	4.73	5.17	6.33	6.41	7.66	1.80	4.27	6.83	–	–	2.54	2.4	0.08	0.07
GnRH	*5b*	21.2	–	–	1.05	3.45	1.72	1.16	5.09	5.14	1.73	7.44	5.92	–	–	2.57	1.97	0.09	0.07
GnRH	*6b*	16.3	15	17 (0.2 ml)	2.14	2.94	1.10	5.00	6.80	5.79	5.35	6.54	7.34	–	–	2.34	2.26	0.06	0.06
GnRH	*7b*	26.5	22	–	1.28	2.15	0.92	1.86	5.21	5.82	5.87	7.99	8.96	–	–	2.3	2.11	0.11	0.1
hCG	*8b*	16.3	11	19 (0.2 ml)	0.32	2.95	3.38	7.89	7.61	9.15	2.50	3.37	1.55	0.2	–	2.69	2.88	0.08	0.08
hCG	*9b*	18.1	–	–	2.68	4.20	4.42	8.38	9.15	5.29	6.45	6.03	9.90	–	80	2.57	2.59	0.08	0.08
GnRH	*10b*	25.1	–	–	0.76	3.80	1.84	4.30	4.66	5.76	7.90	6.26	7.88	–	–	1.5	2.58	0.05	0.08
Mean		*22.1*			*1.38*	*3.62*	*3.07*	*4.63*	*7.26*	*7.28*	*4.21*	*6.87*	*7.41*			*2.5*	*2.52*	*0.078*	*0.078*
SD		6.28			0.75	0.84	1.62	2.66	1.9	2.09	2.19	2.39	2.55	0.25		0.37	0.32	0.02	0.01
Sign.		*0.000*			*0.06*	*0.000*	*0.006*	*0.85*	*0.000*	*0.000*	*0.66*	*0.13*	*0.007*			*0.09*	*0.3*	*0.91*	*0.24*

The weight of both the left and the right testicle was higher in the *ad libitum* fed animals; however, these differences were not significant, and values of mean relative weight were the same in the two groups. These results are consistent with those obtained by Gábor et al. (1992, 1995), who reported that there were no correlations between the increase of plasma testosterone level after GnRH administration and the fertilising capacity.

There are data that in other species such as boars and bulls a positive relationship exists between testicle size and semen production (Gábor et al., 1995; Tőzsér et al., 2000). The most conspicuous differences were found in the blood level of testosterone. Animals of the same age but kept on different feeding regimes had almost identical blood testosterone concentrations before the hormone treatments (0 hour). Following the treatments, the testosterone concentration of the blood increased suddenly by the 3rd and 6th hours. However, in the *ad libitum* fed group much higher levels were measured (2.2–3.4 times higher than at 0 hour) than in the group given restricted feeding (1.7–2.0 times higher than at 0 hour).

In this study, no correlation like the one shown in female New Zealand White rabbits (Fodor et al., 2001*a*) was found between reproductive status and fat content of the body. Semen production also seemed to be relatively independent of testicle size. The histological examinations did not show any deviation in the intensity of spermatogenesis occurring in the testicles of animals of the two groups. Bucks having higher body fat content did not have better reproductive status in the present trial.

Acknowledgements

The authors thank the Hungarian Scientific Research Fund (OTKA T/030359, T/037518) and Szent István University, Faculty of Veterinary Science Budapest (NKB-2000-Ph.D.-4/020) for the financial support of this study.

References

Adam, C. L. and Robinson, J. J. (1994): The role of nutrition and photoperiod in timing of puberty. Proc. Nutr. Soc. **53,** 89–102.

Ayyat, M. S., Marai, I. F. M. and El-Sayiad, G. A. (1995): A trail to grade New Zealand White rabbits for broiler production at marketing and breeding. World Rabbit Sci. **3,** 75–84.

Berger, J., Faucher, Ch., Turckheim, M., Vevssiere, G., Blanc, M. R., Poirier, J. C. and Jean, C. (1982): Testosterone, LH and follicle stimulating hormone in plasma of rabbit from birth to adulthood. Acta Endocrinol. Copenhagen **99,** 459–465.

Chirecato, G. M., Rizzi, C. and Rostellato, V. (1996): Effect of genotype and environmental conditions on the productive and slaughtering performance of growing rabbits. 6th World Rabbit Congress, Toulouse, Vol. **3,** 147–150.

Coudert, P. and Lebas, F. (1985): Production et morbidité des lapins reproductrices. 1. Effets du rationnement alimentaire avant et pendant la premiere gestation. Ann. Zootech. **34,** 31–48.

Csernus, V. (1982): Antibodies of high affinity and specificity for RIA determination of progesterone, testosterone, estradiol-17β and cortisol. In: Görög, S. (ed.) Advances in Steroid Analysis. I. Akadémiai Kiadó, Budapest, Hungary.

Csíkváry, L., Czibulyás, J. and Holdas, S. (1985): Breeds of domesticated rabbit. In: Holdas, S. (ed.) Manual of Rabbit Breeders (in Hungarian). Mezőgazdasági Kiadó, Budapest, 1985.

Deltoro, J. and López, A. M. (1985): Allometric changes during growth in rabbits. J. Agric. Sci. **105,** 339–346.

Fekete, S. and Brown, D. L. (1993): The major chemical components of the rabbit whole body measured by direct chemical analysis, deuterium oxide dilution and total body electrical conductivity. J. Vet. Nutr. **2,** 23–29.

Fekete, S. and Gippert, T. (1981): Studies on the effect of different restricted rations in broiler rabbit production (in Hungarian, with English abstract). Magyar Állatorvosok Lapja **36,** 484–488.

