Body Measurements and Body Weights of Special-Fed Holstein Veal Calves[1]

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ABSTRACT

Changes in various body dimensions of special-fed veal calves were measured and correlated with body weight (BW) at three specific times during the growth period as contemporaries and over the entire feeding period as noncontemporaries. The calves (n = 826) were weighed and measured for body length, heart girth, wither height, and hip width at 2, 8, and 16 wk after arrival at the veal farms. Each of the four measurements, expressed as ratios to BW, decreased over the feeding period; decline in the ratio of hip width to BW was less than the decreases in the other ratios. Linear models to predict contemporary BW within each age group based on all body measurements were developed; R^2 values for models for 2, 8, and 16 wk were 0.72, 0.77, and 0.76, respectively. Within each of the three age classes, a model including linear, quadratic, and cubic terms of heart girth yielded the highest R^2 values of any single measurement (0.46, 0.63, and 0.67 for data for 2, 8, and 16 wk, respectively). The addition of heart girth as a second linear measurement to three-term models containing only one other measurement increased the R^2 more than did the addition of any other single linear expression, except for the equation based on body length. When all records on all calves were combined and the observations were treated as noncontemporaries, the R^2 was 0.97 for a linear model that included all four measurements. However, this R^2 was essentially the same as the R^2 from a three-term model using only heart girth. The cubic models in descending order of R^2 values were heart girth, body length, hip width, and wither height. These results suggest that BW can be predicted accurately in a group of noncontemporary male veal calves ranging from 2 to 16 wk after the start of the feeding period. However, the BW of calves within contemporary groups (2, 8, and 16 wk) cannot be predicted accurately according to R^2 values.
(**Key words**: special-fed calves, body measurements, veal growth rate, body weight prediction)

Abbreviation key: **BL** = body length, **HG** = heart girth, **HW** = hip width, **WH** = wither height.

INTRODUCTION

Body measurements of beef cattle are used for several purposes, including prediction of growth rate (1, 2, 4, 5), body condition, and conformation (5, 10). Body measurements of dairy cattle are also used primarily to monitor the growth of the female, to estimate contemporary weight as a part of the growth monitoring process (3, 6, 7, 11, 13, 14), and to determine nutritional requirements (9). Earlier studies (7) used cattle in production systems that limited feed intake, such as dairy replacement heifers, to develop equations to estimate BW in the absence of weighing devices. In recent studies (7), regression analyses were based on repeated measurements of noncontemporary heifers ranging in age from 1 to >800 d. The accuracy of estimating BW from measurements of contemporary Holstein veal or dairy beef bull calves has not been determined. The special-fed veal production system is based on 16 to 20 wk of high energy, liquid feeding; the growth performance of special-fed veal calves is greater than the growth performance of calves in other management systems (16). The different production systems for special-fed veal calves could cause differential growth rates and body dimension changes compared with those of beef or dairy breeds managed in more conventional production systems. Present systems to estimate BW based on heart girth (**HG**) measurements were derived from regression analyses of data obtained for cattle in production systems other than those used for special-fed veal calves. In addition, the relationship between BW and body measurements might have changed as breed types changed (6, 7), and the relative changes in the body dimensions of rapid growing veal calves may be different than those observed in dairy heifer calves. The determination of BW at

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different times during the veal feeding period would help producers assess growth performance and plan marketing schedules in the absence of scales. Therefore, the objectives of this research were 1) to determine the changes in various body dimensions during the growth period of special-fed veal and 2) to correlate these body dimensions with BW within specific times (2, 8, and 16 wk) during the growth period (as contemporaries) and over the entire veal feeding period (as noncontemporaries).

MATERIALS AND METHODS

Calves and Housing

Holstein bull calves (n = 826) were purchased from Pennsylvania livestock auctions and transported to seven cooperating veal farms (seven groups of calves). The calves were 3 to 7 d of age and averaged 50.3 kg at the auction market (purchase BW). Calves were housed in individual stalls. The floor space measured 0.6 × 1.6 m, and a divider (0.75 m in length) was placed between calves. Temperature was maintained within a range of 17 to 23°C by thermostatic control of heat and ventilation systems. The calves were weighed at 2 and 8 wk after arrival at the veal farm with a specially designed scale that allowed calves to be weighed contiguous to their stalls. The 16-wk BW was obtained at the end of the feeding period as the calves exited the barn.

