Revista UNIMAR 19(2):549-555, 1997.

EFFECT OF POSTNATAL PROTEIN UNDERNUTRITION ON CHICK (*Gallus domesticus*): ALLOMETRIC STUDY OF STOMACH AND GUT GROWTH

José Lopes Soares Neto[*], Ronald de Mesquita Soares Rega[+] and Margareth Costa-Neves[#]

ABSTRACT. The present work reports a quantitative analysis of the effects of postnatal protein undernutrition on the stomach and gut growth in chicks (*Gallus domesticus*) using the bivariate allometric method. Seventy newborn animals were divided into a control group (n=35) and an undernutrition group (n=35), during forty-two days. The control group was fed with industrial chow (20% protein). The undernutrition group was fed with restrict diet (8% protein). The weights of the stomach and gut were correlated with body weight by the linear allometric model Log Y = K Log X + Log b. The values (CG: Ksto = 0.771 and Kgut = 0.634; UG: Ksto = 0.903 and Kgut = 0.998) showed a negative allometry (K<1) in both groups, however, the undernutrition group presented higher growth rate than the control group. The coefficients of correlation are very high (p<0.001, Tables 2 and 3).

Key words: stomach, gut, protein undernutrition, chick, allometry.

EFEITO DA DESNUTRIÇÃO PROTÉICA PÓS-NATAL EM PINTO (*Gallus domesticus*): ESTUDO ALOMÉTRICO DO CRESCIMENTO DO ESTÔMAGO E DO INTESTINO

RESUMO. O presente estudo analisa quantitativamente o efeito da desnutrição protéica no crescimento pós-natal do estômago e do intestino em pintos (*Gallus*

[*] Laboratório de Morfologia Humana e Animal, Centro Universitário de Porto Nacional, Universidade do Tocantins. Av. Presidente Kennedy, Caixa Postal 25, 77500-000, Porto Nacional-Tocantins, Brasil.

[+] Departamento de Histologia, Centro Universitário de Porto Nacional, Universidade do Tocantins. Av. Presidente Kennedy, Caixa Postal 25, 77500-000, Porto Nacional-Tocantins, Brasil.

[#] Departamento de Anatomia, Centro Universitário de Porto Nacional, Universidade do Tocantins. Av. Presidente Kennedy, Caixa Postal 25, 77500-000, Porto Nacional-Tocantins, Brasil.

Correspondence to José Lopes Soares Neto.

Received 11 April 1997.

Accepted 28 May 1997.

domesticus) através do método alométrico bivariado. Utilizaram-se setenta animais recém-nascidos divididos em dois grupos: controle (n=35), e desnutrido (n=35) durante quarenta e dois dias. O grupo controle recebeu alimentação industrial própria para pintos (20% de proteína). O grupo desnutrido recebeu ração hipoprotéica (8% de proteína). Os valores obtidos (GC: Kest = 0,771 e Kint = 0,634; GD: Kest = 0,903 e Kint = 0,998) mostram que houve alometria negativa (K<1) em ambos os grupos, entretanto, o grupo desnutrido apresentou maior taxa de crescimento do que o grupo de controle. Os coeficientes de correlação foram bastante elevados (p<0,001; Tabelas 2 e 3).

Palavras-chave: estômago, intestino, desnutrição protéica, pinto, alometria.

INTRODUCTION

Undernutrition is a great problem in underdeveloped countries. It affects mainly children during their first years of life. Some qualitative studies have evaluted the effects of protein undernutrition on the nervous system growth in pre and postnatal period (Sima and Persson, 1975; Gopinath *et al*., 1976; Lepri *et al*., 1994). Quantitative studies about the effects of protein undernutrition in the organic postnatal growth in chicks are still scarce on literature, however, works using the allometry have been recently reported by our laboratory. Costa-Neves and Rega (1997) presented the data obtained in central nervous system. The authors showed a decrease in brain and cerebellum growth in chicks treated with restrict diet. Neto *et al*. (1997) analysed the effect of protein undernutrition on heart, liver and pancreas and showed an increase in heart and liver growth and a decrease in pancreas growth. The present study has the purpose of establishing quantitative data about the effects of protein undernutrition on postnatal growth of the stomach and gut, using bivariate allometry and regression method II.

MATERIAL AND METHODS

Animals

Seventy newborn chicks (*Gallus domesticus*) were taken to study the effects of protein undernutrition on postnatal growth of the stomach and gut. Chicks showing obvious pathological conditions were excluded from the study. The animals were kept in the Laboratory of Human and Animal Morphology (CUPN - Unitins) and caged in two groups with

thirty five each: a control group (CG) and an undernutrition group (UG). The control group received industrial chow (20% protein) (Table 1) and the undernutrition group was fed restrict diet (8% protein) prepared with industrial chow, vitamin, starch and minerals according of American Institute of Nutrition (A.I.N. 1977). Animals were weighted and anaesthetized with ether inhalation until all breathing had stopped and killed by intracardiac perfusion of 4% formaldehyde in saline solution through the left heart ventricle. Immediately after perfusion, each chick was dissected and stomach and gut removed under a stereo microscope. The organs were fixed by immersion of 10% formaldehyde phosphate at pH 7.2 at room temperature. The wet weights of stomach and gut were measured with a precision balance (sensitive to 0.001 g).

