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THE ESTIMATION OF PREWEANING ENERGY INTAKE FROM LITTER MASS IN RATS*

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(Sleutelwoorde: *Rot, voorspeense energie-inname)*

OPSOMMING: DIE BERAMING VAN VOORSPEENSE ENERGIE-INNAME VANAF WERPSELMASSA BY ROTTE

'n Beraming van die hoeveelheid energie ingeneem deur werpsels tot op speen, in terme van prenatale verbruik en die melkproduksie van die moeders, word dikwels benodig in die bestudering van doeltreffendheid van groei. Dikwels is dit egter nie moontlik om hierdie energie-inname direk te meet nie. 'n Metode is dus ontwikkel waarvolgens die werpselmassa gebruik word om die kumulatiewe energie-inname deur rotte tot op speen te beraam. 'n Vergelyking is ook ontwikkel om hierdie kumulatiewe energie-inname van 'n werpsel tussen die individue van die werpsel te verdeel.

SUMMARY:

An estimate of the total energy intake of litters until weaning, including both energy obtained in-utero and that derived post-natally from milk consumed, is often required in experiments on growth efficiency. Frequently it is, however, impossible to measure this energy directly. Consequently, a method was developed using litter mass to estimate the cumulative energy intake by rats to weaning. An equation was also developed to divide this cumulative energy intake of a litter between the individuals of the litter.

In the analyses of experiments involving the quantification of animal growth and efficiency of feed utilization (Parks, 1970; 1972; 1973; 1975a & 1975b; Meissner, Roux & Hofmeyr, 1975; Roux, 1976; Meissner, 1977; Kemm, 1979) the cumulative form of energy intake is required, since the initial body mass needs to be related to an initial cumulative intake. This cumulative energy intake (μ), whether it is in the form of milk or food, utilized by an animal before the beginning of an experimental phase is frequently not available, and methods of estimating it would be useful.

Rats are often weaned at 21 days of age, so that the mass of the rats at this stage is a function of the milk production of the dam and the prenatal energy consumption of the fetus. It is, however, very difficult to determine the prenatal energy consumption and frequently impracticable to determine the milk production if many dams are involved.

Material and methods

Females of the outbred Wistar line were kept under conventional conditions, with a room temperature of 21 ± 2°C, a relative humidity of 35 – 50% and a lighting regime with 12 hours of simulated day and 12 hours of darkness. The milk production of 8 females was determined according to the method described by Reddy, Donker & Linnerud (1964), Reddy & Donker (1965), Kumaresan, Anderson & Turner (1967) and Morag (1970). In this method, pups are separated from their dams for a certain period (secretion interval). Prior to being returned to the dam their body mass is measured, whereafter they are allowed to suckle for a given period (suckling time). The body mass is then measured once again. The increase in live mass of the litter during suckling time serves as an estimate of the amount of milk secreted during the secretion interval. Litter size was standardized at 12 pups, with a secretion interval of 6 hours and a suckling time of 60 minutes. This method was used to determine the milk production on days 3, 6, 9, 12, 15, 18 and 21 of lactation.

As there appears to be no study on the description of the lactation curve of the rat, an equation, $y = \underline{a}x^{\underline{b}}e^{\underline{c}x}$, used by Wood (1969) to describe the lactation curve of cows, was used. If $\underline{a}$ and $\underline{b}$ are larger than zero, the equation is linearized by transformation to the logarithmic scale. Therefore, the equation

$$\ln y = \ln \underline{a} + \underline{b} \ln x + \underline{c}x \quad .....(1)$$

is linear in ln y, lnx and x where y is milk production on day x.

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Table 1

Values for a, b and c plus standard errors

	a	b	c
Value	0,2690	1,7362	– 0,0833
Std. error	0,5620	0,7033	0,0626

Results

Estimates of $\underset{\cdot}{a}$, $\underset{\cdot}{b}$ and $\underset{\cdot}{c}$ for equation 1 were obtained by multiple regression analysis for each rat. The values of $\underset{\cdot}{a}$, $\underset{\cdot}{b}$ and $\underset{\cdot}{c}$ with standard errors are given in Table 1.

It was then possible to estimate the milk production of rats on the different days by using equation (1). The estimated and determined values for every third day could be compared by calculating r^2, a measure of the goodness of fit of a regression line. The calculated value of r^2 was 0,98, which indicates that equation (1) is a fair description of the milk production of a rat. These values were plotted against each other, and compared to a regression line with slope one and intercept zero (Fig. 1) to determine if there was any bias in the estimates. It is evident from fig. 1 that there was no significant bias, so that equation (1) seems to be a useful equation to predict