Body Measurements

Data were obtained for BW, body length (**BL**), HG, hip width (**HW**), and wither height (**WH**); HG was not measured at 16 wk on one farm (n = 719). The HG was measured as the minimal circumference around the body immediately behind the front shoulder; WH was the distance from the floor beneath the calf to the top of the withers directly above the center of the shoulder; BL was the distance from the point of the shoulders to the ischium; HW was the widest point at the center of the stifle. The four body measurements were obtained on all calves at 2, 8, and 16 wk after arrival at the veal production facilities on the same day as BW was obtained. All linear measurements were obtained with specially designed aluminum calipers; HG was measured with a plastic-coated fiber tape measure similar to the HG measurement tapes available commercially. All measurement devices were in metric graduations.

Diets

Commercially available veal milk replacers were used for all groups of calves; the same source of feed was used within each of the seven groups of calves. Over all groups, the starter diets averaged 21% CP, 16% fat, 0.5% crude fiber, 8% ash, 13,646 IU/kg of vitamin A, and 3272 IU/kg of vitamin D_3. The medicated starter contained 662 g/tonne of neomycin base (from neomycin sulfate) and 331 g/tonne of oxytetracycline. Starter diets were fed until d 27 when finisher diets (16% CP, 18% fat, 0.8% crude fiber, 8% ash, 5334 IU/kg of vitamin A, and 930 IU/kg of vitamin D_3) were blended with the starter diets (d 27 through 35); finisher diets were then fed through the end of the feeding period. No medications were fed via the milk replacer after d 35. Beginning on d 27 to 35, depending on calf group, water was provided for ad libitum intake to the calves in feed buckets at approximately 1200 h. The amount of milk replacer and the amount of water used to reconstitute the milk replacer were according to the recommendations of the feed manufacturer. Additional information on the feeding and management of calves in this study was provided by Wilson et al. (16).

Statistics

Calf group was included in the analyses as a categorical covariate; therefore, the analyses were conducted on a within-group basis. The regression analysis of BW was performed using the general linear models procedure of SAS (12). Linear, quadratic, and cubic effects of the independent variables on BW were included in the following model:

$$Y_i = b_0 + b_1X_i + b_2X_i^2 + b_3X_i^3 + e_i$$

where

Y_i = BW observation i adjusted for the effects of calf group;
b_0 = intercept,
X_i = body measurement i (HG, WH, BL, or HW);
b_1, b_2, or b_3 = corresponding linear, quadratic, or cubic regression coefficients; and
e_i = residual error term i.

Several different regression analyses were conducted: 1) all four body measurements, expressed as linear functions, were combined in a BW prediction equation; 2) each body measurement was included separately in regression analyses as linear, quadratic, and cubic expressions to predict BW; and 3) the linear expression of each other measurement was then also added to the model as described previously. Each of these three regression analyses were applied to the three ages (2, 8, and 16 wk after arrival) to estimate contemporary BW. In addition, all records

TABLE 1. Mean BW (kilograms) and body measurements (centimeters) of Holstein veal calves at different ages.[1]

Age	BW			HG			WH			BL			HW		
(wk)	$\overline{X}$	SD	(no.)	$\overline{X}$	SD	(no.)	$\overline{X}$	SD	(no.)	$\overline{X}$	SD	(no.)	$\overline{X}$	SD	(no.)
2	53.1	4.21	826	86.0	3.15	826	86.7	2.53	826	72.8	3.13	826	23.7	0.96	826
8	101.0	9.36	822	106.2	4.16	822	90.5	2.78	822	87.3	3.57	822	29.9	2.01	822
16	187.9	21.55	784	132.9	4.26	719	104.9	3.18	784	106.6	6.19	784	37.0	3.76	784

[1]HG = Heart girth, WH = wither height, BL = body length, and HW = hip width. Measurements of HG at 16 wk were from six farms (n = 719); all other data were from seven farms.

were included in analyses over all calf ages. Repeated measurements on the same calves were treated as noncontemporaries. Also, to determine the change in each of the four body measurements relative to BW, the ratio of each measurement to the contemporary BW at 2, 8, and 16 wk was calculated.

RESULTS AND DISCUSSION

BW and Measurement Means

The means for BW and each body measurement at 2, 8, and 16 wk are presented in Table 1. Mean BW at the auction markets at purchase was 50.3 kg (data not presented). A 2.8-kg mean BW gain from the purchase weight obtained at the auction markets to the 2-wk BW (50.3 vs. 53.1 kg) was observed. This result indicates that, although the first 2 to 4 wk of the veal calf feeding regimen is considered to be an acclimation period, BW gain was 0.20 kg/d during the first 2 wk of the feeding period. The average daily gain from 2 to 8 wk was 1.14 kg/d per head and from 8 to 16 wk was 1.55 kg/d per head. Wilson et al. (16) reported an average daily gain from 0 to 96 d of 1.37 kg/d per head and concluded that growth performance of special-fed veal calves was greater than that of calves of similar ages in other management systems.

