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THE USE OF THE DAILY PRODUCTION FUNCTION TO SELECT THE FEEDING PROGRAM FOR GROWING AND FATTENING CATTLE

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Introduction

Everyday the beef cattle producer faces the decision of how much to feed his animals. Feeding programs can be divided into "ad libitum," in which the animal is allowed to eat to appetite satisfaction, and "restrictive" ones in which the animal's appetite is not fully satisfied. Blaxter [2,3,4] and Dosworth [6] have stated that as daily intake of feed of a given quality increases, "efficiency" (body-weight gain per kg of feed) also increases. The explanation for the increase in efficiency with daily feed intake is given by the fact that a large portion of the feed intake is used for maintenance and only a relatively small part for production.

Since biological "efficiency" is equivalent to the "average physical product" of economics it is possible to infer that as daily feed intake increases average physical product increases. In Figure 1 the theoretical daily production function is shown. The total physical product (TPP), the average physical product (APP) and the marginal physical product (MPP) are presented, as well as the voluntary intake restriction. The appetite restrictions bounds the production function to Stage I (see Figure 1). The animal does not eat enough feed to reach the point where average physical product declines. The portion of the production function to the right of the appetite restriction is irrelevant.

Applying the theory of production to a situation of ever-increasing average physical product it is possible to conclude that the greatest return over cost of the input will be obtained with the greatest amount possible of the input, assuming constant input and output prices.

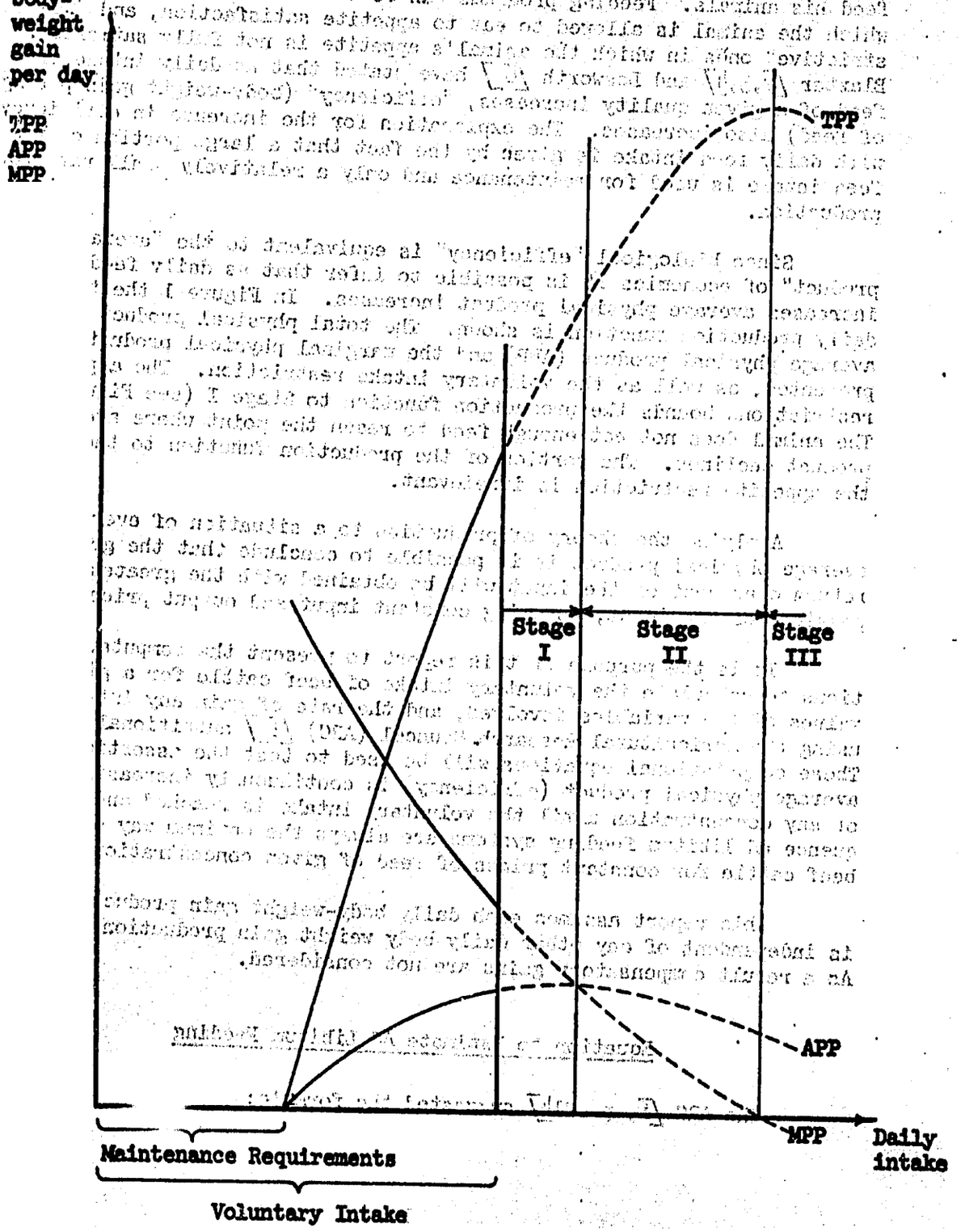
It is the purpose of this report to present the computational equations to calculate the voluntary intake of beef cattle for a given set of values of the variables involved, and the rate of gain any intake produces using the Agricultural Research Council (ARC) [1] nutritional information. These computational equations will be used to test the assertion that the average physical product (efficiency) is continuously increasing for feed of any concentration until the voluntary intake is reached and as a consequence ad libitum feeding systems are always the optimum way of feeding beef cattle for constant prices of feed of given concentration and cattle.

