A PREDICTION OF BODY WATER COMPARTMENTS OF GROWING CATTLE *IN VIVO*

J. Sekine[1], K. Fujita[2] and Y. Asahida

Animal Science Department, Faculty of Agriculture, Hokkaido University
Sapporo 060, Japan

Summary

Body water compartments *in vivo* were determined in Holstein cattle with age ranging from 5 to 521 days to obtain an equation to estimate volumes of body water. Live weight ranged from 47 to 480 kg. Compartments were determined as antipyrine space for total body water (TBW), thiocyanate space for extracellular water (ECW) and Evans blue dye space for plasma water (PW). Body water compartments expressed as a percentage of live weight decreased as age in days increased and significantly correlated with age in days. Regression analyses revealed that prediction equations had low accuracy. Regression equations of body water compartments on live weight (WT, kg) were useful for the prediction of body fluid with a high accuracy. Live weight significantly regressed on age in days (Day), which was inferred to be utilized for estimation of standardized live weight in case animals were emaciated by certain causes such as severe diarrhea or dehydration. In conclusion, following equations were presented to estimate body water compartments of cattle *in vivo*:

TBW in liters = 0.556 (± 0.007) WT + 10, r = 0.993, SE ± 0.7
ECW in liters = 0.321 (± 0.008) WT + 10, r = 0.978, SE ± 0.8
PW in liters = 0.0502 (± 0.0012) WT + 1.6, r = 0.983, SE ± 0.1
WT (kg) = 0.772 (± 0.018) Day + 24, r = 0.982, SE ± 2.3.

(**Key Words**: Cattle, Body Water, Antipyrine, Thiocyanate, Evans Blue Dye)

Introduction

To estimate energy values of the bovine body, body water concentration has been studied in relation to age in days and the fat content (Reid et al., 1955). The regression equation reported (Reid et al., 1955), however, does not satisfy to estimate body water compartments of growing cattle *in vivo*. When animals dehydrated by severe diarrhea or other causes are required for supplementation of fluid or physiological saline, it needs to estimate how much fluid to be supplemented. There has been, however, no report on the prediction of body water compartments of cattle *in vivo* with the growth of cattle under practical feeding regimens.

The present study was to determine changes in body water compartments of growing cattle *in vivo* and to obtain an equation to estimate volumes of body compartments of cattle.

Materials and Methods

Animals used in the present study were 8 Holstein castrated male calves. Feeding regimen was followed to the conventional method practiced in the second experimental form of Hokkaido University as shown in table 1. They were kept in an individual stall up to 180 days of age and thereafter moved to a stanchion stall with a free access to drinking water. Determinations of body water compartments were started when calves were at 6 days of age. Measurements were carried out at intervals of 30 days until calves grew up to about 250 kg at about 300 days of age and at intervals of 60 days, thereafter.

Solutions of antipyrine (AP), sodium thiocyanate (NaSCN) and Evans blue dye (T-1824) were used to determine compartments of total body water (TBW), extracellular water (ECW) and plasma water (PW), respectively. Autoclaved 50 ml's of 3 to 6% (w/v) AP, 3 to 6% (w/v) NaSCN and 0.5% (w/v) T-1824 were mixed and injected into the jugular vein after a blood sample was taken at about 3 to 4 hours after morning feed-

[1]Address reprint requests to Dr. J. Sekine, Dept. of Vet. Sci., Fac. of Agric., Tottori Univ., Tottori 680, Japan.

[2]Present address: Hiroshima Prefecture Livestock Experiment Station, Shobara 727, Japan.

Received July 27, 1990
Accepted November 19, 1991

ing. Animals were weighed prior to the initiation of injections and were deprived of feed and water during the period for sampling the blood. Blood samples were taken from the opposite jugular vein to the injected at intervals of 30, 60, 120 and 240 minutes after the administration of the AP, NaSCN and T-1824 solutions.

Antipyrine was determined by the method described by Brodie et al. (1949) and the analysis of SCN was made by the method of Bowler (1944) on trichloroacetic acid filtrates of plasma. The concentration of T-1824 was determined by the method described by Hix et al. (1959). Concentrations of AP, SCN and T-1824 in plasma were calculated by the extrapolation back to the time at the injection completed, and corrected for the quantities of solids in plasma for each estimation. Then, body water compartments were calculated by the following equations:

TBW = the quantity of AP injected/concentration of AP in plasma,

ECW = the quantity of SCN injected/concentration of SCN in plasma,

PW = the quantity of T-1824 injected/concentration of T-1824 in plasma.

