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QUANTITATIVE GROWTH OF RABBIT ORGANS

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INTRODUCTION

There have not been many papers published on rabbit quantitative growth.

Most of those published relate to live weight (SAGER, 1983; FL'AK, 1982) or carcass weight (RUDOLPH and SOTTO, 1984) and some are related to organs growth. Digestive tract and liver have received more attention (PRUD'ON et al., 1970; RAO et al., 1977; LEBAS and LAPLACE, 1972) than other organs like kidneys or heart lungs (RAO et al., 1970). These papers studied the evolution of the organs weight over different periods and did not consider their growth parameters like the maturity degree or relative growth rate.

Other works (Cantier et al., 1969; BARON et al., 1970) have studied the growth of some organs in respect to body weight using the allometric equation. Only the former papers have considered the effect of sex on organ growth but the effect of the strain was not mentioned.

The aims of this paper were:

1) Select the proper model, among four common ones (Bertalanffy, logistic, Gompertz and Richards), to describe organs growth.
2) Study growth patterns of some rabbit organs considering the maturity degree, relative and absolute growth rate.
3) Estimate the effect of sex and strain on organs growth patterns.

MATERIAL AND METHODS

A cross-sectional design including 320 rabbits from two lines (New Zealand White and California) and both sexes were used. Animals were slaughtered at weekly intervals from 1 to 20 weeks of age. In order to use animals at the same stage of maturity only animals whose body weight, irrespective of their line and sex, was around $\pm$ 15% of mean weight of base population, were considered.

After slaughter, the skin (PI), urinary bladder and digestive tract (TD) were removed and their contents were eliminated. The carcass was left at environmental temperature until a completly bled. After 24 h at 4^{o}C, the following organs were removed and weighed: liver (HI), kidneys (RI), thymus (TI), heart-lungs (PC). Digestive tract was splited in stomach (E), caecum (C) and intestine (I).

Four growth models were fitted to data: logistic, Bertalanffy, Gompertz as mentioned by FITZHUGH (1976), BROWN et al. (1976) and Richards' model as described by RICHARDS (1969) and modified by KNIZETOVA et al., (1983). Two selection criteria for the choice of the proper model were used: the coefficient of determination (R^2) and the percentage deviation of the observed values (PD) at each slaughter point (BROWN et al., 1976; FITZHUGH, 1976; KNIZETOVA et al., 1983 and 1985).

Once a proper model had been selected, the estimated of its parameters were used to estimate the evolution of the absolute and relative growth rate and the maturity degree (FITZHUGH, 1976).

Differences in organ growth due to sex or line were examined using the F test (DRAPPER and SMITH, 1981).

RESULTS AND DISCUSSION

GROWTH MODELS

Coefficients of determination and the average percentage deviations of the observed values (APD) for organs growth models are presented in table 1.

Richards' growth model showed the best fitness in all cases but kidneys. Richards' model increased the R^2 values with respect to the other models, but its main advantage was the reduction in PD absolute values throughout the experimental period. With respect to the kidneys, R^2 from logistic and Richards' equations were similar meanwhile PD values were slightly higher than the logistic model.

TABLE 1. Coefficients of determination (R^2) and average percentage deviations of the observed values (APD) organs growth models.

MODELS / ORGANS	GOMPERTZ R^2	GOMPERTZ APD	LOGISTIC R^2	LOGISTIC APD	BERTALANFFY R^2	BERTALANFFY APD	RICHARDS R^2	RICHARDS APD
SKIN	.9822	-3.34	.9850	.41	.9790	-4.57	.9850	.27
LIVER	.9340	-10.14	.9440	-4.85	.9250	-9.73	.9485	1.10
KIDNEYS	.9790	-1.82	.9840	.14	.9400	-2.44	.9843	.65
THIMUS	.9220	-10.27	.9400	-6.61	.9130	-11.74	.9546	1.90
HEART-LUNGS	.9331	-3.29	.9389	-1.10	.9282	-3.84	.9493	-.22
DIG. TRACT	.9839	-2.83	.9835	4.09	.9840	-8.74	.9844	.31
STOMACH	.9771	-.83	.9742	3.65	.9761	2.84	.9769	-.58
CAECUM	.9753	6.81	.9706	29.91	.9752	-3.92	.9752	1.53
INTESTINE	.9760	-4.75	.9790	1.56	.9720	-7.15	.9789	.79