Each ratio of the different body measurements to BW at 2, 8, and 16 wk decreased during the growth period (Figure 1). However, the decline in the ratio of HW to BW was less than the decreases in the ratios of HG to BW, WH to BW, and BL to BW, which were similar to one another.

Regressions of Contemporary BW on Measurements

Table 2 presents the results of regression analyses, in which linear expressions of all four body measurements were used simultaneously within each age group to predict contemporary BW. The R^2 values for prediction of BW at 2, 8, and 16 wk were 0.72, 0.77, and 0.76, respectively. The R^2 values were less than anticipated, which suggested that the models did not account for enough of the variation in BW to give an accurate prediction of BW within a contemporary age group. These R^2 values, based on contemporary BW and measurements, were less than the R^2 values of >0.94 reported for repeated measurements of noncontemporary Holstein heifers (1 to >800 d of age) (7). The range and variation in measurements and BW were small in the present study when calf measurements were obtained and analyzed as contemporaries (within age group) compared with the results of an earlier study (7); this difference partially explains the differences in the observed R^2 values.

Results of regression analyses, including linear, quadratic, and cubic terms of each body measurement within each age group, and the effects of the addition of the linear expression of each other measurement (referred to as second measurement) are presented in Table 3. The coefficients presented are from regression analyses that included the linear effect of a second measurement. The R^2 values for the 2-wk measurements ranged from 0.16 (not presented) for an equation of the linear effects of WH to 0.46 when

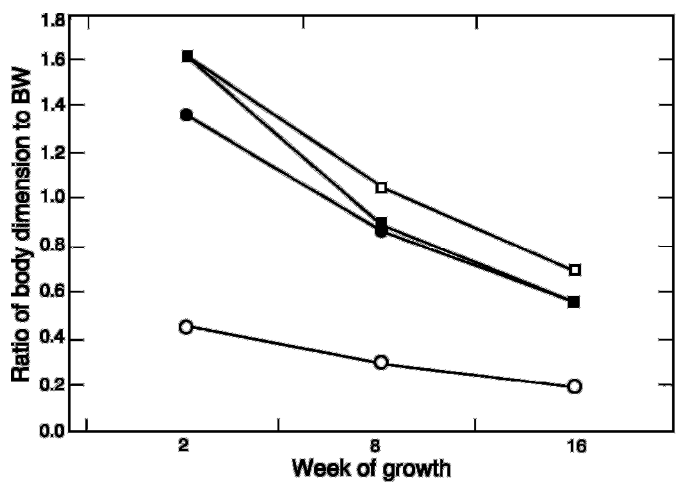

Figure 1. Ratios of body measurements (□ = heart girth, ■ = wither height, ● = body length, and ○ = hip width) (measured in centimeters) to BW (kilograms) of special-fed veal calves at 2, 8, and 16 wk during the production period.

all three effects of HG were included. The next most useful body measurement in relation to BW in the 2-wk data was HW; the R^2 value was 0.37 from a model including linear, quadratic, and cubic terms. The HG measurement increased the R^2 more (0.14 to 0.32) than did the other measurements (0.04 to 0.21) when added as a second measurement.

From the data obtained from the 8-wk-old calves, HG again yielded the highest R^2 value, 0.63. Although most of the regression coefficients for WH from the model that included all three terms were significant ($P < 0.01$), the R^2 was extremely small ($R^2 = 0.03$). The addition of BL, HG, and HW as the second linear measurements increased the R^2 values by 0.35, 0.59, and 0.18, respectively, when used in combination with equations that included all three WH terms. The HG, as a second linear measurement, was also apparently most important in the equations based on BL and HW as the first measurements. Comparison of results at 2 and 8-wk showed that the R^2 values for HG and BL increased, the R^2 value for WH declined, and the R^2 values associated with HW changed only slightly.

