Basic Dividing of Foods between Ruminants and Humans when based on the Production of Forages or Grain Crops, or Both - A Simple Analytic Description -

Shimojo, Masataka Laboratory of Animal Feed Science, Faculty of Agriculture, Kyushu University

Bungo, Takashi Shikoku National Agricultural Experiment Station

Imura, Yoshimi Laboratory of Animal Feed Science, Faculty of Agriculture, Kyushu University

Tobisa, Manabu Laboratory of Animal Feed Science, Faculty of Agriculture, Kyushu University

他

https://doi.org/10.5109/24330

出版情報:九州大学大学院農学研究院紀要. 44 (3/4), pp.287-292, 2000-02. Kyushu University バージョン: 権利関係: J. Fac. Agr., Kyushu Univ., 44 (3.4), 287-292 (2000)

Basic Dividing of Foods between Ruminants and Humans when based on the Production of Forages or Grain Crops, or Both – A Simple Analytic Description –

Masataka Shimojo, Takashi Bungo*, Yoshimi Imura, Manabu Tobisa, Mitsuhiro Furuse, Yasuhisa Masuda, Yasukatsu Yano, Yutaka Nakano**, Tao Shao, Muhammad Yunus and Ichiro Goto***

Laboratory of Animal Feed Science, Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan (Received October 29, 1999 and accepted November 5, 1999)

The present study suggested a simple analytic description of the basic dividing of foods between runniants and humans when it was based on the production of forages or grain crops, or both. The results obtained were as follows. (1) Humans depended basically on the grain crop and forage production for the raw materials of foods, where harvest index of grain crops and the production ratio between forages and grain crops were essential factors. (2) Forages and straws from grain crops were used as runniant feeds. (3) Grains and animal protein from runninants were used for human consumption. The results (1), (2) and (3) supported the human life.

INTRODUCTION

The production of ruminants from forages is of importance due to the ruminants' capability of converting plant fibers into animal protein for human consumption (Van Soest, 1982; Minson, 1990; Cecava, 1995b). This can avoid the grain competition between ruminants and humans, because straws from grain crops and forages are unavailable in the digestive tract of humans. The food competition problem is very difficult to solve because of the effects of many complicated factors, but simple analytic descriptions might be expected to help us to understand the basic dividing of foods between ruminants and humans.

The present study was designed, using the hypothetic equation reported by Shimojo $et \ al.$ (1998), to suggest a simple analytic description of the basic dividing of foods between ruminants and humans when based on the production of forages or grain crops, or both.

ANALYSES OF BASIC DIVIDING OF FOODS

Procedures common to analyses

There are three procedures (A), (B) and (C) common to analyses in the present study.

(A) The following hypothetic equation [H] suggested by Shimojo et al. (1998), which

^{*} Shikoku National Agricultural Experiment Station, Kagawa 765-8508

^{**} Kyushu University Farm, Fukuoka 811-2307

^{***} University of the Air, Fukuoka Study Center, Fukuoka 812–0016

shows a stretch of W as follows, is used. Thus,

$$\mathbf{H} = \left(\frac{1}{\alpha} \cdot \frac{d\beta}{dt}\right) \cdot \left(\frac{\alpha}{\gamma}\right) \cdot \left(\frac{dW}{d\beta}\right),\tag{1}$$

where *W*=weight of something, *t*=time, α , β and γ are parameters.

(B) The following items are taken up for the insertion into equation (1) in various analyses. (i) W_{R} =ruminant body weight. (ii) W_{u} =human body weight. (iii) F [F is regarded as not only the harvested forage weight but also the cumulative forage intake by ruminants on condition that there is a complete consumption]. (iv) G+S [G+S, where G is the grain weight for human consumption and S is the straw weight as a ruminant feed, is regarded as the cumulative grain and straw intake as well as the harvested grain crop weight on condition that there is a complete consumption].

(C) Equation (1) is used in the form of differential equation basically, but in some cases $dW/d\beta$ is allowed to be regarded as W/β when W and β show plant factors, because they are each given the cumulative value over the period of growth.