This report assumes each daily body-weight gain production function is independent of any other daily body weight gain production function. As a result compensatory gains are not considered.

Equation to Estimate Ad Libitum Feeding

The ARC [1, p. 214] suggested the formula:

Figure 1. The theoretical daily production function of fattening beef cattle.



$$VI = (9.1\,Q - 0.74\,Q^2 - 194)\,W^{0.73} \qquad (1)$$

where:

VI is the voluntary intake of feed dry matter (gr/day)

Q is the metabolizability of feed energy (percent)

W is the weight of the animal (kg)

This equation applies to sheep receiving long roughages containing more than 8.5 percent of protein; it was originally proposed by Blaxter [5]. Without complete information for beef cattle, a 15 percent increase over the values obtained by equation (1) was suggested [1, p. 214].

This equation and all subsequent ones are transformed so that the variable which is related to quality is always expressed as concentration of the diet (M/D) in Mcal of metabolizable energy per kg of dry matter (Mcal ME/kg DM). 1/ This transformation serves the purpose of making them more useful given the fact that many of the available tables of feed composition present the energy contents as concentration rather than in percentage. For this purpose it is assumed that the calorific value (gross energy) of all feeds is 4.4 Mcal/kg DM [1, p. 211]. Then:

$$Q = (100/4.4)(M/D) \qquad (2)$$

where:

(M/D) is the concentration of the diet (Mcal ME/kg DM)

Replacing (2) in (1) and multiplying by 1.15 to obtain the recommended 15 percent increase gives:

$$VI = [237.84\,(M/D) - 43.957\,(M/D)^2 - 223.10]\,W^{0.73} \qquad (3)$$

Equation to Estimate the Rate of Weight Gain

Gross ME Intake

The amount of the gross ME intake is given by the following equation:

$$M = I\,(M/D) \qquad (4)$$

where:

M is gross ME intake (kcal ME/day).

I is dry matter intake (gr DM/day).

The ME Requirements for Maintenance

The computational equation to estimate maintenance requirements was presented by Zulberti and Reid [7] as follows:

1/Mcal ME/kg DM is equivalent to kcal ME/gr DM.

$$Mm = [(14{,}139 - 10.36\,A + 0.0052\,A^2)\,W^{0.73} + 100\,MW]/[54.6 + 6.75(M/D)] \quad (5)$$

where:

Mm is the amount of ME needed for maintenance (kcal ME/day)

A is age (days)

MW is the amount of ME required for muscular work and thermal regulation (kcal ME/day)

The True ME of the Ration

The term "true" ME is employed here in the same sense the ARC used it [1, p. 211] and it implies a correction of the "gross" ME ingested in accordance with the feeding level. "Gross" ME is distinct from "true" ME as it represents the feed intake expressed in Mcal ME uncorrected for the decreasing biological value as the feeding level is increased.

$$M^* = M \cdot f \quad (6)$$

where:

