GROWTH ANALYSIS AND FOOD CONSUMPTION IN FINAL CROSSBREDS OF THE HYPLUS BROILER RABBIT*

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The experiment was carried out within the period from 42 to 84 days of age. Least square means (LSM) for body weights, average daily gain, feed consumption and feed consumption per 1 kg average daily gain during the fattening period were estimated for two crossbreds of the HYPLUS broiler rabbit crossbreds. At the initial phases of fattening the differences ranged between the crossbreds mostly non-significant. At the final phase both crossbreds reached the same value in most of the traits with the exception of the average daily gain. The LSM were used for the estimation of growth and food consumption curve parameters. The feasibility of the asymptotic and exponential function was tested. Expected values of the asymptotic function for the body weight were in a better agreement with the observed values then the values of the exponential function (σ_e^2 = 427.49, 6437.72 and 242.44, 3311.81, respectively). Both functions were more appropriate for the description of body weights than for feed consumption (σ_e^2 = 174.24, 27.19 and 444.08, 47.02, respectively).

rabbit; growth; feed consumption; growth curves

INTRODUCTION

Rabbit meat production in the Czech Republic is based on the breeding of specialized broiler rabbit lines. These broiler rabbits are generally two-way or four-way crosses of specialized lines. Knowledge of the growth and development is a primary presumption for the breeding success. The base of a successful animal production and therefore also of a successful rabbit meat production is the choice of suitable lines for crossing which is based on the knowledge of the growth dynamics. Appropriate models for the description of the growth dynamics are mathematical models which display a very good agreement between the estimated and real body weight. The most suitable models for growth curves are nonlinear regressions or functions which can be linearized by transformation (e.g., using a logarithmic scale). The growth curves were analyzed by Kaps et al. (1999), López de Tore et al. (1992), Nešetřilová (2001) in cattle, Mignon-Grasteau (2000) in chickens, Sezer and Tarhan (2005) in Japanese quail, and especially in meat rabbit breeds as well as broiler rabbits by Gomez and Blasco (1992), Ptak et al. (1993), Seeland et al. (1996), Maj (1997) and by Blasko and Piles (2003).

The objective of this paper is to analyse of the growth and feed consumption, as well as the estimation of the growth curve parameters for body weight and feed consumption of two final crossbreds of the HYPLUS broiler rabbit (sire line 59 × dam line 19 and sire line 119 × dam line 19).

MATERIAL AND METHODS

Growth performance of two-line crossbreds – sire line 59 × dam line 19 and sire line 119 × dam line 19 of the HYPLUS broiler rabbit was analyzed. The performance test of 66 broiler rabbits in total was carried out in two independent replications in the test stations at the Department of Genetics and Breeding of the Czech University of Life Sciences in Prague. The rabbits were taken from farms at the age of 34–35 days and placed into individual cages and fed *ad libitum* on a pelleted diet containing 17.1% crude protein, 15.6% crude fiber and 4.2% crude fat. The growth performance recording (body weight and average daily gain during the test) and feed consumption (feed consumption and feed consumption per one kilogram of gain during the fattening period) started at 42 days of age. From this starting point the traits were measured weekly until the age of 84 days.

The growth data were analyzed by the least-squares method using the GLM procedure (SAS, 2005). The following linear model was used:

$$y_{ijk} = \mu + CROSS_i + REPLIC_j + (CROSS \times REPLIC)_{ij} + e_{ijk}$$

where: y_{ijk} – observation
μ – overall mean
$CROSS_i$ – fixed effect of the *i*-th crossbred
$REPLIC_j$ – fixed effect of the *j*-th replication
$(CROSS \times REPLIC)_{ij}$ – fixed effect of the *ij*-th interaction crossbred × replication
e_{ijk} – random residual error

The differences between the least squares means were tested at the significance level of $*P < 0.05$, $**P < 0.001$, $***P < 0.001$.