The correlation and regression analyses were carried out by the method described by Snedecor (1966).

Results

When body water compartments were expressed as a percentage of live weight, the quantities of body water compartments decreased as age in days increased as shown in figure 1. The regression analysis revealed that changes with days of age in body water compartments were fitted with semilogarithmic equations. Total body water compartments expressed as a percent of live weight (TBW %) decreased rapidly up to the age of about 180 days and thereafter, decreased slowly to about 55% of live weight at about 500 days of age. The regression equation of TBW% (%) on age in days (Day) was calculated as follows:

TBW% (%) = 93.6 − 14.0 (±1.0) logDay, $r = -0.851$, SE ± 0.4.

TABLE 1. FEEDING REGIME FOR GROWING CATTLE[1]

Age	Milk replacer	Calf starter	Calf grower	Concentrate for fattening	Rice straw
day	kg/day				
4-6	0.4				
7-8	0.6				
9-10	0.8				
11-15	1.0	0.1			
16-20	1.0	0.2			
21-25	1.0	0.3			
26-30	1.0	0.4			
31-35	0.8	0.7			
36-40	0.6	1.0			
41-45	0.4	1.3			
46-50		1.8			
51-70		2.0			
71-90		2.5	1.0		
91-110		1.5	2.0		
111-130		1.0	2.5		
131-150		0.5	2.5		
151-300			2.5		
301 or over				2% of live weight	1% of live weight

[1] Second cutting hay was given *ad libitum* from 9 to 300 days of age.

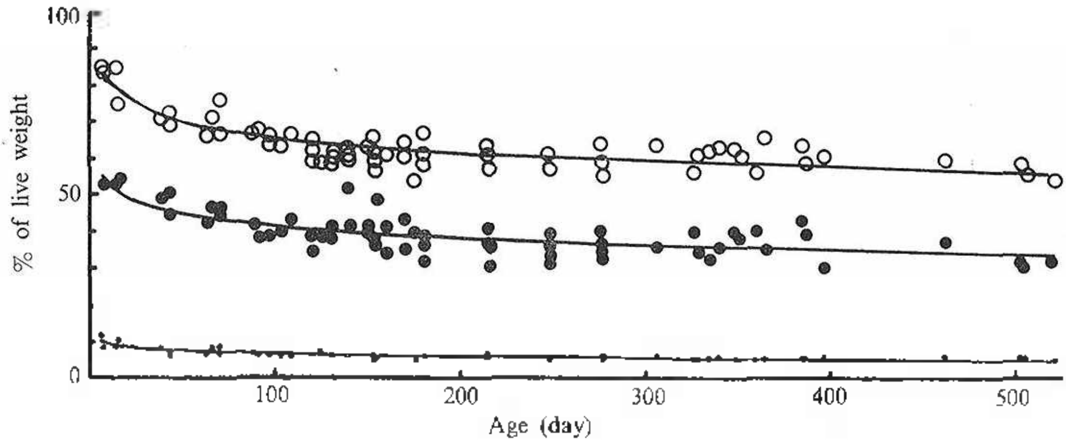

Figure 1. Charges with age (day) in compartments of total body water (○), extracelular water (●) and plasma water (•) of growing cattle expressed as percentage of live weight (Regression equations were presented in the text).

Similar patterns of changes with age in days were observed in ECW compartment expressed as a percent of live weight (ECW%) and PW compartment (PW%). The regression analyses gave following equations for corresponding compartments :

ECW% (%) = 65.0 − 11.6 (±1.1) logDay, r = −0.785, SE ±0.4,

PW% (%) = 12.4 − 2.81 (±0.23) logDay, r = −0.858, SE +0.10.

Daily depression rates of ECW% and PW% were smaller than that of TBW% and calculated to be about 83 and 20% of that of TBW%, respectively. The coefficients of determination revealed that the accuracy for the estimation of each body water compartment was statistically low for the corresponding regression equation.

Regression analyses of body water compartments in liters, therefore, were done on age in days. Calculated simple regression equations for compartments of TBW (TBW l), ECW (ECW l) and PW (PW l) were as follows :

TBW l = 0.430 (±0.011) Day+23.0, r = 0.977, SE ±1.4,

ECW l = 0.249 (+0.008) Day + 17.3, r = 0.965, SE ±1.0,

PW l = 0.038 (±0.0016) Day + 17.3, r = 0.954, SE ±0.2.