Food dividing based on forage or grain crop production

(A) Analysis based on forage production

In equation (1) $\alpha = W_R$, $\beta = F$ and $\gamma = W = W_H$, then, H based on the forage production $[H_r]$ is described as follows:

$$H_{\rm F} = \left(\frac{1}{W_R} \cdot \frac{dF}{dt}\right) \cdot \left(\frac{W_R}{W_H}\right) \cdot \left(\frac{dW_H}{dF}\right), \qquad (2)$$
$$= \frac{1}{W_H} \cdot \frac{dW_H}{dt}. \qquad (3)$$

Three terms in equation (2) are explained as follows. (i) $(1/W_R) \cdot (dF/dt)$ shows the forage ingestion rate per unit W_R [FIRW_R]. (ii) W_R/W_H , which is the body weight ratio, is regarded as the ruminant body mass supplied for human consumption [RBMHC]. (iii) dW_H/dF is regarded as the ratio of W_H changes to F [W_H-F ratio]. W_H-F ratio is not the efficiency of F for W_H changes, because F is unavailable for direct human consumption. The term in equation (3), $(1/W_H) \cdot (dW_H/dt)$, shows the relative growth rate of W_H [RGRW_H].

Equations (2) and (3) show that humans depend basically on the forage production $[dW_u/dF, \text{ or } (W_u \text{ changes})/F]$ for the raw materials of foods, where ruminants eat forages $[(1/W_u) \cdot (dF/dt)]$ and supply animal protein for human consumption $[W_u/W_{tl}]$ to support the human life $[(1/W_u) \cdot (dW_u/dt)]$. This agricultural system may be found in the region where the land is unavailable for grain crop production for human consumption. (B) Analysis based on grain crop production

In equation (1) $\alpha = W_s$, $\beta = G + S$ and $\gamma = W = W_s$, then, H based on the grain crop production [H_G] is described as follows:

$$H_{G} = \left(\frac{1}{W_{R}} \cdot \frac{d(G+S)}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dW_{H}}{d(G+S)}\right), \quad (4)$$
$$= \frac{1}{W_{H}} \cdot \frac{dW_{H}}{dt}. \quad (5)$$

288

Three terms in equation (4) are explained as follows. (i) $(1/W_R) \cdot (d(G+S)/dt)$ shows the grain and straw ingestion rate per unit W_R [GSIRW_R]. (ii) W_R/W_R =RBMHC. (iii) $dW_R/d(G+S)$ is regarded as the ratio of W_R changes to G+S [W_R-GS ratio]. W_R-GS ratio is not the efficiency because S is unavailable for direct human consumption. The term in equation (5), $(1/W_R) \cdot (dW_R/dt)$, is RGRW_R.

Equations (4) and (5) show that humans depend basically on the grain crop production $[dW_n/d(G+S), \text{ or } (W_n \text{ changes})/(G+S)]$ for the raw materials of foods, where only animal protein from ruminants is available for human consumption $[W_n/W_n]$ to support the human life $[(1/W_n) \cdot (dW_n/dt)]$ because ruminants eat grains as well as straws $[(1/W_k) \cdot (d(G+S)/dt)]$. This agricultural system is unusual because the grain eating habit of humans is ignored. Therefore, the form of equation (4) should be changed so as to include the grain eating by humans. Thus,

$$\begin{aligned}
\mathbf{H}_{G} &= \left(\frac{1}{W_{R}} \cdot \frac{d\left(G+S\right)}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dW_{H}}{d\left(G+S\right)}\right) \\
&= \left\{\frac{1}{W_{R}} \cdot \left(\frac{dG}{dt} + \frac{dS}{dt}\right)\right\} \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dW_{H}}{d\left(G+S\right)}\right) \\
&= \left(\frac{1}{W_{R}} \cdot \frac{dG}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dW_{H}}{d\left(G+S\right)}\right) + \left(\frac{1}{W_{R}} \cdot \frac{dS}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dW_{H}}{d\left(G+S\right)}\right) \\
&= \left(\frac{dW_{H}}{d\left(G+S\right)}\right) \cdot \left\{\left(\frac{1}{W_{H}} \cdot \frac{dG}{dt}\right) + \left(\frac{1}{W_{R}} \cdot \frac{dS}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right)\right\}.
\end{aligned}$$
(6)

Four terms in equation (6) are explained as follows. (i) $dW_{\rm H}/d(G+S)=W_{\rm H}-GS$ ratio. (ii) $(1/W_{\rm H})\cdot(dG/dt)$ shows the grain ingestion rate per unit $W_{\rm H}$ [GIRW_H]. (iii) $(1/W_{\rm H})\cdot(dS/dt)$ shows the straw ingestion rate per unit $W_{\rm R}$ [SIRW_R]. (iv) $W_{\rm R}/W_{\rm H}$ =RBMHC.