The sex of the rabbits was not taken into consideration due to the absence of sexual dimorphism of these traits (Krogmeier, Dzapo, 1991). The estimated least squares means (LSM) were used as input data to estimate the growth and feed consumption curve. The suitability of

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Table 1. Least squares means (LSM) and standard errors (SE) for the crossbreds

Trait	Crossbred				Significance
	59 × 19		119 × 19		
	66				
	LSM	SE	LSM	SE	
AGE (day)					
BW 42	1359.30	21.58	1351.42	20.26	0.7910
BW 49	1590.60	25.20	1583.50	23.65	0.8379
BW 56	1853.83	27.16	1786.92	25.45	0.0768
BW 63	2123.18	29.70	2047.58	27.87	0.0682
BW 70	2387.78	32.43	2276.58	30.43	0.0151*
BW 77	2618.78	35.13	2516.92	32.96	0.0385*
BW 84	2822.48	36.43	2723.00	34.18	0.0508
ADG 42–49	33.04	2.22	33.16	2.08	0.9711
ADG 49–56	37.60	1.90	29.06	1.78	0.0017**
ADG 56–63	38.48	2.29	37.24	2.15	0.6940
ADG 63–70	37.80	1.31	32.75	1.23	0.0064**
ADG 70–77	33.00	1.64	34.33	1.54	0.5567
ADG 77–84	29.10	1.50	29.44	1.41	0.8686
ADF 42–49	123.20	4.46	147.87	4.18	0.0002**
ADF 49–56	157.72	5.19	153.00	5.07	0.5266
ADF 56–63	178.66	5.01	170.49	4.70	0.2388
ADF 63–70	186.24	4.23	172.81	3.97	0.0239*
ADF 70–77	164.30	4.29	178.76	4.03	0.0168*
ADF 77–84	161.42	4.10	173.05	3.85	0.0430*
FC 42–49	3.81	0.20	4.47	0.19	0.0179*
FC 49–56	4.45	0.21	5.37	0.20	0.0026**
FC 56–63	4.60	0.21	4.87	0.20	0.3508
FC 63–70	4.91	0.16	5.26	0.16	0.1212
FC 70–77	5.05	0.22	5.39	0.20	0.2577
FC 77–84	5.94	0.29	5.86	0.27	0.8350
AFC	4.67	0.08	5.13	0.08	0.0002**
TDG	1463.18	29.54	1371.58	27.72	0.0273*
TDF	6800.68	118.3	6971.83	111.05	0.2957

* $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$, BW – body weight, ADG – average daily gain, ADF – average daily feed consumption, FC – feed conversion, AFC – average feed conversion, TDG – total gain, TDF – total feed consumption

two growth and feed consumption curves was tested using the residual variance and coefficient of determination (r^2).

These two growth functions were used:

Exponential $W = Ae^{cX}$

Asymptotic $W = \alpha - \beta\rho^X$

where: W – estimated value
A – population parameters
e – natural logarithm
c – regression coefficient
α – asymptotic value
β – parameters – starting point of the curve at birth
ρ – parameters – curve design ($0 < \rho < 1$)
X – age

The two mentioned non-linear functions were chosen for the short test period (42 days), which have not an inflexion point.

RESULTS AND DISCUSION

The LSM and SE of body weight and feed consumption for crossbreds 59 × 19 and 119 × 19, replications 1 and 2 and the significance of the fixed effects and interaction crossbred × replication are illustrated in Tables 1 and 2.

Body weight

The difference between both crossbreds was significant for the body weight at 70 and 77 days of age ($P <$

Table 2. Least squares means (LSM) and standard errors (SE) for the replications and the significance of interaction crossbred × replication

