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A MODIFIED JANOSCHEK EQUATION FOR POSTNATAL GROWTH OF NEW ZEALAND WHITE RABBITS

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In many countries a great deal of progress has been made in the production of rabbit meat (Owen, 1981; Lebas and Matheron, 1982). In addition, rabbits are greatly used as animal models for biomedical research. In view of these promising dimensions of rabbit raising the information on mathematical description of postnatal growth is hitherto limited. Sawin and associates published a great number of papers on morphogenetic studies of the rabbit which were mainly directed to the effects of gene and genome interactions on growth gradients (Sawin and Gow, 1967). Rao et al. (1977) investigated the growth rate of New Zealand White rabbits. Least squares analysis yielded a seventh-order equation. However, Scharf (1979) emphasized that a rational polynomial does not sufficiently reflect the dynamics of the growth process.

In the German Democratic Republic Lehmann (1975) initiated studies on postnatal growth of domestic animals modifying the function elaborated by Gompertz. He made two contributions dealing with the application of this formulation to the normal postnatal growth of rabbits (Lehmann, 1980,1982). The results stimulated further investigations (Fl'ak, 1982; Sager, 1982). Sager recently carried out comprehensive mathematical studies on the growth process of animals. It is by suggestion of Lehmann and Sager that we have dealt with research in this field. Comparing growth equations we have found that a modified Janoschek function (Sager, 1983) seems to be suitable in view of the approximation to our observed data. Moreover, to our surprise, the mentioned function proved to be applicable to some results gained on carcass quality of rabbits. There are no comparable references available apart from the studies on growth allometry carried out by a French research group some years ago (Cantier et al., 1969, 1974; Baron et al., 1970; Vézinhet et al., 1972; Dulor et al., 1976).

Materials and Methods

The young New Zealand White rabbits (n = 187; ♂ 91, ♀ 96) of a closed stock bred at our Section since 1974 were weighed individually at weekly intervals (0 - 147 d), in each case at about 8 a.m. They were weaned at 35 days (litter size at birth: 6 - 8 rabbits). After weaning, the animals were placed in individual galvanized wire cages (0.216 m^2/rabbit; light:dark schedule = 12:12 h). Pellets (500 EFs, 17 % crude protein) and water were available ad libitum throughout the study. Small amounts of hay were fed as a supplement.

Observations on some traits of carcass quality were made at intervals of 4 weeks (0 - 147 d). Apart from 0 d (n =60) and 147 d (n = 42) about 20 animals each were analysed. The rabbits were fasted for approximately 7 hours. Preslaughter weight was only then recorded. Carcass traits were determined according to TGL 22440/02 (cut-up parts of rabbits). Muscles, fat and bones were separated (legs, loin). Giblets (heart, liver, kidneys) were removed.

As to the mathematical procedure, Janoschek's growth function, modified by Sager (1983), was used for approximations (W = body weight or weight, respectively; t = time from 0 days of age). The structure is as follows (parameters in brackets):

$$W = W_{\infty} - (W_{\infty} - W_0)\, e^{-\frac{k}{p} t^p} \qquad (W_{\infty}, k, p)$$

Results of the approximations estimated by minimizing the absolute and squared deviations, the parameters, the point of inflection (t_w, W_w), the relation W_w/W_{∞} and W_{147}/W_{∞} are listed in the tables. In addition, the sum of absolute and squared deviations as well as the residual variance and the residual sum of squares are recorded.

Results and Conclusion

The measurements of postnatal growth (Tables 1, 2 and 3) reflect a course of the curve that can be evaluated as a normal one under the condition of our experiment. As to the approximations of the Janoschek function to our observed data there are only slight differences between the weights recorded weekly or monthly, respectively. In general, there is an excellent goodness of fit over most parts of the empirical mean curve apart from a poorer fit for the first week. This is also true in the case of carcass weight as well as legs, lean meat of legs and loin as well.

The results of the approximations indicate that it might be possible to describe mathematically growth of body weight and selected characteristics of carcass quality by using monthly instead of weekly measurements. However, this should be confirmed by future experiments. The co-ordinates of the curves' inflection point indicate unequal growth rates of different parts of the body.

The Janoschek function seems to provide reasonable approximations to some traits of growth in rabbits of our stock. As Sager (1982) pointed out changes in the basic data can lead to another function ranking on the first place. The same may be true when different genotypes or special feeding regimes are considered. Therefore, growth functions should only be applied to empirical data under certain standardized experimental conditions.

Mathematical descriptions of the growth process will be of importance for the future. They can help reveal biological relationships and serve as a guide to improving methods of animal production for meat purposes.