Semilogrithmic equations for corresponding compartments were obtained as follows :

logTBW l = 1.63 × 10^{-3}(+4.9×10^{-5}) Day+1.6577, r = 0.971, SE + 6.2×10^{-3},

logECW l = 1.53 × 10^{-3}(±4.9×10^{-5}) Day+1.4741, r = 0.967, SE ±6.2×10^{-3},

logPW l = 1.45 × 10^{-3}(±5.6×10^{-5}) Day+0.6888, r = 0.962, SE ±7.8×10^{-3}.

These equations had higher coefficients of determination than those of corresponding equations of body water compartments expressed as a percentage of live weight.

Figure 2 shows changes with live weight (WT, kg) in body water compartments in liters. Simple regression equations for each compartment were calculated as follows :

TBW l = 0.556(±0.007) WT + 10, r = 0.993, SE ±0.7,

ECW l = 0.321(+0.008) WT + 10, r = 0.978, SE ±0.8,

PW l = 0.0502(±0.0012) WT + 1.6, r = 0.983, SE ±0.1.

The coefficients of determination obtained for each regression equation were much higher than those obtained for the equations with the age in days.

Discussion

Results of regression analyses showed that body water compartments of growing cattle is predictable with age in days as shown by Reid et al. (1955). Estimations with the percentage of live weight in body water compartments, however, are inferred to have a low accuracy considering

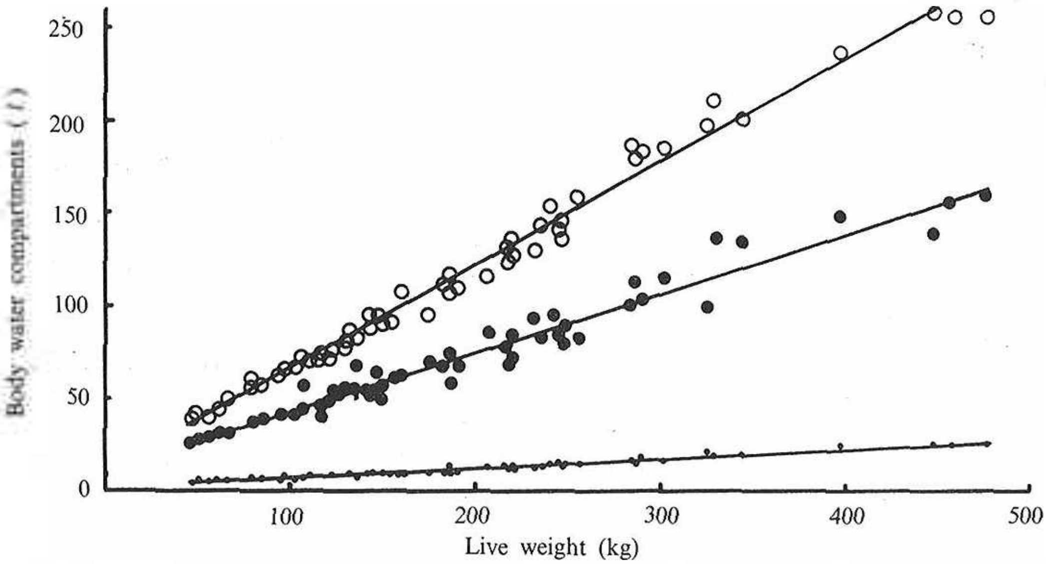

Figure 2. Changes with live weight in compartments (l) of total body water (○), extracellular water (●) and plasma water (•) of growing cattle (Regression equations were presented in the text).

with coefficients of determination for regression equations. The coefficients of determination were higher in case that body water compartments in liters regressed on age in days than those of the percentage of live weight. These equations, however, appear to fit poorly with changes in body water compartments in younger or older age of animals as shown in figure 3. Body water compartments of animals less than 100 and over 400 days of age appear to be overestimated by the semilogarithmic equations and underestimated by the simple linear equations. Therefore, the accuracy of the regression equation would be lower for the prediction of body water compart-