Better fitness achived by Richards' model in relation to other models for animal growth has been mentioned previously (EISEN et al., 1969; BROWN et al., 1976; DENISE and BRINKS, 1985). The non-constant variable form of the inflection parameter of Richards' model could explain its better fitness in respect to the other models considered. Logistic, Gompertz and Bertalanffy models are particular cases of Richards' model having specific constant values for the inflection parameter (FITZHUGH, 1976; BROWN et al., 1976).

Estimated values for the Richards' model parameters ($W = A\ (1 \pm b\ e^{-kt})1/n$) are presented on table 2.

TABLE 2. Estimated Richards model parameters for rabbit organs.

ORGAN	A	b	k	n
SKIN	438.09	15.19	.332	.945
LIVER	77.93	2.9×10^4	1.451	3.354
KIDNEY	15.18	35.50	.553	1.467
THYMUS	4.56	9.8×10^9	2.518	8.784
HEART-LUNGS	27.27	48.76	.494	1.469
DIGESTIVE TRACT	138.01	3.42	.398	.387
STOMARCH	28.12	.197	.305	.045
CAECUM	37.11	.654	.233	-.169
INTESTINE	75.26	17.33	.543	.849

ORGANS GROWTH PATTERNS

The evolution of weight, maturity degree, absolute and relative growth rate of some organs was studied using the estimates of Richards' model parameters mentioned above.

In relation to organs weight, liver and thymus concluded their growth at about 13 week of age meanwhile the other organs achived their asymptotic weight later (FIG. 1). Similar results have been reported by BUTTERFIELD et al. (1983), PRECOTT et al. (1985) for livēr and by BARON et al (1970) related to thymus.

Among digestive tract parts, the intestine completed its growth at 17 weeks of age, earlier than the caecum and stomach. Caecum weight was very low at the first 2 weeks (e.q. 0.37 g at the first week) then a important weight increase was observed coinciding with the appearance of solid material in the stomach.

Maturity degree trend (Fig. 2) denoted that organ growth was not synchronic. The ranking of organs accordingly to their maturity degree changed during the first five weeks. During the first week this order was: kidneys, heart-lungs, thymus, skin, liver and finally digestive tract. If

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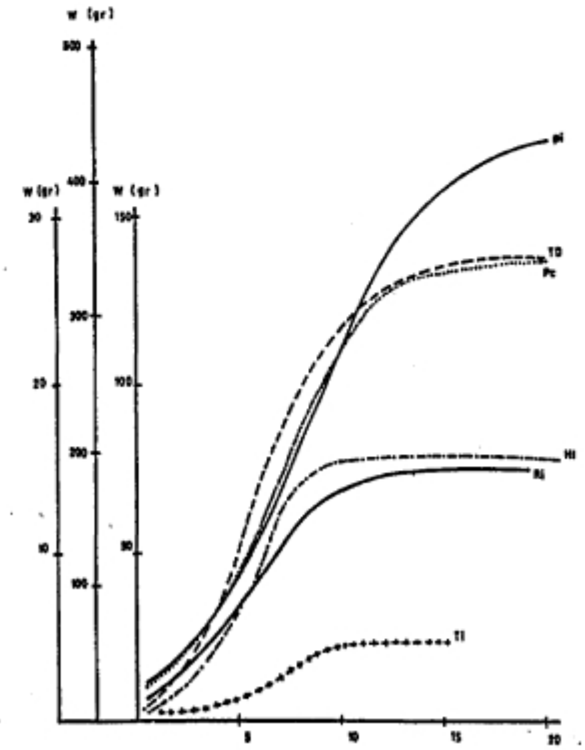
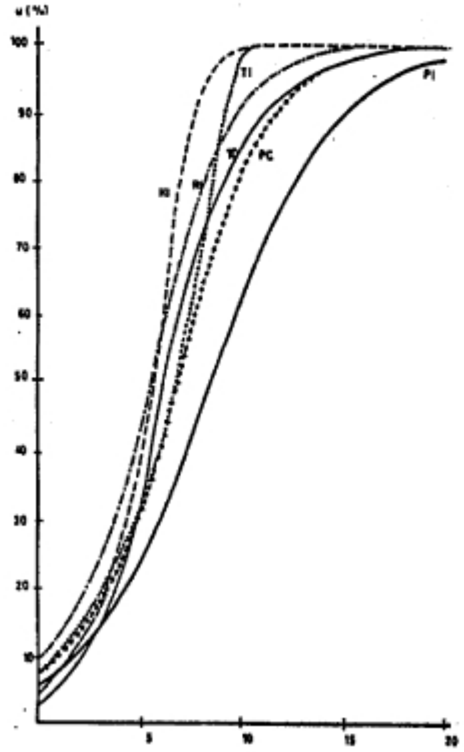
Figure 1: EVOLUTION OF ORGANS WEIGHT. Figure 2: ORGANS MATURITY DEGREE TREND.