Trait	Replication				Significance	Significance of the interaction crossbred × replication
	1		2			
	66					
	LSM	SE	LSM	SE		
BW 42	1278.13	22.47	1432.59	19.27	< 0.0001***	0.0217*
BW 49	1500.15	26.23	1673.94	22.49	< 0.0001***	0.2857
BW 56	1762.44	28.23	1878.31	24.20	0.0028**	0.0169*
BW 63	2063.80	30.92	2106.97	26.51	0.2932	0.0085**
BW 70	2316.33	33.76	2348.03	28.95	0.4787	0.0113*
BW 77	2562.28	36.57	2573.42	31.35	0.8180	0.0607
BW 84	2738.92	37.92	2806.56	32.51	0.1807	0.1639
ADG 42–49	31.72	2.31	34.48	1.98	0.3672	0.1319
ADG 49–56	37.47	1.98	29.20	1.70	0.0023**	0.0043**
ADG 56–63	43.05	2.39	32.67	2.05	0.0016**	0.3825
ADG 63–70	36.08	1.37	34.44	1.17	0.3658	0.6655
ADG 70–77	35.13	1.71	32.20	1.47	0.1975	0.1316
ADG 77–84	25.24	1.56	33.31	1.34	0.0002***	0.1368
ADF 42–49	132.98	4.64	138.08	3.98	0.4068	0.0014**
ADF 49–56	168.21	5.62	142.51	4.82	0.0010**	0.0453*
ADF 56–63	189.70	5.23	159.45	4.47	< 0.0001***	0.0124*
ADF 63–70	185.40	4.40	173.64	3.77	0.0468*	0.1804
ADF 70–77	169.94	4.47	173.12	3.83	0.5908	0.0047**
ADF 77–84	155.45	4.27	179.02	3.66	< 0.0001***	0.0001***
FC 42–49	4.20	0.21	4.08	0.18	0.6466	0.7641
FC 49–56	4.80	0.22	5.02	0.19	0.4465	0.3064
FC 56–63	4.70	0.22	4.77	0.19	0.8129	0.0955
FC 63–70	5.18	0.17	4.98	0.14	0.3606	0.7978
FC 70–77	0.14	0.23	5.44	0.19	0.1376	0.3452
FC 77–84	6.15	0.30	5.64	0.26	0.2106	0.9704
AFC	4.84	0.09	4.96	0.07	0.3009	0.5199
TDG	1460.80	30.76	1373.97	26.37	0.0360*	0.9871
TDF	7011.80	123.20	6760.72	105.63	0.1269	0.3964

* $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$, BW – body weight, ADG – average daily gain, ADF – average daily feed consumption, FC – feed conversion, AFC – average feed conversion, TDG – total gain, TDF – total feed consumption

0.05). The difference between crossbreds for the body weight in the rest of observations was non-significant. The crossbred 59 × 19 achieved higher body weights than the crossbred 119 × 19 during the whole fattening period. The highest difference between both crossbreds was found at the age of 70 days (5.6%). From this moment the difference between the crossbreds for body weight gradually declined. The differences between the replications were for the body weight non-significant in the majority of observations. The second replication showed significant ($P <$ 0.001, $P < 0.001$ and $P < 0.05$) higher body weights than the first replication during the whole period with the exception of 42, 49 and 56 days. The interactions crossbred × replication were significant for the body weight at 42, 56 and 70 days of age ($P < 0.05$).

Feed consumption

The crossbred 59 × 19 had a significant lower feed consumption than the crossbred 119 × 19 at 42 ($P < 0.01$), 77 and 84 days ($P < 0.05$). On the contrary the crossbred 119 × 19 displayed a significant lower feed consumption at 70 days ($P < 0.05$). The differences between the crossbreds for feed consumption were non-significant for the rest of days.

A lower feed consumption at 49, 77 and 84 days showed the replication 1. The replication 2 displayed a minor feed consumption at 56, 63 and 70 days. The differences between the replications were highly significant at 63 and 84 days ($P < 0.001$) and 56 days ($P < 0.01$) and significant at 70 days ($P < 0.05$). The differences between the replications were non-significant at 49 and 77 days.

The interaction crossbred × replication for feed consumption was highly significant at 84 days ($P < 0.001$) and

49 and 77 days ($P < 0.01$) and significant at 56 and 63 days ($P < 0.05$). The interaction crossbred × replication at 70 days was non-significant.

Average daily gains

Both crossbreds showed almost consistent average daily gains in the most of cases. Highly significant differences were recorded for the average daily gains in favor of the crossbred 59 ×19 at the intervals of 49–56 and 63–70 days ($P < 0.01$). The crossbred 119 × 19 had highly significant higher average daily gains at the interval 77–84 days. The interaction crossbred × replication were highly significant only at the interval 49–56 days ($P < 0.01$). The other intervals showed non-significant crossbred × replications. Therefore the rank of crossbreds for average daily gains is in both replications the same.

Feed consumption per one kilogram of gain

A lower feed consumption per one kilogram of gain was noted by the crossbred 59 × 19 in comparison with the crossbred 119 × 19 at the age of 42–49 days ($P < 0.05$) and 56–63 days ($P < 0.001$). The interactions crossbred × replication were in all periods of fattening non-significant.