M* is the true ME of the ration (kcal ME/day)

f is the correction factor for feeding level

The equation for the correction factor for feeding level was presented by Zulberti and Reid [7] as follows:

$$f = [0.8 + 0.418/(M/D)] + [0.11 - 0.418(M/D)](M/Mm) \quad (7)$$

Substituting equations (4) and (7) into equation (6) and simplifying, results in the following equation:

$$M^* = [0.89(M/D) + 0.418]I + [0.11(M/D) - 0.418]/[I^2(M/D)/Mm] \quad (8)$$

ME Left for Body-Weight Gain

The amount of ME left for body-weight gain is obtained by subtracting the ME energy required for maintenance from the true ME of the ration as follows:

$$Mf = M^* - Mm \quad (9)$$

where:

Mf is the ME left for body-weight gain (kcal ME/day)

ME Retained

The ME retained is obtained by multiplying the ME left for

body-weight gain by the efficiency coefficient with which ME is utilized for body-weight gain as follows:

$$S = \frac{kf}{100} M \qquad (10)$$

where:

S is the ME retained (kcal ME/day)

kf is the efficiency coefficient with which ME is utilized for body-weight gain (percent)

The equation for this efficiency coefficient [1, p. 242] is:

$$kf = 3.0 + 18.4(M/D) \qquad (11)$$

Replacing equation (9) and (11), in (10) the following equation is obtained:

$$S = [3.0 + 18.4(M/D)](M^* - Mm)/100 \qquad (12)$$

Calorific Value of the Body-Weight Gain

The equation for the calorific value of the body-weight gain was presented by Zulberti and Reid [7] as follows:

$$C = 1425 + 3.65\ W + (0.231 + 0.00011\ W)\ S \qquad (13)$$

where:

C is the calorific value of the body-weight gain (kcal ME/kg)

Replacing equation (12) in (13) the following equation is obtained:

$$C = 1425 + 3.65\ W + (0.231 + 0.00011\ W)\ [3.0 + 18.4(M/D)]\ (M^* - Mm)/100 \qquad (14)$$

The Rate of Body-Weight Gain

The rate of body-weight gain is obtained by dividing the ME retained by the calorific value of the body-weight gain as follows:

$$G = \frac{S}{C} \qquad (15)$$

where:

G is the rate of body-weight gain (kg/day)

Replacing equations (12) and (14) in (15) the following equation is obtained:

$$G = [3.0 + 18.4(M/D)](M^* - Mm)/100\ ]\ /\ [1425 + 3.65\ W + (0.231 + 0.00011\ W)[3.0 + 18.4(M/D)](M^* - Mm)/100] \qquad (16)$$

Finally, to obtain the rate of body-weight gain (G) as a function of the given values of the variables: concentration of the feed (M/D), weight of the animal (W), age (A), muscular work and thermal regulation (MW) and intake (I), equation (5) which gives the value of the ME needed for maintenance (Mm), and equation (8) which gives the value of the true ME (M*) have to be substituted in equation (16). Given that equations (5) and (8) are long equations in themselves this procedure will be avoided in sight of simplicity.

The Form of the Daily Average Product Function for Rate of Body-Weight Gain

To test the validity of assertion made in the introduction the contour of the daily total physical product function and the average physical product function for rate of body-weight gain will be presented for some values of the variables under consideration and the limitation produced by voluntary intake. The marginal physical product function will also be shown to specify the highest value of the average physical product function. (The MPP function intersects the APP function at its maximum value and indicates the value of input for which Stage I ends).

The values of the variables chosen were as follows:

For concentration of the feed three values were used

2.4, 2.8 and 3.2 Mcal ME/kg DM

For weight of the animal three values were used

200, 350, 500 kg

For age three values were used

200, 350 and 500 days,

respectively associated with the three weights.

For muscular work and thermal regulation the value 2 kcal ME per kg of weight per day was used. This is the approximate energy cost of muscular work [1, p. 221].

For intake several values were used to shape the average physical product function.

Figures 2, 3 and 4 show the results only for positive values of body-weight gain because there is no information in the ARC report to justify the use of the same function when the requirements for maintenance are not covered.

It is possible to see that the voluntary intake limits the average physical product function (efficiency) to increasing values for the three concentrations considered. The maximum value of the average physical product function (efficiency) is theoretically obtained well to the right of the voluntary intake.

Figure 2. The daily total, average, and marginal production functions and the voluntary intake limitations for cattle eating feed with an energy concentration of 2.4 Mcal ME/kg DM.