The results at 8 and 16 wk were similar except that the R^2 values associated with WH were higher in the 16-wk (0.03 vs. 0.26). The R^2 values for BL at 16 wk were similar to those at 8 wk. Use of HG as the second measurement (linear expression) in combination with equations based on WH and HW increased the R^2 more (0.42 and 0.22, respectively) than did the use of other parameters as the second measurement. The R^2 values for equations based on linear, quadratic, and cubic expressions of HG, WH, BL, and WH were 0.67, 0.26, 0.40, and 0.45, respectively. The increased predictive value of most of the body measurements from 2 to 16 wk was probably due to the greater variation in BW and in most measurements of the older calves compared with those of younger calves, as was evidenced by the higher standard deviations (Table 1).

Several researchers (3, 8, 15), using different types of cattle or calves, also concluded that HG was more highly correlated with BW than were other body measurements; the results of this study are in agreement with the results of those earlier reports. Higher R^2 values for models that contained linear, quadratic, and cubic expressions of HG, WH, HW, and BL of 0.99, 0.96, 0.98, and 0.96, respectively, were obtained from data on Holstein heifers varying in age from 1 to >800 d (7).

Regression of BW on Body Measurements over all Ages

Regressions of BW over all ages (2, 8, and 16 wk; considering the calves as noncontemporaries) on the linear expressions of HG, WH, BL, and HW resulted in R^2 values of 0.95, 0.69, 0.90, and 0.83, respectively (data not presented). Corresponding R^2 values for three-term models based on HG, WH, BL, or HW were 0.97, 0.73, 0.93, and 0.88, respectively (Table 4). Therefore, because measuring HG was much easier than obtaining all four measurements on each calf, the equations containing only HG seem to be the most efficient and effective. These results are in general agreement with earlier studies (3, 8, 15) indicating that HG was the most useful and reliable body measurement in the prediction of BW. For the other three measurements, BL yielded the highest R^2 values (0.93), and WH yielded the lowest R^2 values (0.73); HW was intermediate ($R^2 = 0.88$) for the three-term models (data not presented.)

Table 4 presents the results of the addition of a single linear measurement to equations based on linear, quadratic, and cubic terms of each of the four measurements, combining data over 2, 8, and 16 wk. The regression coefficients presented are from analyses that included the linear effect of the second measurement. The addition of BL, HW, or WH as a second measurement to a three-term equation based

TABLE 2. Regression of BW of Holstein veal calves on the linear effects of body measurements at different ages.[1]

Age	no.	Intercept	HG[2]	WH	BL	HW	R^2
(wk)							
2	826	–58.36**	0.602**	0.044	0.319**	1.307**	0.72
8	822	–132.99**	1.160**	0.378**	0.776**	0.669**	0.77
16	784	–285.23**	1.881**	0.808**	0.515**	2.483**	0.76

[1]HG = Heart girth, WH = wither height, BL = body length, and HW = hip width. Calf group was included in the analyses and was significant ($P < 0.05$).

[2]Measurements of HG at 16 wk were from six farms (n = 719); all other data were from seven farms.

$^{**}P < 0.01$.

on HG increased the R^2 value only 0.01. Therefore, none of the linear expressions added to the cubic model that contained HG appreciably increased the R^2 values. However, the addition of any second linear expression of BL, HG, or HW to a cubic model based on WH resulted in an increase in the R^2 value ranging from 0.18 when HW was added to 0.24 when HG was added. The addition of HG as a linear effect to a three-term equation of WH, BL, and HW increased R^2 values by 0.24, 0.06, and 0.10, respectively; these increases were greater than the increases in R^2 caused by the addition of any other measurement as a linear function.

CONCLUSIONS

The BW of Holstein veal calves can be predicted accurately based on R^2 values over a range of ages

TABLE 3. Regression of BW of Holstein veal calves on one body measurement and the linear effect of an additional measurement.[1,2]