Skin (PI), Digestive tract (TD), Heart-lungs (PC), Liver (HI), Kidneys (Ri) and Thymus (ti).





liver and thymus were excluded because they had finished their growth earlier, the order from 6 to 20 weeks of age, was: kidneys, digestive tract, heart-lungs and skin. With respect to the digestive tract parts the intestine and the stomach had greater maturity degree than caecum throughout the experimental period.

Maturity degree at the inflection point (FITZHUHGH, 1976) indicated that all organs showed a self-accelerating phase (BRODY, 1945) that remained by about one half of the growth period. The inflection point was achived at a different age for each organ, being lesser for digestive tract and greater for skin and thymus. This result suggested the existence of some specific growth regulator systems for each organ instead of a general one.

The relative growth rate followed a sigmoid shaped trend for all organs except for caecum and stomach, which followed an exponential trend. Digestive tract relative growth rate showed the strongest decrease while for liver and thymus it remains constant between the first 5 and 7 weeks of age respectively.

EFFECT OF SEX AND LINE

Differences among Richards' equations for skin, digestive tract and caecum, due to sex, were detected. From 12 to 20 weeks of age skin weight was 10% heavier in males than in females whereas maturity degree of females skin was greater during the experimental period.

Digestive tract and specially caecum weights were greater (7 and 18% respectively) in females than in males. Maturity degree for both, digestive tract and caecum, was always greater in females than in males.

Liver and stomach growth were affected by line. From 12 to 20 weeks of age liver from New Zealand White line was 9% heavier than the California one. With respect to the stomach, opposite results were observed, being 9% heavier for California than for New Zealand rabbits.

CONCLUSION

Our results confirm the usefulness of Richards' model on the estimation of organs growth with respect to the other models with constant inflection parameters. This model achived better percentage deviations of the observed values and at least similar R^2 values with respect to the other growth models.

The parallelism between liver and digestive tract for relative growth rate and maturity degree trends suggest a functional relationship between both organs growth. Among digestive tract parts the caecum showed a later growth than stomach and intestine.

Differences in organ growth due to sex or line are, basically related to organs associated with digestive process.

LITERATURE CITED

BARON, R.; VEZINHET, A.; CANTIER, . 1970. Ann. Biol. Anim. Bioch. Biophys. 10: 535-548.

BRODY, S. 1945. Bionergetics and growth. Reinhold. New York.

BROWN, J.E.; FITZHUGH, H.A.; CARTWRIGHT, T.C. 1976. J. Anim. Sci. 42-810-818.

BUTTERFIELD, R.M.; ZAMORA, J.; JAMES, A.M., THOMPSON, J.M.; REDDACLIFF, K.V. 1983. Anim. Prod. 36: 461-470.

CANTIER, J.; VEZINHET, A.; ROUVIER R.; DAUZIER, L. 1969. Ann. Biol. Anim. Bioch. Biophys. 9: 5-39.

DENISE, R.S.K.; BRINKS, J.S. 1985. J. Anim. Sic. 61: 1431-1440.