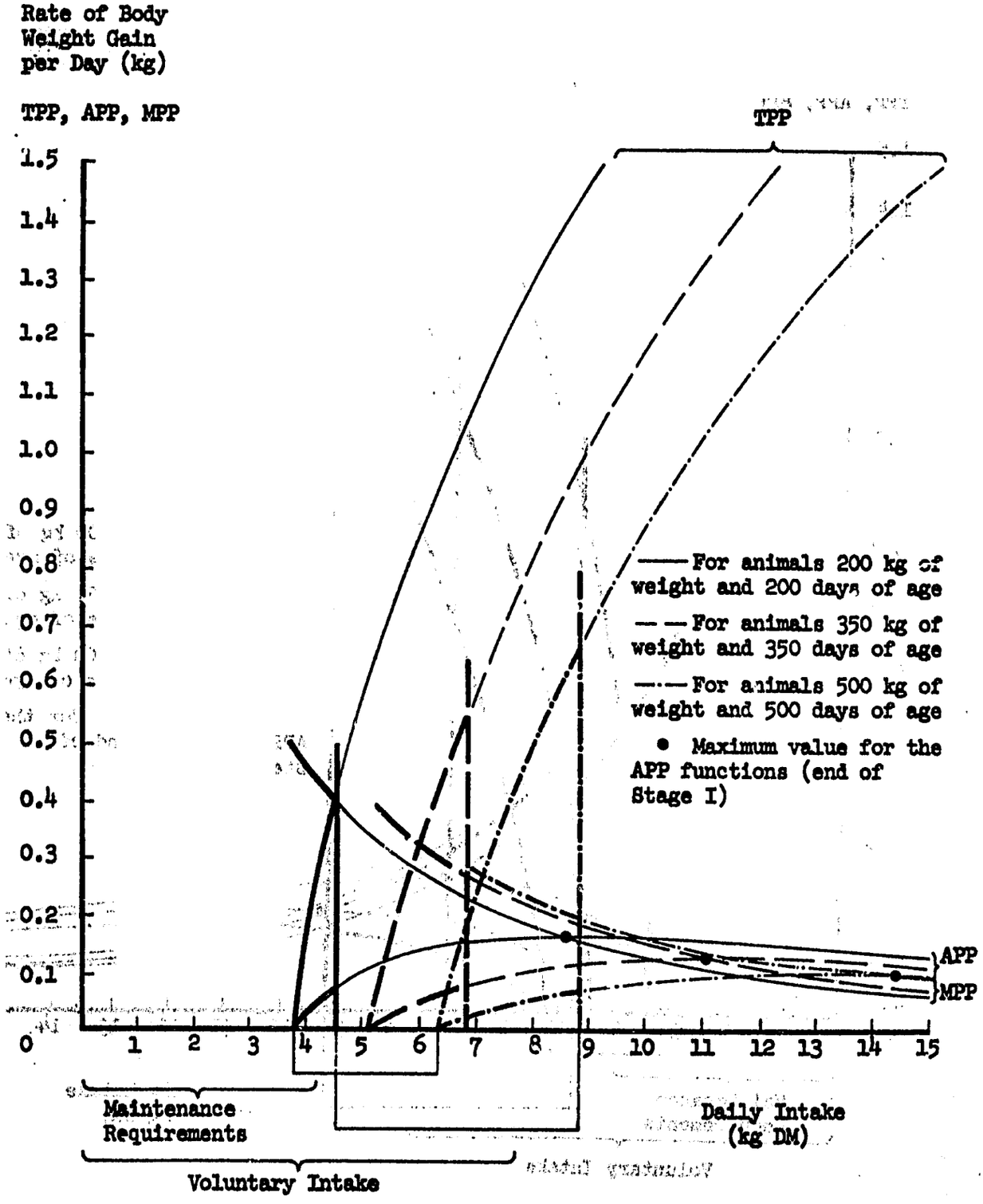


Figure 3. The daily total, average, and marginal production functions and the voluntary intake limitations for cattle eating feed with an energy concentration of 2.8 Mcal ME/kg DM.