Equation (6) shows that straws are used as a ruminant feed $[(1/W_R) \cdot (dS/dt)]$ and humans consume both grains $[(1/W_R) \cdot (dG/dt)]$ and animal protein from ruminants $[W_R/W_R]$. Straws from grain crops are low in the nutrient concentration and are usually given various treatments to improve the nutritive value before given to ruminants (Sundstøl and Owen, 1984; Preston and Leng, 1987). This agricultural system may avoid the food competition between ruminants and humans.

Food dividing based on forage and grain crop production

(A) Analysis based on the grain crop and forage production

In equation (1) $\alpha = W_R$, $\beta = G + S$, $\gamma = W_H$ and W = F, then, II based on the grain crop and forage production [H_{G-F}] is described as follows:

$$\begin{split} \mathbf{H}_{\mathrm{G-F}} &= \left(\frac{1}{W_{R}} \cdot \frac{d\left(G+S\right)}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dF}{d\left(G+S\right)}\right) \\ &= \left\{\frac{1}{W_{R}} \cdot \left(\frac{dG}{dt} + \frac{dS}{dt}\right)\right\} \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dF}{d\left(G+S\right)}\right) \\ &= \left(\frac{1}{W_{R}} \cdot \frac{dG}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dF}{d\left(G+S\right)}\right) + \left(\frac{1}{W_{R}} \cdot \frac{dS}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dF}{d\left(G+S\right)}\right) \end{split}$$

M. Shimojo et al.

$$= \left(\frac{1}{W_R} \cdot \frac{dF}{dt}\right) \cdot \left(\frac{W_R}{W_H}\right) \cdot \left(\frac{dG}{d(G+S)}\right) + \left(\frac{1}{W_R} \cdot \frac{dF}{dt}\right) \cdot \left(\frac{W_R}{W_H}\right) \cdot \left(\frac{dS}{d(G+S)}\right), \quad (7)$$

$$= \left(\frac{1}{W_{H}} \cdot \frac{dG}{dt}\right) \cdot \left(\frac{dF}{d(G+S)}\right) + \left(\frac{1}{W_{R}} \cdot \frac{dS}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \cdot \left(\frac{dF}{d(G+S)}\right).$$
(8)

Four different terms in equation (7) are explained as follows. (i) $(1/W_n) \cdot (dF/dt) = \text{FIRW}_n$. (ii) $W_n/W_n = \text{RBMHC}$. (iii) dG/d(G+S) is regarded as G/(G+S), the proportion of *G* to G+S [G–GS proportion]. G–GS proportion is something like harvest index of grain crops. (iv) dS/d(G+S) is regarded as S/(G+S), the proportion of *S* to G+S [S–GS proportion]. (S–GS proportion) + (G–GS proportion)=1. Three terms, which are given in equation (8) but not shown in equation (7), are explained as follows. (v) $(1/W_n) \cdot (dG/dt) = \text{GIRW}_n$. (vi) $(1/W_n) \cdot (dS/dt) = \text{SIRW}_n$. (vii) dF/d(G+S) is regarded as F/(G+S), the ratio of *F* to G+S[F–GS ratio]. F–GS ratio is associated with the production ratio between them.