Age and first measurement	Second measurement	Intercept	Effect of first measurement			R^2 from First measurement	Linear effect of second measurement	Addition to R^2 from second measurement
			Linear	Quadratic	Cubic			
2 wk								
HG	BL	734.52**	–26.766**	0.32532**	–0.001277**	0.46	0.359**	0.05
	HW	634.61**	–23.307**	0.28276**	0.001108**	0.46	1.443**	0.07
	WH	836.96**	–30.972**	0.37377**	–0.001456**	0.46**	0.446**	0.11
WH	BL	–4359.88**	152.808**	–1.78157**	0.006921**	0.22	0.589**	0.13
	HG	–2695.02**	91.581**	–1.04792**	0.004006**	0.22	0.835**	0.32
	HW	–3791.42**	132.473**	–1.54475**	0.006003**	0.22	2.320**	0.21
BL	HW	–116.49	5.918	–0.10133	0.000581	0.27	2.046**	0.16
	HG	–347.02	14.858	–0.22042	0.001110	0.27	0.666**	0.20
	WH	–572.95	25.739	–0.37707	0.001870	0.27	0.303**	0.05
HW	BL	940.99**	–116.004**	4.77063**	–0.063936**	0.37	0.412**	0.05
	HG	1000.46**	–124.615**	5.09127**	–0.068110**	0.37	0.587**	0.14
	WH	673.24*	–85.109*	3.60600*	–0.049298*	0.37	0.281**	0.04
8 wk								
HG	BL	1704.00**	–51.118**	0.50408**	–0.001607**	0.63	0.716**	0.04
	HW	2365.30**	–69.793**	0.68966**	–0.022129**	0.63	0.615**	0.01
	WH	2693.77**	–79.655**	0.78709**	–0.002529**	0.63	0.204**	0.01
WH	BL	–4034.25*	130.887*	–1.435*	0.005229*	0.03	1.791**	0.35
	HG	–1760.45	54.218	–0.58123	0.002076	0.03	1.649**	0.59
	HW	–10,226.74**	341.107**	–3.77715**	0.013914**	0.03	2.482**	0.18
BL	HW	–1288.75	43.277	–0.48129	0.001847	0.37	1.413**	0.06
	HG	–617.48	18.278	–0.20214	0.000775	0.37	1.355**	0.29
	WH	–1550.06*	53.041*	–0.58550	0.002223	0.37	–0.030	0.00
HW	BL	–324.85**	19.437*	–0.37346	0.001987	0.33	1.341**	0.16
	HG	–253.29**	13.841*	–0.29368	0.001868	0.33	1.416**	0.32
	WH	–358.39**	30.291**	–0.59214*	0.003237	0.33	–0.100	0.07
16 wk								
HG	BL	7813.79**	–193.471**	1.58867**	–0.004273**	0.67	0.596**	0.02
	HW	6732.92**	–167.154**	1.38061**	–0.003729**	0.67	1.247**	0.02
	WH	7703.92**	–191.238**	1.57814**	–0.004260**	0.67	0.323**	0.02
WH	BL	–3238.92**	88.060**	–0.80317**	0.002484**	0.26	1.366**	0.12
	HW	6663.31**	–200.587**	2.00497**	–0.006607**	0.26	3.235**	0.18
	HG	1389.83	–42.506	0.45160	–0.001504	0.26	0.046	0.42
BL	HW	267.25**	–16.892**	0.25274**	–0.001031	0.40	2.561**	0.16
	HG	427.19**	–24.223**	0.36230**	–0.001470**	0.40	0.017	0.04
	WH	170.33**	–12.166**	0.16560**	–0.000616**	0.40	1.570**	0.08
HW	BL	–489.92**	31.772**	–0.54645**	0.002868**	0.45	0.973**	0.06
	HG	–408.40	28.908	–0.37510	0.000715	0.45	0.033**	0.22
	WH	–623.50**	38.529**	–0.67047**	0.003441**	0.45	1.165**	0.04

[1]HG = Heart girth, WH = wither height, BL = body length, and HW = hip width. Farm was included in the analyses and was significant ($P < 0.05$).

[2]Measurements of HG at 16 wk were collected from six farms; all other data were collected from seven farms; n = 826 for 2-wk data, n = 822 for 8-wk data, and n = 784 for 16-wk data, with the exception of HG data (n = 719).

*$P < 0.05$.

**$P < 0.01$.

TABLE 4. Regression of BW of Holstein veal calves over all ages (2, 8, and 16 wk) on one body measurement and the linear effects of an additional measurement.[1,2]