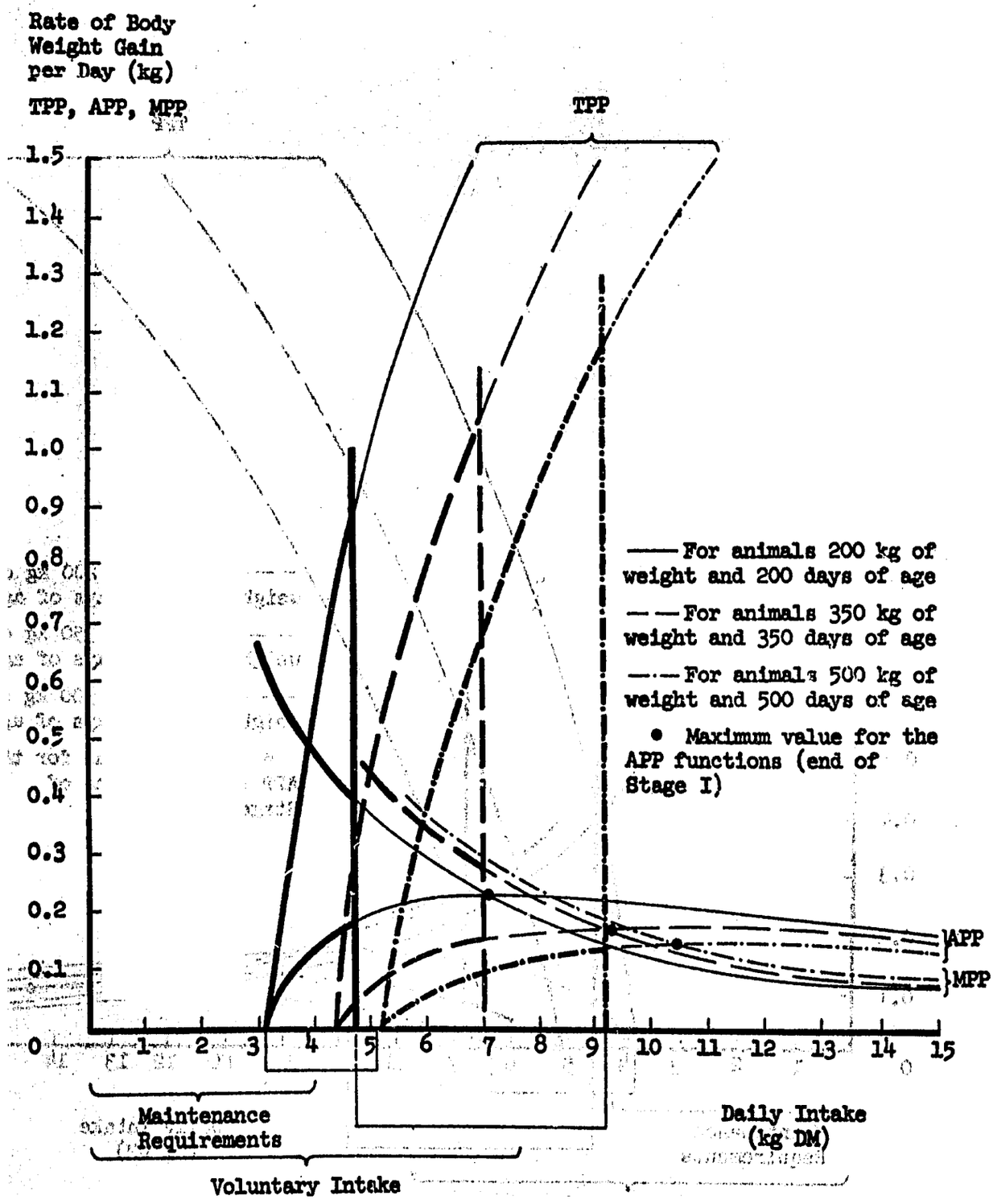
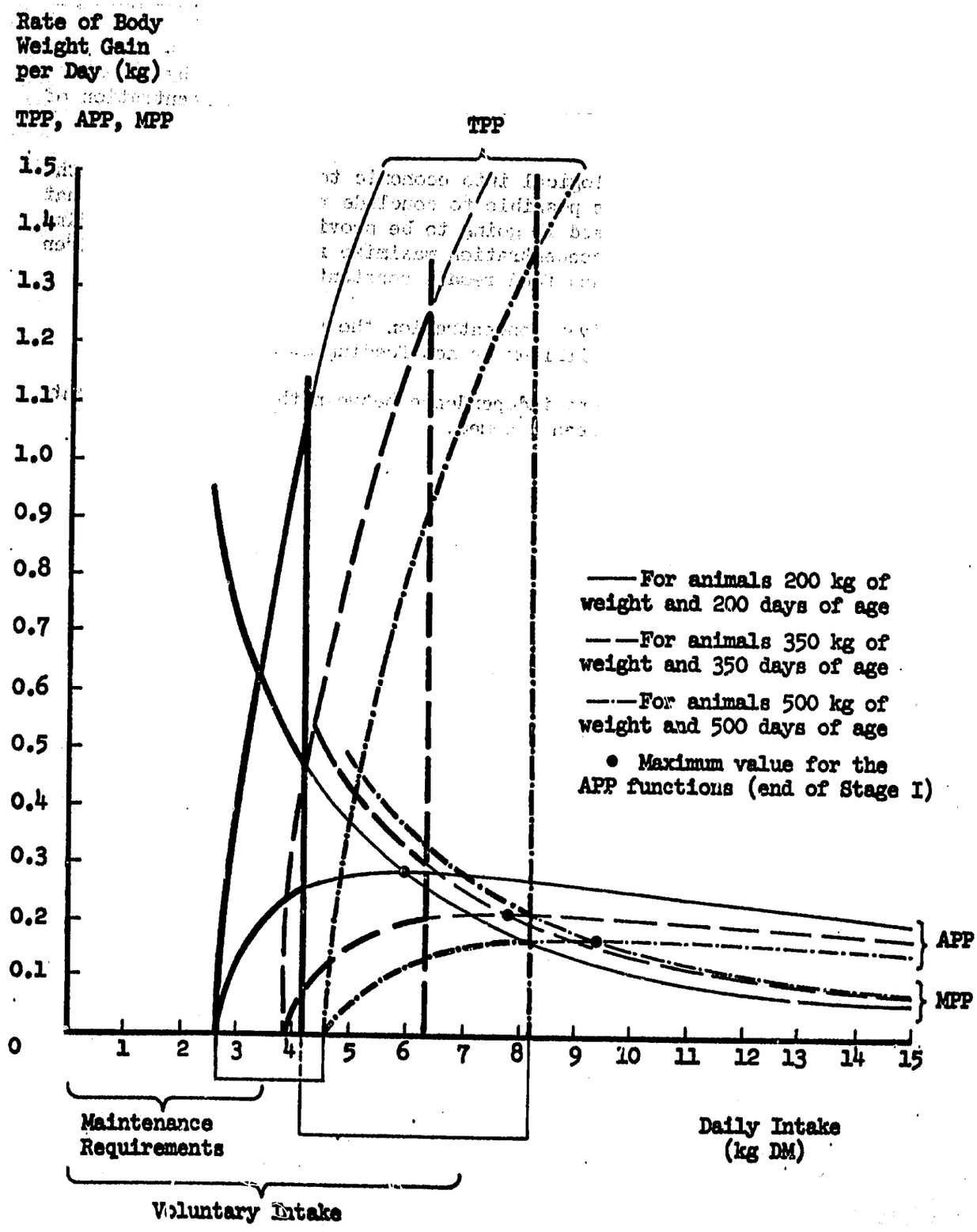


