Pak. j. life soc. Sci. (2016), 14(2): 77-82 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

RESEARCH ARTICLE

Heritability, Genetic and Phenotypic Correlations of Body Capacity Traits with Milk Yield in Sahiwal Cows of Pakistan

Musarrat Abbas Khan[1,*] and Muhammad Sajjad Khan[2]

[1]Department of Livestock Production and Management, University College of Veterinary and Animal Sciences, The Islamia University of Bahawalpur, Bahawalpur, Pakistan

[2]Institute of Animal Science, University of Agriculture, Faisalabad, Pakistan

ARTICLE INFO

Received:	Jan 26, 2016
Accepted:	Jul 15, 2016
Online:	Jul 18, 2016

Keywords

Body capacity traits

Genetic parameters

Milk yield

Sahiwal cows

***Corresponding Author:**

drmusarratabbas@yahoo.com

ABSTRACT

The present study was conducted to estimate heritability and genetic and phenotypic correlations between body measurement traits and milk yield in Sahiwal cows. The body measurements and milk yield records of 310 cows were utilized. The model included fixed effects of herd, parity and stage of lactation. The herd and parity was a significant source of variation for heart girth (HG), paunch girth (PG), chest depth (CD), body depth (BD), top wedge area (TWA), front wedge area (FWA), side wedge area (SWA) and sprung at 6^{th} rib (S6R) ($P<0.001$). Stage of lactation was a significant source of variation for HG, PG, BD and SWA ($P<0.001$). The linear and quadratic effects of age of cows were significant for FWA and SWA ($P<0.001$) and for sprung at last rib (SLR), PG, BD ($P<0.01$) and CD ($P<0.05$). The least squares means and standard deviations (mean±SD) for HG, PG, CD, BD, S6R, SLR, TWA, FWA and SWA were 158.7±21.39, 244.5±29.70, 65.3±3.40, 68.1±3.93, 39.8±3.71, 56.7±5.35, 1429.5±153.57, 814.5±99.97 and 2232.4±279.2 cm^2, respectively. The heritability estimates for HG, PG, CD, BD, S6R, SLR, TWA, FWA and SWA were 0.84±0.02, 0.75±0.02, 0.66±0.03, 0.69±0.03, 0.70±0.03, 0.63±0.03, 0.82±0.02, 0.76±0.02 and 0.70±0.03, respectively. The HG had the highest genetic correlation with measurement day milk yield (0.29±0.00) and 305-day milk yield (0.22±0.00). All the traits were found highly heritable and could be improved through selection. The genetic correlation between some traits and milk yield was positive and considerable, so a correlated response in milk yield could result when selecting Sahiwal cows for body capacity traits.