First measurement	Second measurement	Intercept	Effect of first measurement			R^2 from First measurement	Linear effect of second measurement	Addition to R^2 from second measurement
			Linear	Quadratic	Cubic			
HG	BL	750.03**	–23.103**	0.21709**	–0.000606**	0.97	0.8979**	0.01
	HW	1039.03**	–30.717**	0.28894**	–0.000820**	0.97	1.7019**	0.00
	WH	808.49**	–25.925**	0.25129**	–0.000725**	0.97	0.8498**	0.01
WH	BL	–762.41**	17.117**	–0.17385**	0.000642**	0.73	2.9383**	0.20
	HG	1456.42**	–52.152**	0.54848**	–0.001863**	0.73	2.3776**	0.24
	HW	5511.60**	–182.457**	1.94561**	–0.006787**	0.73	6.1791**	0.18
BL	HW	–180.09**	0.812	0.69724**	–0.004934**	0.93	2.3865**	0.00
	HG	539.30**	–67.165**	2.10627**	–0.020792**	0.93	2.2847**	0.06
	WH	–459.53**	17.964**	–0.21781**	0.000757**	0.93	2.1405**	0.02
HW	BL	225.67**	–10.615**	0.12962**	–0.000402**	0.88	2.6078**	0.07
	HG	–2.85**	–3.139**	0.18931*	0.000042	0.88	1.9246**	0.10
	WH	267.17**	–14.988**	0.19436**	–0.000648**	0.88	1.1865**	0.07

[1]HG = Heart girth, WH = wither height, BL = body length, and HW = hip width. Farm was included in the analyses as a covariate and was significant ($P < 0.05$).

[2]Measurements of HG at 16 wk were from six farms (n = 719); all other data were from seven farms.

*$P < 0.05$.

**$P < 0.01$.

from approximately 2 to 16 wk. The linear, quadratic, and cubic expressions of HG are the most useful. When any of the other three measurements (BL, HW, or WH) were used in models that contained linear, quadratic, and cubic terms, HG generally made the most important contribution compared with other body dimensions when added as second measurements (linear expression). Although BW cannot be predicted accurately by body measurements within contemporary groups of calves, calf BW can be estimated quite accurately based on the R^2 values in calves ranging in age from 2 to 16 wk.

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REFERENCES

1 Brody, S. 1945. Bioenergetics and Growth. Reinhold Publ. Corp., New York, NY.
2 Brown, C. J., J. E. Brown, and W. T. Butts. 1973. Evaluating relationships among immature measures of size, shape and performance of beef bulls. 2. The relationships between immature measures of size, shape and feedlot traits in young beef bulls. J. Anim. Sci. 36:1021.
3 Davis, H. P., W. W. Swett, and W. R. Harvey. 1961. Relation of heart girth to weight in Holsteins and Jerseys. Nebraska Agric. Exp. Stn. Res. Bull. 194, Univ. Nebraska, Lincoln.
4 Doren, P. E., J. F. Baker, C. R. Long, and T. C. Cartwright. 1989. Estimating parameters of growth curves of bulls. J. Anim. Sci. 67:1432.
5 Flock, D. K., R. C. Carter, and B. M. Priode. 1962. Linear body measurements and other birth observations on beef calves as predictors of preweaning growth rate and weaning type score. J. Anim. Sci. 21:651.
6 Heinrichs, A. J., and G. L. Hargrove. 1987. Standards of weight and height for Holstein heifers. J. Dairy Sci. 70:653.
7 Heinrichs, A. J., G. W. Rogers, and J. B. Cooper. 1992. Predicting body weight and wither height in Holstein heifers using body measurements. J. Dairy Sci. 75:3576.
8 Johansson, I., and S. G. Hildeman. 1954. The relationship between certain body measurements and live and slaughter weight in cattle. Anim. Breed Abstr. 22:1.
9 National Research Council. 1989. Nutrient Requirements of Dairy Cattle. 6th rev. ed. Natl. Acad. Sci., Washington, DC.
10 Nelsen, T. C., R. E. Short, W. L. Reynolds, and J. J. Urick. 1985. Palpated and visually assigned condition scores compared with weight, height, and heart girth in Hereford and crossbred cows. J. Anim. Sci. 60:363.
11 Raymond, A. K., P. F. Cheac, and A. S. Borham. 1982. Relationship between body weight and heart girth in cross bred cattle. Malaysian Agric. J. 53:299.
12 SAS® User's Guide: Statistics, Version 6, 4th Edition. 1990. SAS Inst., Inc., Cary, NC.
13 Swanson, E. W. 1960. Effect of rapid growth with fattening of dairy heifers on their lactational ability. J. Dairy Sci. 43:377.
14 Swanson, E. W. 1967. Optimum growth patterns for dairy cattle. J. Dairy Sci. 50:244.
15 Verma, D. N., and K. Q. Hussein. 1985. The estimation of the body weight of calves from heart girth measurements. Indian Vet. Med. J. 9:112.
16 Wilson, L. L., C. L. Egan, and T. R. Drake. 1994. Blood, growth, and other characteristics of special-fed veal calves in private cooperator herds. J. Dairy Sci. 77:2477.