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Table 1: Approximations to the weight of lean meat

n	age (d)	loin (g)	Janoschek	legs (g)	Janoschek
60	0	2.0	- 5.1	2.2	- 1.5
20	28	42.5	65.4	63.3	66.8
22	56	153.4	180.8	201.9	219.6
20	84	333.4	303.8	391.8	382.3
23	112	443.5	417.2	512.7	505.0
42	147	518.8	533.9	585.0	588.1
W_∞			766.1		628.9
k			0.0009136		0.0003739
p			1.5232		1.9131
t_w (d)			54.7		59.3
W_w (g)			219.1		237.7
W_w/W_∞ (%)			28.6		37.8
W_{147}/W_∞ (%)			69.7		93.5
$\sum \lvert f \rvert$ (g)			128.4		45.2
$\sum f^2$ (g^2)			3121.4		498.4
s_R (g)			50.7		41.9
s_R^2 (g^2)			2567.7		1754.1

Table 2: Approximations to quantitative traits of carcass quality

n	Age (d)	Preslaughter weight (g)	Janoschek	carcass (g)	Janoschek	loin (g)	Janoschek	legs (g)	Janoschek
60	0	49.4	33.8	26.3	22.6	4.1	3.7	3.5	7.3
20	28	574.3	581.7	314.8	342.0	65.7	73.0	84.8	82.5
22	56	1572.1	1659.3	1001.1	977.4	209.2	240.0	254.4	273.6
20	84	2754.5	2736.9	1638.8	1642.7	440.8	438.3	472.9	470.0
23	112	3610.2	3536.5	2161.3	2173.9	649.1	624.4	619.9	604.0
42	147	4074.6	4092.7	2590.7	2586.6	798.0	804.1	674.5	679.3
W_∞			4409.0		2886.9		1023.7		704.0
k			0.0006058		0.0005617		0.0003437		0.0003246
p			1.7955		1.7781		1.8033		1.9899
t_w (d)			54.5		58.5		73.8		56.4
W_w (g)			1599.8		1037.7		365.6		276.4
W_w/W_∞ (%)			36.3		36.0		35.7		39.3
W_{147}/W_∞ (%)			92.8		89.6		78.6		96.5
$\Sigma \lvert f \rvert$ (g)			219.6		75.2		79.2		48.9
Σf^2 (g^2)			13971.0		1506.0		1719.6		673.0
s_R (g)			279.9		214.9		67.3		49.2
s_R^2 (g^2)			77947.6		46169.9		4530.7		2420.7

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Table 3: Approximations to live weight data

n	Age (d)	live weight (g)	Janoschek
187	0	53.4	33.3
127	7	139.6	89.4
127	14	235.1	212.7
127	21	332.3	383.5
127	28	549.9	590.3
107	35	854.6	823.8
107	42	1063.8	1076.1
107	49	1288.5	1340.1
107	56	1566.5	1609.5
85	63	1863.8	1879.0
85	70	2160.9	2144.1
85	77	2428.0	2400.8
85	84	2678.6	2646.2
65	91	2877.2	2878.0
65	98	3106.3	3094.4
65	105	3342.9	3294.5
65	112	3533.3	3477.8
42	119	3612.9	3644.0
42	126	3764.6	3794.5
42	133	3901.1	3926.9
42	140	4032.3	4045.0
42	147	4124.2	4148.6
W_∞			4717.5
k			0.0007538
p			1.6962
t_W (d)			56.0
W_W (g)			1610.2
W_W/W_∞ (%)			34.1
W_{147}/W_∞ (%)			88.0
$\Sigma \lvert f \rvert$ (g)			654.1
Σf^2 (g^2)			24442.4
s_R (g)			243.4
s_R^2 (g^2)			59485.6

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Summary

Mathematical descriptions of postnatal growth in rabbits were carried out only by a few authors. Rao et al. (1977) employed least squares analysis which yielded a seventh-order equation. Lehmann (1980, 1982) and Fl'ak (1982) used a modified function of Gompertz. Sager (1982) compared several growth functions. In our investigation a function of Janoschek, modified by Sager (1983), was used for approximations to growth data. The results revealed that it might be possible to describe mathematically growth of body weight and selected quantitative traits of carcass quality, respectively (observations made at intervals of 4 weeks). The coordinates of the curves' inflection point indicate unequal growth rates of different parts of the body. Mathematical descriptions of the growth process can help interpret biological relationships and serve as a guide to improving methods of animal production for meat purposes.

Resumen

La descripsión matemática del crecimiento postnatal del conejo ha sido llevada a cabo hasta ahora por pocos autores. En un análisis de Rao y col. (1977) fueron ajustados los datos en un polinómio de septimo grado. Lehmann (1980, 1982) y Fl'ak (1982) emplearon una modificación de la función de Gompertz. Sager (1982) comparó varias funciones. En nuesta investigación, los datos del curso del crecimiento de 187 conejos de la raza Blanco Nuevazelandia fueron puesto a la aproximación mediante la modificada función de Janoschek, Sager (1983). Los resultados muestran que es posible la descripsión matemática del crecimiento y de algunos carácteres quantitativos de la canal (los datos son comunicado a un intervalo de 4 semanas). Las coordenadas del punto de inflexión indican que diferentes partes del cuerpo tienen distinta intensidad de crecimiento. La descripción matemática del crecimiento puede ayudar a explicar relaciones biológicas y a la vez tiene gran significado en el mejoramiento de los métodos de producción de carne.