EISEN, E.J.; LANG, B.J.; LEGATES, J.E. 1969. Theor. Appl. Genet. 39: 151-260.

FITZHUGH, H.A. 1976. J. Anim. Sci. 42: 1036-1051.

FL'AK, P. 1983. 2nd Int. Congress Rostock, 75-78.

KNIZETOVA, H.; KNIZE, B.; HYANEK, J.; SIZER, R.; HYANAKOVA, L.; PLACHY, J.; VILHELMOVA, M. 1983. Genet. Sel. Evol. 15: 533-558.

KNIZETOVA, H.; HYZNEK, J.; HATKOVA; H.; KNIZE, B.; SILER, R. 1985. Z. Tierzüchtg. Züchtgsbiol. 102: 256-270.

LEBAS, F.; LAPLACE, J.P. 1972. Ann. Zootech. 21: 37-47

PRESCOTT, N.J.; WATHES, C.M.; KIRWOOD, J.K.; PERRY G.C. 1985. Anim. Prod. 41: 239-245.

PRUD'HON, M.; VEZNINHET, A.; CANTIER, J. 1970. B.T.I. 248º 203-221.

RAO, D.R.; CHEN, C.P.; SUNKI, G.R. and JOHNSON, W.M. 1978. J. Anim. Sci. 46: 578-583.

RAO, D.R.; SUNKI, G.R.; JOHNSON, W.M.; CHEN, C.P. 1977. J. Anim. Sci. 44: 1021-1025.

RICHARDS, F.J. 1969. The quantitative analysis of growth. In: Plant physiology. 1-76. F.C. Steward Ed.

RUDOLPH, W.; SOTTO, V. 1984. 3rd World Rabbit Congress. Roma. II: 562-569.

SAGER, G. 1983. 2nd Int. Congress. Rostock 79-86.

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Quantitative growth of some rabbit organs using a cross-sectional design was studied. A sample of 320 animals from 2 lines (California and New Zealand White) and both sexes were slaughtered at weekly intervals between 1 to 20 weeks of age. Logistic, Bertalanffy, Gompertz and Richards growth models were fitted. The model with the highest R^2 value was then used to estimate the trends of the absolute and relative growth rates and the degree of maturity. Differences between curve shapes due to sex or line were analysed using the F test. Richards equation always showed the best fittnes ($R^2 > .94$). The liver and the thymus concluded their growth at 13 weeks of age meanwhile the other organs achived their asymptotic weight later. The maximum absolute growth rate ocurred at diferent ages and at different degrees of maturity between organs. In relation to the digestive tract, both parameters were shorter than the same parameters of the other organs. Maturity degree trend suggested that organ growth is not synchronic. The organs ranking by their degree of maturity changed during the first 5 weeks of age and then it remained constant as follows: kidney, digestive tract, heart-lungs and skin.

CRECIMIENTO CUANTITATIVO DE LOS ORGANOS DEL CONEJO

Se estudió el crecimiento cuantitativo de algunos organos del conejo usando un diseño "cross-sectional" con 320 animales de 2 líneas y ambos sexos. Los conejos se sacrificaron semanalmente entre 1 y 20 semanas de edad. Se ajustaron los modelos logístico, Bertalanffy, Gompertz y Richards y a partir del que mostró mejor ajuste se estimó la evolución de la velocidad absoluta y relativa y del grado de madurez. Las diferencias entre ecuaciones causadas por sexo o línea se evaluaron con pruebas de F. El modelo de Richards fue el que logró mejor ajuste en todos los casos ($R^2 > .94$). El hígado y el timo concluyeron su desarrollo a las 13 semanas de edad mientras que los demás órganos lo hicieron más tardiamente. La edad y el grado de madurez en el momento de máxima velocidad absoluta variaron para los distintos órganos siendo menores en el caso del tubo digestivo. La evolución de los grados de madurez sugieren que los órganos no tienen un desarrollo sincrónico ya que los órdenes de precocidad variaron en las primeras 5 semanas de edad manteniendose constante a partir de la sexta semana.

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