Figure 4. The daily total, average, and marginal production functions and the voluntary intake limitations for cattle eating feed with an energy concentration of 3.2 Mcal ME/kg DM.



Conclusions

Blaxter [2,3,4] and Dodsworth [6] have stated that as daily intake of feed of a given quality increases, "efficiency" (body-weight gain per kg of feed) also increases.

Using the available nutritional information supplied by the ARC report, this statement is shown to be correct for every concentration of the feed.

By translating biological into economic terminology and using the theory of production it is possible to conclude that given the fact that at least some amount of feed is going to be provided, ad libitum feeding programs of feeds of any concentration maximize returns over costs given that the price of cattle and feed remain constant.

For feeds of any given concentration the producer has only to decide between feeding ad libitum or not feeding at all.

For these conclusions independence between the daily body weight production functions has been assumed.

BIBLIOGRAPHY

[1] Agricultural Research Council. The Nutrient Requirements of Farm Animals, No. 2, Ruminants: Technical Reviews and Summaries. London: Agricultural Research Council, 1965.

[2] Blaxter, K. L. "The Efficiency of Energy Transformation in Ruminants," Energy Metabolism of Farm Animals. European Association for Animal Production, Publication No. 12, 1967.

[3] _____. "The Efficiency of Feed Conversion by Livestock," Journal of the Royal Agricultural Society of England, 125 (1964), 87-99.

[4] _____. The Energy Metabilism of Ruminants. London: Hutchinson, 1967.

[5] _____. "Utilization of the Metabolizable Energy of Grass," Proceedings of the Nutrition Society, 23 (1964), 62-71.

[6] Dodsworth, T. L. "The Feeding of Farm Animals. 2. Beef Cattle," Scottish Agriculture, 62 (Summer, 1962), 5-7.

[7] Zulberti, C. A. and Reid, J. T. "An Equation Suitable for Computer Use, Based on the ARC Feeding System to Determine the Energy Requirements of Growing and Fattening Cattle," Animal Production 14 (1972), 17-23.