Concluding evaluation

The average feed conversion (average feed consumption per one kilogram gain) was significantly lower for the crossbred 59 ×19 than for the crossbred 119 × 19 ($P < 0.001$) and corresponded also with a significant higher total gain during the whole period of fattening for the crossbred 59 ×19 ($P < 0.05$).

The difference between both crossbreds for the total feed consumption was non-significant. The replication 1 showed a significant higher total gain than the replication 2 ($P < 0.05$). The interactions crossbred × replication for all traits were non-significant. Dědková et al. (2002) came to similar results for the body weight, average daily gain and average feed consumption in the crossbred 59 ×19 (Table 3).

Growth curves

The residual variance of the asymptotic function was generally lower than the exponential function (Table 4) for all traits. Lower values of the residual variance were registered for both growth functions in the crossbred 119 ×19, whereas the residual variance for body weight reached in the crossbred 119 ×19 approximately 50% of the residual variance in the crossbred 59 ×19 and for feed consumption reached the crossbred 119 ×19 approximately 10% of the residual variance in the crossbred 59 ×19. The lower residual variance of the asymptotic function signalizes a better availability than the exponential function.

The same values of the coefficients of determination (r^2) were registered for both growth functions in the crossbreds 59 ×19 and 119 ×19 for the growth curve (0.9990, 0.9809; 0.9993, 0.9989). The higher coefficients of determination (r^2) for the feed consumption correspond with the lower residual variances of the asymptotic function. On the contrary the lower coefficients of determination (r^2) for the feed consumption correspond with the higher residual variances of the exponential function (Table 5).

Table 3. Owen results in comparison with the results of Dědková et al. (2002)

AGE (day)	Trait (g)					
	Dědková et al. (2002)			Authors' results		
	BW	ADG	ADF	BW	ADG	ADF
49	1557.30	45.10	177.10	1587.10	31.10	135.50
56	1794.00	42.10	129.70	1820.80	33.30	155.40
63	2089.30	42.20	182.40	2085.40	37.90	174.60
70	2382.70	41.90	203.30	2332.20	35.30	179.50
77	2623.30	34.40	207.50	2567.90	33.70	171.50
84	2869.30	35.10	125.70	2772.70	29.30	167.20

BW – body weight, ADG – average daily gain, ADF – average daily feed consumption

Table 4. Residual variance of functions

Trait	Functions	
Live weight	Asymptotic	Exponential
59 × 19	427.49	6437.72
119 × 19	242.44	3311.81
Feed conversion		
59 × 19	174.24	444.08
119 × 19	27.19	47.02

Table 5. Coefficients of determination (r^2)

Trait	Functions	
Live weight	Asymptotic	Exponential
59 × 19	0.9993	0.9990
119 × 19	0.9989	0.9809
Feed conversion		
59 × 19	0.8959	0.7877
119 × 19	0.7578	0.2810

From Table 5 results a better availability of the asymptotic function than the exponential one. The determination coefficients were for the feed consumption higher in the crossbred 119 ×19 (0.8959, 0.7578) than in the crossbred 59 ×19 (0.7877, 0.2810). Both functions can be better utilized for the description of the growth curve than for the feed consumption.

The expected and observed values of the parameters for all traits of both functions and both crossbreds are presented in the Figs 1–4. From figures it is evident that using the asymptotic function a higher agreement between the observed and expected body weights was observed. Only the body weight at 56 days was overestimated. In both crossbreds the exponential function led to an overestimation of body weights at the age of 42 and 84 days and to an underestimation of body weight at the age of 56, 63 and 77 days.