Equations (7) and (8) show the basic dividing of foods between ruminants and humans, where ruminants eat forages $[(1/W_{s}) \cdot (dF/dt)]$ and straws from grain crops $[(1/W_{\scriptscriptstyle H}) \cdot (dS/dt)]$ and humans consume grains $[(1/W_{\scriptscriptstyle H}) \cdot (dS/dt)]$ and animal protein from ruminants $[W_R/W_H]$. This agricultural system also includes, as essential factors, harvest index of grain crops [dG/d(G+S)], or G/(G+S) and the production ratio between forages and grain crops [dF/d(G+S)], or F/(G+S). Modern rice plant breeders have bred the short culm type showing higher harvest index than the long culm type of native breeds, because the short culm type shows resistance to lodging compared with the long culm type (Tanaka, 1987). It was suggested that resistance to lodging was related to a higher content of silica in the culm, but silicified straws were less digestible to ruminants (Hasan et al., 1993). Mahadevan (1982) reported that the net annual calorie balance in the human food production was much better in the grain crop production than in the forage production, when the human food composed of grains and milk from buffaloes fed alkali-treated straws and other by-products supplemented with minerals and non-protein nitrogen was compared with that composed of milk from buffaloes given the cultivated forage and concentrates. This choice is considered of great importance in the region where there are many people and the agricultural land use is limited. (B) Summarizing the suggestions from equations (7) and (8)

Equations (7) and (8) are summarized into an equation [H_s] when $\alpha = W_{\mu}$, $\beta = (G + S) + F$, $\gamma = W = W_{\mu}$ in equation (1). Thus,

$$H_{S} = \left\{ \frac{1}{W_{R}} \cdot \frac{d\left(\left(G + S \right) + F \right)}{dt} \right\} \cdot \left(\frac{W_{R}}{W_{H}} \right) \cdot \left\{ \frac{dW_{H}}{d\left(\left(G + S \right) + F \right)} \right\}.$$
(9)

Equation (9) gives the following two equations (10) and (11), respectively.

$$H_{S} = \left\{ \frac{1}{W_{R}} \cdot \frac{d(G+S+F)}{dt} \right\} \cdot \left(\frac{W_{R}}{W_{II}} \right) \cdot \left\{ \frac{dW_{II}}{d(G+S+F)} \right\}$$
$$= \left(\frac{1}{W_{R}} \cdot \frac{dG}{dt} \right) \cdot \left(\frac{W_{R}}{W_{H}} \right) \cdot \left(\frac{dW_{II}}{d(G+S+F)} \right) + \left(\frac{1}{W_{R}} \cdot \frac{d(S+F)}{dt} \right) \cdot \left(\frac{W_{R}}{W_{H}} \right) \cdot \left(\frac{dW_{II}}{d(G+S+F)} \right)$$

290

Ruminant Feed and Human Food

$$= \left(\frac{dW_{H}}{d(G+S+F)}\right) \cdot \left\{ \left(\frac{1}{W_{H}} \cdot \frac{dG}{dt}\right) + \left(\frac{1}{W_{R}} \cdot \frac{d(S+F)}{dt}\right) \cdot \left(\frac{W_{R}}{W_{H}}\right) \right\}.$$
 (10)

$$H_{S} = \left\{ \frac{1}{W_{R}} \cdot \frac{d(G+S+F)}{dt} \right\} \cdot \left(\frac{W_{R}}{W_{II}} \right) \cdot \left\{ \frac{dW_{II}}{d(G+S+F)} \right\}$$
$$= \frac{1}{W_{H}} \cdot \frac{dW_{II}}{dt} .$$
(11)

Four terms in equation (10) are explained as follows. (i) $dW_{u}/d(G+S+F)$ is regarded as the ratio of W_{u} changes to G+S+F [W_u-GSF ratio], but it is not the efficiency due to the unavailability of S+F for direct human consumption. (ii) $(1/W_{u}) \cdot (dG/dt) = \text{GIRW}_{u}$. (iii) $(1/W_{R}) \cdot (d(S+F)/dt)$ shows the straw and forage ingestion rate per unit W_{R} [SFIRW_R]. (iv) W_{u}/W_{u} =RBMHC. The term in equation (11), $(1/W_{H}) \cdot (dW_{H}/dt)$, is RGRW_u.