Table 1. Control diet composition.

Corn	59.80%
soybean pellets	20.03%
meat flour	15.00%
Dicalcium phosphate	01.45%
Salt	00.72%
Supplements	03.00%

Statistical analysis

The stomach and gut weights were analysed after logarithmic transformation using a multiplicative model or power function (Huxley, 1924 and 1932; Mandarim-de-Lacerda, 1994)

1 - multiplicative model: $Y= bX^K$
2 - linear model: $\log Y= (K) \log X + \log b$

were *log b* is the initial growth coefficient, *K* is the allometric growth coefficient, *Log X* the body weight (independent variable) and *Log Y* the stomach and gut weights (dependent variables).

In order to solve the problem of biased estimates of slope of Y on X when both variables are subject to measurement error, it the K of principal axis of the standardized variables or reduced major axis R.M.A. Were computed (Teissier, 1948; Ricker, 1973; Jolicoeur, 1975; Sokal and Rohlf, 1981).

R^2 and F-statistic were used to determine the significance of each regression. The t-test was used to test for significance departure from a

predicted slope ($\alpha = 0.05$) examined with residual analysis (Wittink, 1988). Isometry is indicated by K = 1.0 when the variables have the same units (weight / weight) (Gould, 1966 and 1977; Schmidt-Nielsen, 1984).

RESULTS

Tables 2 and 3 show the results of quantitative study of the effects of protein undernutrition on postnatal growth of the stomach and gut in chicks.

Table 2. Correlation (r) and determination (r^2) coefficients.

Groups		r	r^2
CG	stomach	0.988	0.976
	gut	0.963	0.927
UG	stomach	0.917	0.841
	gut	0.942	0.887

Table 3. Results of the stomach and gut growth in the chick (*Gallus domesticus*) using the bivariate allometric equation: Log Y=K Log X + Log b. Control group (n = 35). RMA = reduced major axis and CI = confidence interval for the K. CG - control group and UG - undernutrition group.

Log X	Log Y	K(RMA)	CI - 95%(K)	Log b	p<
body (CG)	stomach	0.771	0.729-0.814	-0.679	0.001
body(CG)	gut	0.634	0.572-0.699	-0.360	0.001
body(UG)	stomach	0.903	0.760-1.049	-0.638	0.001
body(UG)	gut	0.998	0.876-1.121	-0.831	0.001

Correlation Analysis

Standard statistics (R^2 and F-statistic) indicated that all regressions were significant ($r > 0.90$) and linear models were appropriate. Table 2 shows the correlation and determination coefficients of body and organ weights. The correlation coefficients were over 0.91 in both groups, however, the determination coefficients were over 0.92 only in control group.

Allometric Analysis

Table 3 shows the results of the bivariate analysis in control and undernutrition groups. The stomach and gut growth presents negative

allometry (K < 1.0) in both groups, however, the gut growth tends to isometry in the undernutrition group (K = 1).

The undernutrition group presents higher growth than the control group. These data suggest that the undernutrition group presented higher body weight/organ weight rates than the control group during the same period (forty-two days).

By testing the significance of these coefficients with t-test all coefficients were statistically significant ($p<0.001$).

DISCUSSION

In this study weight was chosen became it is easily verified and is not affected by induced error of the observer. Many researchers utilize weight to evaluate the embryonary and fetal human growth and the effect of aspirin on bird postnatal growth (Streeter, 1920; Spencer e Coulomb, 1964; Costa-Neves *et al*, 1991 and 1993; Rega *et al*., 1992; Neto *et al*., 1998). The bivariate allometric method was chosen because it gives na efficient index for growth interpretation (Laird *et al*., 1968; Katz, 1980; Mattfeldt and Mall, 1987). In allometric studies both variables are usually subject to error (measurement error). Simple minimum square regression analysis or model I regression is inadequade. In view of this situation, some authors have suggested other regression methods which allow for error in both variables (model II regression ou Reduced Major Axis - RMA) (Sokal and Rohlf, 1981; Mandarim-de-Lacerda, 1994).