Fekete, S., Hullár, I., Andrásofszky, E., Bersényi, A. and Szakáll, I. (1997): Changes in body composition of growing rabbits owing to age and sex. Z. Ernährungswiss. **36,** 326.

Fodor, K., Fekete, S., Eszes, F., Gáspárdy, A., Zöldág, L. and Bersényi, A. (2000): Influence of feeding intensity on the growth of different body measurements in rabbits. Papers of the 12th Scientific Days of Rabbit Breeding. PATE, Kaposvár, pp. 17–21.

Fodor, K., Fekete, S. Gy., Zöldág, L., Bersényi, A., Gáspárdy, A., Andrásofszky, E., Kulcsár, M. and Eszes, F. (2001*a*): Influence feeding intensity on corporeal development, body composition and sexual maturity in female rabbits. Acta Vet. Hung. **49,** 399–411.

Fodor, K., Fekete, S., Eszes, F., Gáspárdy, A., Zöldág, L. and Bersényi, A. (2001*b*): Influence of feeding intensity on the growth of different body measurements in rabbits II. Hungarian Giant rabbit. Papers of the 13th Scientific Days of Rabbit Breeding, PATE, Kaposvár, pp. 89–93.

Gábor, Gy., Mézes, M., Tőzsér, J., Bozó, S., Szűcs, E. and Bárány, I. (1995): Relationship among testosterone response to GnRH administration, testis size and sperm parameters in Holstein Friesian bulls. Theriogenology **43,** 1317–1324.

Gábor, Gy., Pethes, Gy., Sinkovics, Gy., Falkay, Gy., Mézes, M. and Lakatos, E. (1992): GnRH test in rabbits (in Hungarian, with English abstract). Magyar Állatorvosok Lapja **47,** 410–414.

Gáspárdy, A., Eszes, F., Bodó, I., Koppány, G., Keszthelyi, T. and Márton, F. (2001): Type comparison of different Hungarian Tsigaja (Berke) sheep variants (in Hungarian, with English abstract). Állattenyésztés és Takarmányozás **50,** 33–42.

Jakubec, V., Rafay, E., Rehác, E. and Parkányi, V. (1985): Analysis of gene action in the control of body weight from birth to 84 days of age in the rabbit. Z. Tierzucht. Züchtungskunde **108,** 285–291.

Kenessey, Á., Szendrő, Zs., Fris, J. J., Radnai, I. and Bíróné Németh, E. (1998): Effect of genotype, age and body weight on the carcass traits of growing rabbits between 6 and 16 weeks of age. Papers of the 10th Scientific Days of Rabbit Breeding, PATE, Kaposvár, pp. 95–106.

Lambertini, L., Bergoglio, G., Masoero, G. and Gramenzi, A. (1996): Comparison between Provisal and Hyla rabbit strains. I. Slaughtering performances and muscle composition. Proc. 6th World Rabbit Congress, Toulouse, Vol. **3,** 195–199.

Maertens, L. (1995): Energy and nutrient requirements of does and their young. Proc. 9th Symposium On Housing and Diseases of Rabbits, Fur-bearing animals and Pet Animals, Celle, pp. 76–91.

Maertens, L. (1998): Rabbit nutrition: some actual considerations in view of future developments. Papers of the 10th Scientific Days of Rabbit Breeding, PATE, Kaposvár.

Moulton, C. R. (1923): Age and chemical development in mammals. J. Biol. Chem. **57,** 79–97.

Nagy, P., Solti, L., Kulcsár, M., Reiczigel, J., Huszenicza, Gy., Abaváry-Mihály, K. and Wölfling, A. (1998): Progesterone determination in equine plasma using different immunoassays. Acta Vet. Hung. **46,** 501–513.

Nouris, M. J. (1988): SPSS/PC+ ™ V3.0 Update Manual. SPSS Inc., Chicago, USA.

Petersen, J., Schweicher, I. and Gerken, M. (1988): The age-related development of body composition of hybrid rabbits. Züchtungskunde **60,** 72–84.

Püski, J., Bozó, S., Borka, Gy., Györkös, I., Gáspárdy, A. and Szűcs, E. (2001): Vergleich von vier Merkmalen innerhalb der 50-punkte-Exterieurbeurteilung mit den erfasten Körpermassen bei Holstein-Friesian Kühen. Arch. Tierzucht **44,** 33–45.

Rivers, J. P. W. and Burger, I. H. (eds) (1989): Nutrition of Dog and Cat. Cambridge Univ. Press, Cambridge, pp. 67–112.

Szendrő, Zs., Romvári, R., Andrássyné Baka, G., Metzger, Sz., Horn, P., Repa, I., Radnai, I. and Bíróné Németh, E. (2002): Selection of Pannon White rabbits on computed tomography. Papers of the 14th Scientific Days of Rabbit Breeding, PATE, Kaposvár, pp. 135–140.

Tacke, S. (1995): Einfluss der Haufigkeit der Spermagewinnung auf die Spermaqualität der Rammler. In: Proc. 9th Symposium On Housing and Diseases of Rabbits, Fur-bearing animals and Pet Animals, Celle, Germany, 10–11 May 1995, pp. 41–46.

Tőzsér, J., Mézes, M., Gábor, Gy., Domokos, Z., Póti, P., Alföldi, L., Sváb, L. and Repovszki, J. (2000): Standard values of scrotal circumference of Charolais weaned bull calves and young bulls. Állattenyésztés és Takarmányozás **49,** 469–547.

Zahraan, A. E. and Pingel, H. (1981): Investigation on sexual maturity of rabbits. Roczn. Nauk. Zoot. Warszawa **8,** 67–73.

Wang, K. and Zheng, W. (1993): Relationship between some blood parameters, wool yield and body measurements in the young Angora rabbits. World Rabbit Science **1,** 71–76.