Between the observed and expected feed consumption higher differences were recorded than in the body weight. The asymptotic function gave for the crossbred 59 ×19 precise estimations of the feed consumption at the age of

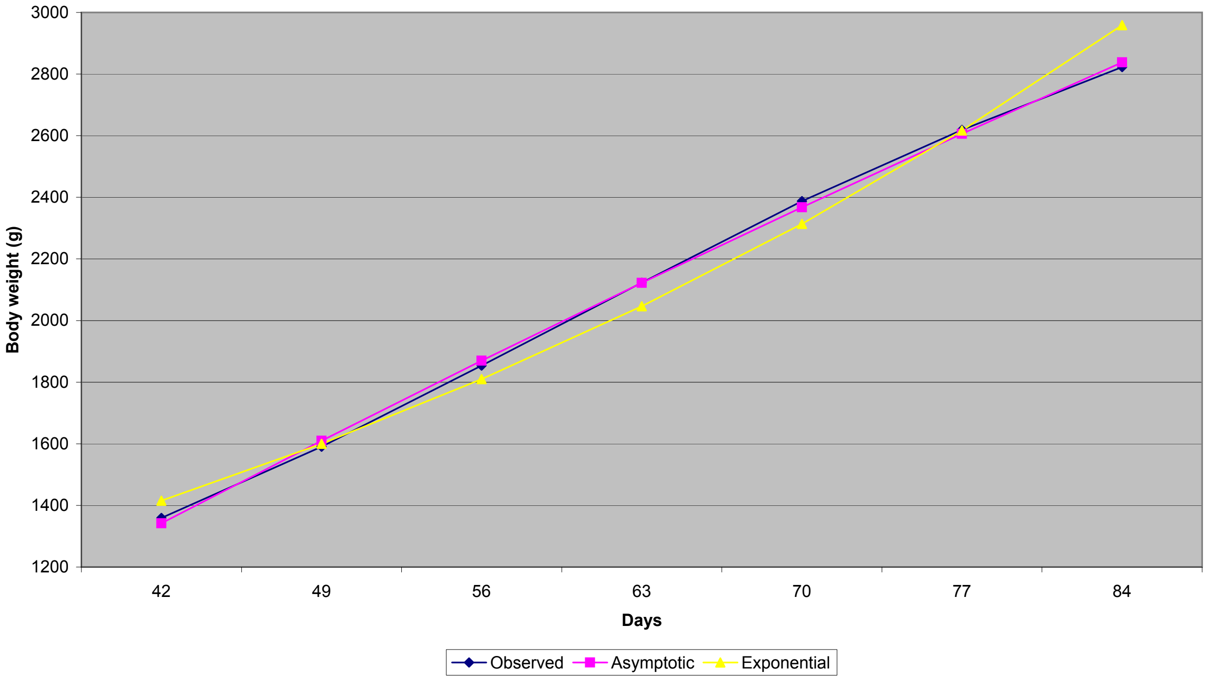

Fig. 1. Growth curve – genotype 59 x 19

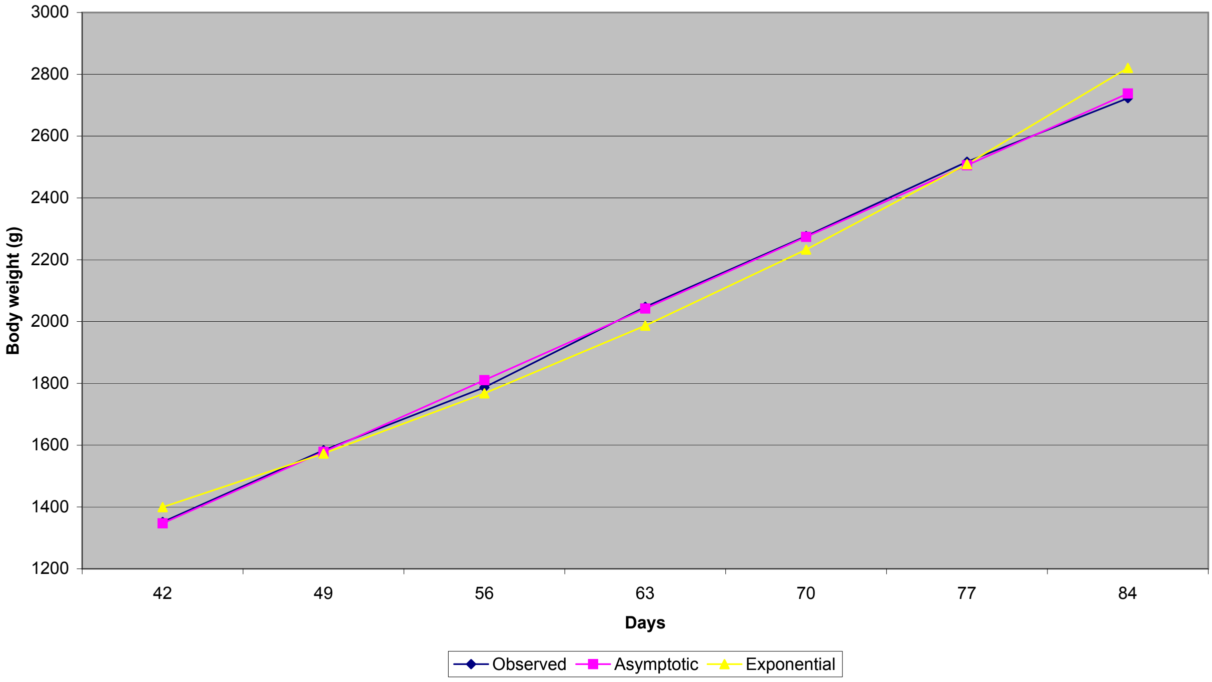

Fig. 2. Growth curve – genotype 119 x 19

49 and 56 days. The feed consumption was underestimated at 63 and 70 days and overestimated at 77 and 84 days. The exponential function offered similar deviations of expected values from the observed values as the asymptotic function. The asymptotic function provided for the crossbred 119 ×19 lower deviations of expected values from the observed values than the exponential functions. The feed consumption estimated by both functions provided the best results in the crossbred 119 ×19.

From the results it is noticeable that the asymptotic function is more convenient for the estimation of the growth capability of broiler rabbits than the exponential function. Gomez, Blasko (1992), Ptak et al. (1993) and Seeland (1996) recommend as more convenient the Gomperz or Brody function. Both functions demand an inflexion point. These functions with an inflexion point cannot be used in case of a short growth and fattening period (42 days).

The results showed that especially the crossbred had a considerable impact on the growth during the fattening period. A substantial difference in the course of the growth was found in the crossbreeds 59 × 19 and 119 × 19. We