Some previous qualitative studies have suggested that undernutrition affects organic growth. Sima and Pearson (1975), Gopinath *et al*. (1976) and Lepri *et al*. (1994) showed that protein undernutrition during gestational and lactational periods in rats cause disturbance to the process of cell migration from the external granular layer of the cerebellum. More recently Costa-Neves and Rega (1997) made a quantitative analysis of effects of protein undernutrition on the nervous system in chick. The results showed a decrease in brain and cerebellum growth during postnatal period. They found different growth rates, with the body growing more rapidly than the brain and cerebellum. Neto *et al*. (1997) showed in their study that the heart and liver growth was higher than pancreas growth in undernutrition chicks. Our results showed that the stomach and gut grow more rapidly than the body. We believe that further investigations are necessary to confirm whether these alterations

are consequences of direct or indirect protein undernutrition effects on the stomach and gut weight increase during the postnatal period.

REFERENCES

AMERICAN INSTITUTE of NUTRITION. Report of the American Institute Nutrition Ad Hoc Committee on Standarts for Nutritional Studies. *J. Nutr., 107*:1340-1348, 1977.

COSTA-NEVES, M., REGA, R.M.S. & WANDERLEY, S.S. Análise quantitativa do crescimento do tronco encefálico em fetos estadiados. *F. Med. (BR), 102*:5-7, 1991.

COSTA-NEVES, M., WANDERLEY, S.S. & REGA, R.M.S. The development of human fetal pons. A quantitative study. *Rev. Bras. Neurol., 29*:23-24, 1993.

COSTA-NEVES, M & REGA, R.M.S. Effect of protein undernutrition on the postnatal growth of brain and cerebellum in the chick: an allometric approach. *Ciencia e Cultura 1997*, (submetido).

GOPINATH, G.V., BIJLANI, M. & DEO, M.G. Undernutrition and development cerebellar cortex in the rat. *J. Neuropath., 35*:125-130, 1976.

GOULD, S.J. Allometry and size in ontogeny and phylogeny. *Biol. Rev., 41*:587-640, 1966.

GOULD, S.J. Ontogeny and phylogeny. Cambridge: Cambridge University Press, 1977.

HUXLEY, J.S. Problems of relative growth. London: Methuen, 1932.

HUXLEY, J.S. Constant differentiation growth rations and their significance. *Nature, 114*:895-896, 1924.

JOLICOEUR, P. Linear regression in fishery research: some comments. *J. Fish. Board Can., 32*:69-79, 1975.

KATZ, M.J. Allometry formula: a celular model. *Growth., 44*:89-96, 1980.

LAIRD, A.K., BARTON, A.D. & TYLER, S.A. Growth and times: an interpretation of allometry. *Growth., 32*:347-354,1968.

LEPRI, E.R., BRUSHI, L.C. & MOURA, A.S. Efeitos da desnutrição protéica durante os períodos pré e pós-natal no desenvolvimento cerebelar. *Rev. Bras. Ciên. Morfol., 11*:23-27, 1994.

MANDARIM-DE-LACERDA, C.A. Manual de quantificação morfológica: morfometria, alometria, estereologia. Rio de Janeiro: CEBIO, 1994.

MATTFELDT, T. & MALL, G. Statistical methods for growth allometry studies. *Growth.*, 51:86-102, 1987.

NETO, J.L.S., REGA, R.M.S. & COSTA-NEVES, M. Effects of postnatal protein undernutrition on heart, liver and pancreas in chicks: an allometric study. Period. Biol., 1997 (in press).

NETO, J.L.S., REGA, R.M.S. & COSTA-NEVES, M. Effect of aspirin on postnatal growth of the heart and liver in chicks (Gallus domesticus): an allometric approach. Biomed. Res., 1998 (in press).

REGA, R.M.S., COSTA-NEVES, M. & WANDERLEY, S.S. Crescimento do globo ocular humano: análise quantitativa no período fetal. *Rev. Bras. Oftal. 51*:41-43, 1992.

RICKER, W.E. Linear regression in fishery research. *J. Fish. Res. Board Can.,* 30:409-434, 1973.

SCHMIDT-NIELSEN, K. Scaling. Why is animal size so important? Cambridge: Cambridge University Press, 1984.

SIMA, A. & PERSSON, L. The effects of pre and postnatal undernutrition on the development of rat cerebellar cortex. Part I (morphological observation). *Neurobiol., 5*:23-24, 1975.

SOKAL, R.R. & ROHLF, F.J. Biometry. The principles and practice of statistics in biological research. New York: Freeman, 1981.

SPENCER, R.P. & COULOMB, M.J. Observations of fetal weight and gestation age. *Growth., 28*:244-247, 1964.

STREETER, G.L. Weight, sitting height, head size, foot lenght and menstrual age of the human embryo. *Contrib. Embr. Carn. Inst. Washington., 11*:163-170, 1920.

TEISSIER, G. La relation d'allometrie: sa signification statistique etbiologique. Biometrics, 4:14-48, 1948.

WITTINK, D.R. The application of regression analysis. Boston: A & Bacon, 1988.