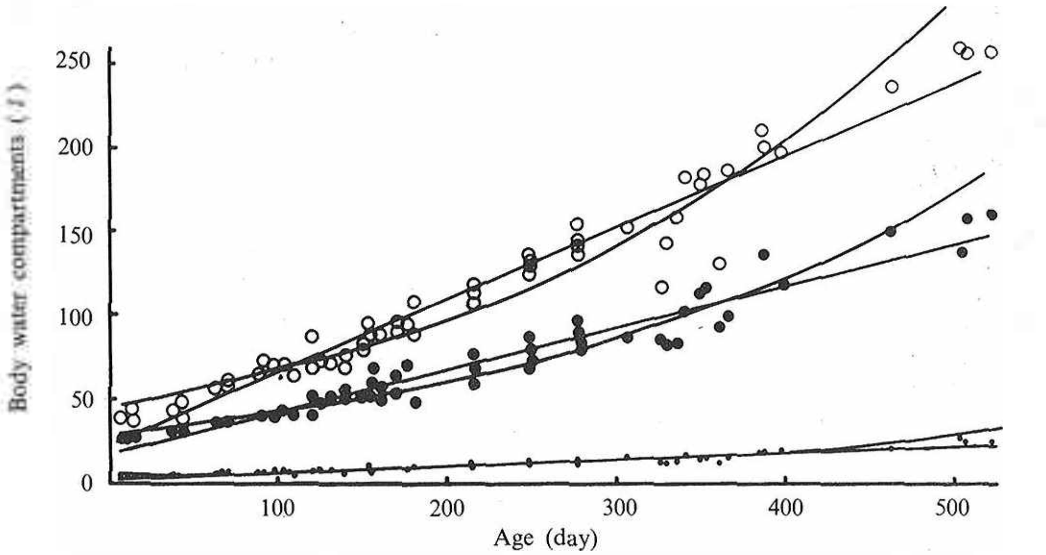

Figure 3. Changes with age (day) in compartments (l) of total body water (○), extracellular water (●) and plasma water (•) of growing cattle (Regression equations were presented in the text).

ments in younger and older animals, even though the coefficients of determination were fairly high for entire regression equations. This controversy may be caused by the diversity of live weight in a given age in days.

Regression equations on live weight had much higher coefficients of determination than those on age in days and fitted well with individual determinations irrespective of the extent of live weight (figure 2). Thus, body water compartments of cattle are inferred to be predicted by these equations with high accuracy. The prediction by live weight, however, may have a drawback because an occurrence of some disorders such as diarrhea or dehydration which may be associated with a decrease in live weight of the animal. Thus, live wight (WT, kg) regressed on age in days (Day) and the following equation was obtained :

$WT = 0.772\ (\pm 0.018)\ Day + 24,$
$r = 0.982,\ SE \pm 2.3.$

From the above equation, a standardized live weight may be predictable and in turn, body water compartments may be estimated. Multiple regression analysis of the compartments on the live weight and age in days failed to give a single equation to predict body water compartments by the live weight and the age in days, since the partial regression coefficient for the age in days showed no statistical significance.

Sekine et al. (1988) have shown that steers weighing 226 to 382 kg had 130 ml of water turnover per kg of live weight daily when they were given hay *ad libitum* with 2 kg of concentrate. Using this figure, proportion of TBW compartment turned-over were calculated to be about 22% in cattle weighing 200 to 400 kg. If amounts to be supplemented were simply determined by the difference between an estimated body water compartment and the standardized body water compartment, certain proportions of water supplemented are to be lost in urine and vaporization through the lung and skin. Therefore, a rate of water turnover may be taken into a consideration, when a cattle is required for fluid supplementation.

Above discussion leads to the conclusion that body water compartments are predictable by the regression equations on the live weight which is standardized by the equation presented in the present study in case animals are emaciated.

Literature Cited

Bowler, R. D. 1944. The determination of thiocyanate in blood serum. Biochem. J. 38:385.

Brodie, B. B., J. Axelrod, R. Soberman and B. B. Levy. 1949. The estimation of antipyrine in biological materials. J. Biol. Chem. 179:25.

Hix, E. L., G. K. L. Underbjerg and J. S. Hughes. 1959. The body fluids of ruminants and their simultaneous determination. Amer. J. Vet. Res. 20:184.

Reid, J. T., G. H. Wellington and H. O. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their application to nutritional investigations. J. Dairy Sci., 38:1344.

Sekine, J., Z. Morita and Y. Asahida. 1988. Water turnover of growing cattle fed fresh cut grass or hay and grazed on pasture. AJAS 1:163.

Snedecor, G. W. 1966. Statistical Methods, 5th ed., Iowa State Univ. Press, Ames, Iowa.