Equations (10) and (11) show that humans depend basically on the grain crop and forage production $[dW_{\mu}/d(G+S+F), \text{ or } (W_{\mu} \text{ changes})/(G+S+F)]$ for the raw materials of foods, where humans consume, to support the life $[(1/W_{H}) \cdot (dW_{H}/dt)]$, grain crops $[(1/W_{R}) \cdot (dG/dt)]$ and animal protein from ruminants $[W_{R}/W_{R}]$ eating straws from grain crops and forages $[(1/W_{R}) \cdot (d(S+F)/dt)]$. This agricultural system is considered reasonable because it gives the basic dividing of foods to avoid the food competition between ruminants and humans.

Suggestions from the present analyses

The present study shows a simple analytic description of the basic dividing of foods between ruminants and humans. A feature of these analyses is that forages, grain crops, ruminants and humans are all included in a hypothetic equation and basic relationships among them are derived from this equation, suggesting a sort of harmonic relationship between ruminant agriculture and human life.

Masuda (1999) suggests that grassland and forage crop sciences will make a contribution to the avoiding of food crisis, the solving of environmental issues and the establishing of sustainable agriculture. This implication seems to be based on the following three points. (1) The life zone of ruminants, which live on herbage basically, spreads from the human life zone to the zone of wildlife, where plants produce organic matter from solar energy (Cecava, 1995a). (2) This wide distribution of ruminants is supported by the capability of plant fiber digestion in the rumen and conversion into animal protein for human consumption without food competition with humans. (3) The vegetation of both native and improved grasslands, as well as the undergrowth of forests, may be controlled appropriately by the skillful use of ruminants, which will lead to the sustainable agriculture, the green sphere preservation and the protection from desertification.

The basic dividing of foods between ruminants and humans, which is shown analytically by equations (10) and (11) in the present study, may make a small contribution to the avoiding of food crisis, the point (2) related to Masuda's implication (1999).

291

M. Shimojo et al.

REFERENCES

- Cecava, M. J. 1995a Rumen Physiology and energy requirements. *In* "Beef Cattle Feeding and Nutrition (2nd ed.)", ed. by T. W. Perry and M. J. Cecava, Academic Press, Inc., San Diego, pp. 3–24
- Cecava, M. J. 1995b Pasture and forages. *In* "Beef Cattle Feeding and Nutrition (2nd ed.)", ed. by T. R. Perry and M. J. Cecava, Academic Press, Inc., San Diego, pp. 91–103
- Hasan S., M.Shimojo and I. Goto 1993 Chemical components influencing lodging resistance of rice plant and its straw digestibility in vitro. Asian–Aust. J. Anim.Sci., 6: 41–44
- Mahadevan, P. 1982 Pastures and animal production. In "Nutritional Limits to Animal Production from Pastures", ed. by J. B. Hacker, CAB International, Farnham Royal, U. K., pp. 1–17
- Masuda, Y. 1999 In the cause of new development in grassland and forage crop sciences. Jap. Soc. Grassl. Sci., Kyushu Branch Rep., 29:1 (in Japanese)
- Minson, D. J. 1990 Ruminant production and forage nutrients. In "Forage in Ruminant Nutrition", Academic Press, Inc., San Diego, pp. 1–8
- Preston, T. R. and R. A. Leng 1987 Feeding systems: Straws & agro-industrial byproducts. In "Matching Ruminant Production Systems with Available Resources in the Tropics and Sub-Tropics", Penambul Books, Armidale, Australia, pp. 129–160
- Shimojo, M., T. Bungo, M. Tobisa, Y. Imura, N. Koga, S. Tao, M. Yunus, Y. Nakano, I. Goto, M. Furuse and Y. Masuda 1998 A hypothetic equation from which growth analysis equations of forages and ruminants are derived as special cases. J. Fac. Agr., Kyushu Univ., 43: 103–109
- Sundstøl, F. and E. Owen 1984 Straw and other fibrous by-products as feed. Elsevier Science Publishing Co. Inc., New York
- Tanaka, K. 1987 Green Revolution and I. *In* "Two decades in Green Revolution", ed. by N. Kanazawa, RRIAP (Nihon University), Ryukeishosha Publishing Co., Tokyo, pp. 19–30 (in Japanese)
- Van Soest, P. J. 1982 Nutrition and the ruminant. In "Nutritional Ecology of the Ruminant", Cornell University Press, New York, U.S.A., pp. 1–22