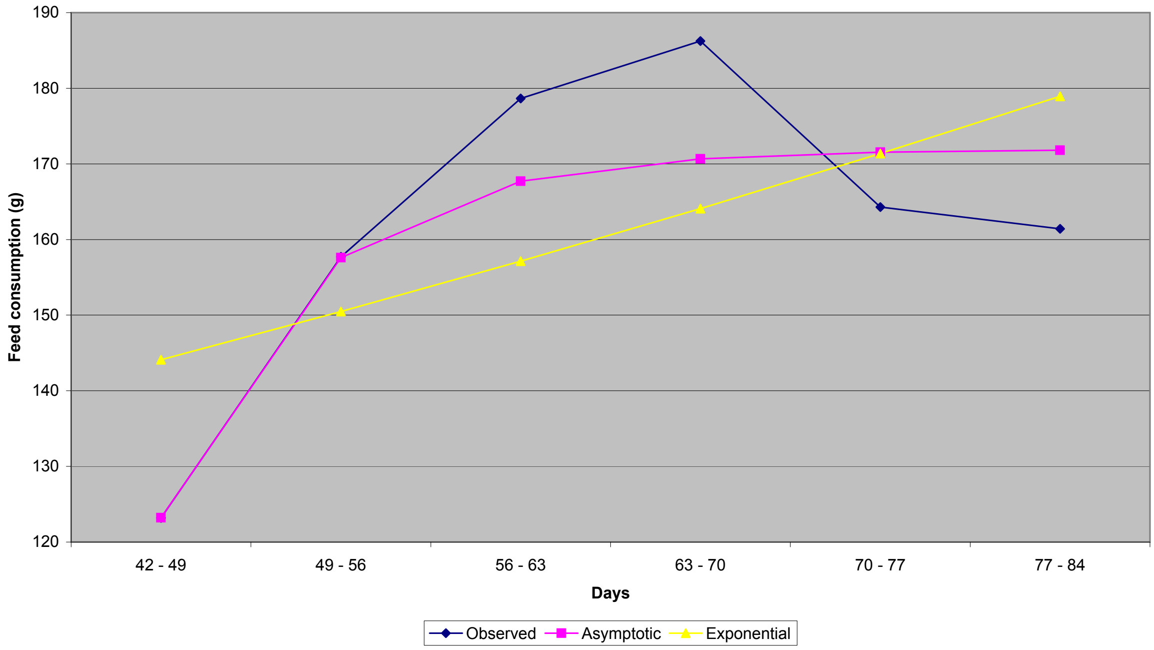

Fig. 3. Feed consumption curve – genotype 59 x 19

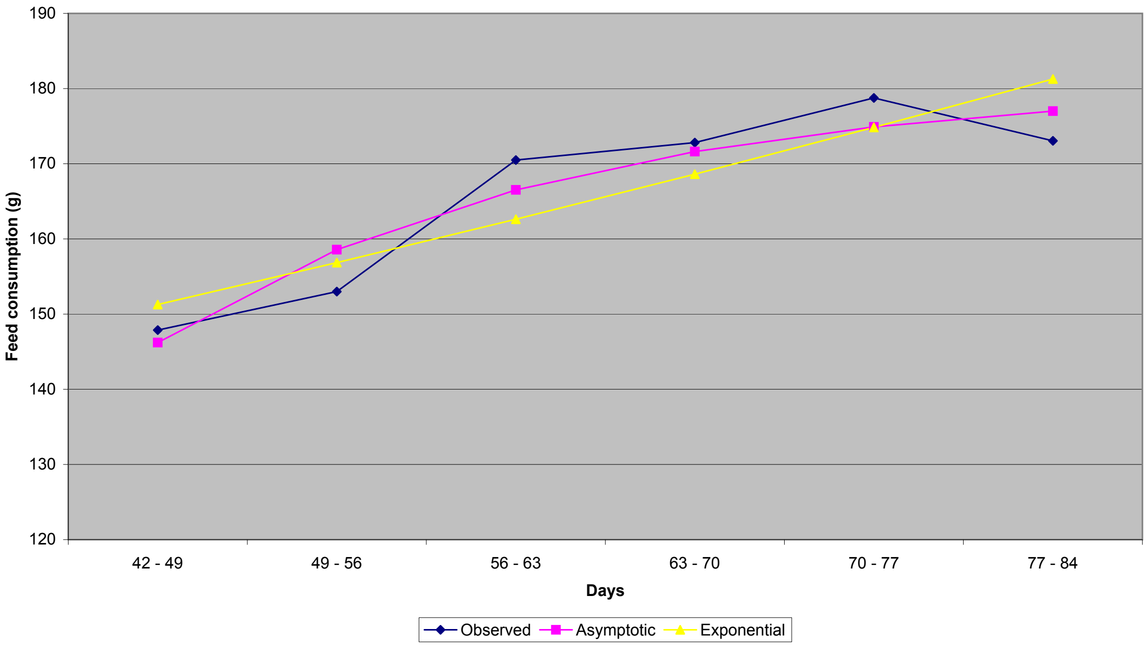

Fig. 4. Feed consumption curve – genotype 119 x 19

found that the crossbred 59 × 19 is especially suitable for fattening to a greater carcass weight then the crossbred 119 × 19. The interaction crossbred × replication was non-significant for all traits. Therefore, we can expect a better repeatability of the fattening results.

The results showed that the asymptotic function fits better for the estimation of the growth ability from 42 to 84 days and final body weight of 2.8 kg of crossbreds broiler rabbits HYPLUS than the exponential function. The estimation of feed consumption by means of non-linear functions is less desirable and using them considerable inaccuracies can be attended.

The prediction of the growth and growth curves within the period from 42 to 84 days of broiler rabbits fattening can be used as a meaningful tool for selection and shortening of the generation interval.

REFERENCES

BLASCO, A. – PILES, M.: A Bayesian analysis of the effect of selection of growth rate on growth curves in rabbits. Genet. Sel. Evol., *35*, 2003: 21–41.

DĚDKOVÁ, L. – MACH, K. – MAJZLÍK, I. – MOHSEN, A.: Analysis of growth and feed conversion in broiler rabbits by factorial crossing. Czech J. Anim. Sci., *47*, 2002: 133–140.

GOMEZ, E. A. – BLASCO, A.: Growth curves of lines selected on growth rate of litter size. J. Appl. Rabbit Res., *15*, 1992: 872–878.