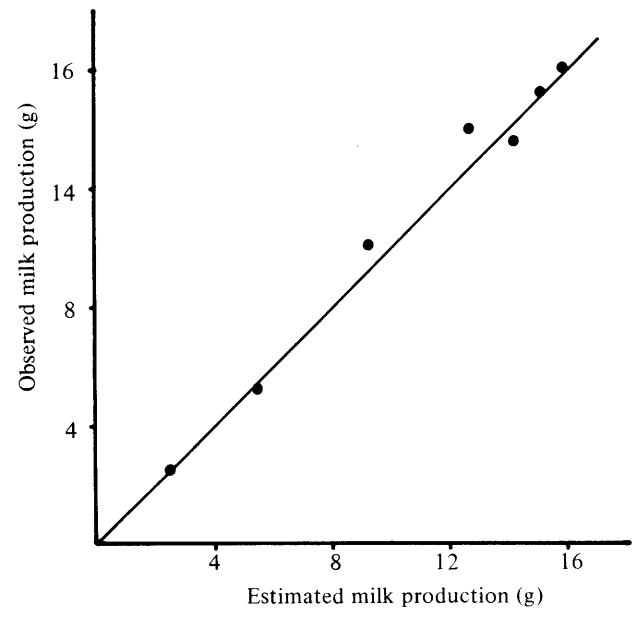

Fig. 1 Plot of observed values against estimated values, and regression line with slope one and intercept zero

milk production of rats. The average total estimated milk production of the dams from 3 to 21 days was 822,16 g.

The energy content of 8 three day-old pups from 4 litters was determined and found to be 3,88 ± 0,09 KJ/g live mass. Kielanowski (1965) reported that early postnatal efficiency was 85 percent. This value was therefore multiplied by $\frac{100}{85}$ to estimate the cumulative energy intake (prenatal and early postnatal) by a three-day-old pup. Six rats were used to obtain milk for the determination of the energy content of rat milk. The rats were anaesthetized and milked by hand every third day from day 3 to day 21. A total of 25,6 g of milk was obtained. The energy content of rat milk was found to be 7,84 KJ/g fluid milk. This corresponds closely with the value of 8,11 KJ/g fluid milk obtained by Romero, Canas & Baldwin (1975). Daily milk production can thus be estimated (equation (1)) and expressed in terms of energy units. By adding the cumulative energy intake of three-day-old pups to the cumulative milk produced by dams from 3 to 21 days post partum (in KJ), it is possible to derive an estimation of the cumulative energy intake (μ) of a 21 day old litter.

Equations

As litter mass is the only variable that can be measured easily, it is desirable to estimate μ from this variable. The well known allometric equation, which expresses efficiency of growth (Roux, 1976), was used to estimate μ from litter mass. The logarithmic transformation of the allometric equation, $y = \underline{a}\, x^{\underline{b}}$, leads to a straight line, thus:

$$\ln y = \ln \underline{a} + \underline{b} \ln x \quad .....(2)$$

where, y = cumulative energy intake and x = litter mass.

The mass of the 8 litters involved in the experiment was measured every third day from day 3 to 21, and cumulative energy intake can be calculated from (1). With y and x known, it is possible to estimate values of $\underline{a}$ and $\underline{b}$ from regression analysis. The average values of slope ($\underline{b}$) and intercept (ln $\underline{a}$) were respectively 0,6289 ± 0,0606 and 2,4440 ± 0,2583.

However, pups suckle as a litter and not as individuals. Therefore, a method of dividing μ of a litter between the individuals of the litter had to be developed. With differentiation the allometric equation becomes $\frac{dy}{y} = \underline{b}\frac{dx}{x}$. Hence on replacing dx by $(x_i - \bar{x})$, dy by $(y_i - \bar{y})$, y by $\bar{y}$ and x by $\bar{x}$ the differential equation results in

$$y_i = \bar{y}\,\frac{x_i - \bar{x} + \bar{x}\underline{b}}{\bar{x}\underline{b}} \quad .....(3)$$

where here y_i = μ of rat i
$\bar{y}$ = average μ of the litter
$\bar{x}$ = average mass of the litter
x_i = mass of rat i
and $\underline{b}$ = slope (0,6289)

Discussion

Since equation (1) seems to describe the milk production of rats fairly well (r^2 = 0,98), it may be useful in estimating the milk production of rats when values for $\underline{a}$, $\underline{b}$ and $\underline{c}$ are available. The relationship between estimated and determined values is a straight line with a slope of one and a intercept of zero

Since the cumulative energy intake of litters at the beginning of an experimental phase is very seldom known, equation (2) can be used to estimate this component when the litter mass is known and values for ln $\underline{a}$ and $\underline{b}$ are available. Our estimates depend on the food, the environmental and experimental conditions and the strain used. For similar circumstances the above values should be adequate. for different circumstances, new values for the constants should be estimated depending on the degree of accuracy required.

Individual body mass values are, for example, needed in selection experiments where individual or within family selection is practised. Equation (3) provides a method by which the μ for a litter can be divided between the individuals of the litter.

Equations (1), (2) and (3) are based on small numbers and may not be very accurate, but appear adequate for the purposes mentioned. It is unrealistic to allocate a cumulative energy intake of zero to a rat at the beginning of an experimental phase. A nonzero estimate, even if it is not very accurate, is to be preferred because the contribution of μ to the cumulative energy intake during, say a growth experiment, decreases rapidly with time. The error in y due to μ thus soon becomes relatively small and unimportant.

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