KAPS, M. – HERRING, W. O. – LAMBERSON, W. R.: Genetic and environmental parameters for mature weight in Angus Cattle. J. Anim. Sci., *77*, 1999: 569–574.

KROGMEIER, D. – DZAPO, V.: Leistungsmerkmale von Kaninchen der Rassen Weisse Neuseeländer, Helle Großsilber und deren reziproker Kreuzungen 2. Mitteilung: Heterosissteigerungen in Mastleistungs-, Schlachtkörperqualitäts- und Fleischbeschaffenhenheitsmerkmalen. Arch. Geflügelk., *55*, 1991: 162–169.

LÓPEZ de TORE, G. – CANDOTTI, J. J. – REVERTER, A. – BOLLIDO, M. M. – VASCO, P. – GARCIA, L. J. – BRINKS, J. S.: Effects of growth curve parameters on cow efficiency. J. Anim. Sci., *70*, 1992: 2668–2672.

MIGNON-GRASTEAU, S. – PILES, M. – VARONA, L. – DE ROCHAMBEAU, H. – POIVEY, J. P. – BLASCO, A. – BEAUMONT, C.: Genetic analysis of growth curve parameters for male a female chickens resulting from selection on shape of growth curve. J. Anim. Sci., *78*, 2000: 2515–2524.

MAJ, D.: Porównanie wzrostu królików ras czystych i ich mieszańców F1 i R1 na podstawie krzywy wzrostu von Berttalanffy'ego. Prace i Materiały Zootech., *51*, 1997: 89–98.

NEŠETŘILOVÁ, H.: Comparison of several growth models for cattle. Czech J. Anim. Sci., *46*, 2001: 401–407.

PTAK, E. – BIENIEK, J. – ZALINSKI, Z.: Anwendung verschiedener Modelle der Wachstumskurven zum vergleich diverser Kaninchenrassen. In: 8. Arbeitstagung über Haltung und Krankheiten der Kaninchen, Pelztiere und Heimtiere, 20.–21. Oktober in Celle, BRD, 1993: 86–91.

SAS: SAS/STAT® 9.1 User's Guide. Cary, NC: SAS Institute Inc. 2004. 5121 pp.

SEELAND, G. – RÖSSLER, B. – RÖDER, B.: Analyse des Wachstums verschiedener Kaninchenrassen mit ausgewählten Wachtumsfunktionen. Arch. Tierz., *5*, 1996: 533–544.

SEZER, M. – TARHAN, S.: Comparison of three non-linear models for describing Japanese quail growth curve. J. Anim. Feed Sci., *14*, 2005: 317–326.

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Analýza růstu a spotřeby krmiva u finálního hybrida brojlerového králíka HYPLUS.

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Byl vyhodnocen růst a spotřeba krmiva u brojlerových králíků během šestitýdenního výkrmu (42 až 84 dní). U dvou genotypů finálních hybridů brojlerového králíka HYPLUS byly odhadnuty průměry nejmenších čtverců pro živou hmotnost, průměrný denní přírůstek, spotřebu krmiva a spotřebu krmiva na 1 kg přírůstku v jednotlivých týdnech výkrmu i za celé období testu. Pokus se uskutečnil od 42. do 84. dne věku králíků. Rozdíly mezi jednotlivými genotypy, většinou bez statistické významnosti, byly pozorovány v počátečních fázích testu. V závěrečné fázi testu dosahovaly oba genotypy shodné hodnoty u většiny vlastností s výjimkou průměrných denních přírůstků. Odhad průměrných nejmenších čtverců byl použit pro odhad parametrů růstových křivek a křivek pro spotřebu krmiva. Testována byla vhodnost funkce asymptotické a exponenciální. Teoretické hodnoty asymptotické funkce pro živou hmotnost odpovídaly naměřeným hodnotám lépe než funkce exponenciální (r^2 = 0,9990, 0,9993 a 0,9809, 0,989). Pro popis průběhu spotřeby krmiva vykazovaly obě funkce menší vhodnost než pro živé hmotnosti (r^2 = 0,8959, 0,7578 a 0,7877, 0,2810).

králíci; růst; spotřeba krmiva; růstové křivky

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