INTRODUCTION

Since the beginning of domestication it has been the concern of human beings to keep those animals that are useful for them. For this reason man has been interested to the morphology of the animals and other body characteristics that has some relation with traits of economic importance. The apparent body capacity of the animal is believed to have some relation with milk yield traits. A body measurement may serve to quantify a change in some performance traits of animals. The barrel of the animal is the main part of the animal body that presents the capacity traits. The traits may include heart girth, paunch girth, chest depth, body depth and wedge shape of the animal. The long term recording needs of the traits of economic importance has led to focus on ancillary traits which can be measured more easily and have some relation with performance traits. A study on Holstein dairy cows with data set including 1898 lactation records and body measurement records reported that cows with smaller heart girth and larger paunch girth had significantly higher yield (Sieber et al., 1988). Side wedge and body length were reported better predictor of milk yield in crossbred heifers (Patel and Tomar, 1990). Mirza et al. (2015) has reported a positive genetic correlation of hearth girth with milk yield in Nili-Ravi Buffaloes. Angularity (Wedge shape) has been reported to be the most important trait to have genetic correlation with production traits (Meyer et al., 1987; Vollema and Groen, 1997, Visscher and Goddard, 1995; Brotherstone, 1994; Misztal et al., 1992; Harris et al., 1992; DeGroot et al., 2002) and (Cruickshank et al., 2002). Physical characterization and body measurements have been reported for Krishna valley cattle in India (Karthickeyan et al., 2006), North Bengal Grey cattle of Bangladesh (Al-Amin et al., 2007), Deshi cattle of West Bengal (Sarkar et al., 2007), crossbred strains of cattle (Mitra et al., 1993) and Holsteins (Vinson et al., 1982). Side wedge has been reported better predictor of milk yield in crossbred heifers (Patel and Tomar, 1990). The body capacity traits could be improved through selection because they are reported heritable in medium to high range. A few studies have reported heritability for body capacity associated traits in high range. The high heritability estimates for chest depth (0.80) and for hearth girth (0.61) have been reported for Holstein cows (Touchberry, 1951). The heritability estimates for heart girth for Holstein, Brown Swiss and Red and White cattle ranged from 0.35±0.02 to 0.38±0.02 with huge data sets in Switzerland (de Haas et al., 2007). The heritability estimate for heart girth was 0.34±0.09 for Holstein in Canada (Lin et al., 1987). The heritability estimate for heart girth was 0.33 and for body depth 0.43 in a data set on Holstein in Netherland (Koenen and Groen, 1998). Multi-trait estimates of heritability and correlations between body measurements and milk production traits for Holsteins have been reported (Lin et al., 1987).

The magnitude of heritability estimates indicates that these traits could be improved in desired direction through selection. The genetic and phenotypic correlations between body capacity traits and milk yield have been reported in low to medium range. The information on the body capacity associated traits that could be used for selection as an aid to other phenotypic performance traits and their genetic control is scarce on Sahiwal cattle. Therefore, the present study was designed to collect information on body measurements, to estimate genetic control of such measurements and to measure their association with milk yield in Sahiwal cattle.

MATERIALS AND METHODS

The freshly calved cows from three Government livestock farms of Punjab province namely Livestock Experiment Station Bahadurnagar, District Okara (LESB), Livestock Experiment Station, Jahangirabad, District Khanewal (LESJ) and Livestock Experiment Station, Khizerabad, District Sargodha (LESK) were selected. Cows with parity up to fifth were included in the study. The measurements were made for heart girth (HG), paunch, girth (PG), chest depth (CD), body depth (BD), sprung at sixth rib (S6thR) and sprung at last rib (SLR). All body measurements were recorded while cows standing with squarely placed four legs and neck raised at normal position.

The heart girth and paunch girth were measured as per (Touchberry and Lush, 1950). The heart girth was measured just behind the fore legs and paunch girth at about last rib position. Chest depth was the vertical distance from the back to the floor of the chest at the smallest part of the chest and body depth was the vertical distance at deepest point of the barrel at last rib position.

The measurements were made with locally manufactured calipers and measuring tape. The measurements were recorded to nearest one centimeter. Some of the variables were created from different body measurements. The top wedge area (TWA) area of triangle formed by wither and hook bones at right and left, front wedge area (FWA) area of triangle formed by point of shoulders on right and left side of animal and withers on the top and side wedge area (SWA) area of triangle formed by three points i.e point of shoulder, hook bone and base of udder were also measured and calculated. Milk yield recorded on and around the day of measurement was called measurement day-yield (average of three days yield near the day of measurement i.e a day before the day of measurement, on the day of measurement and after the day of measurement) while milk yield during that lactation from calving to 305-days (on date of drying if it was before 305-days) was called 305-day milk yield.

The statistical model for studying the effect of various sources of variation in any measured trait included herd, parity and stages of lactation. The linear and quadratic effect of age at measurement was fitted as co-variable. Animal was fitted as random. Stage of lactation effects study was not logical for all the traits. Traits for which there were expectations for meaningful outcome of information were studied as regards stage of lactation effects. Stage of lactation effects were studied for heart girth (HG), paunch girth (PG), body depth (BD) and side wedge area (SWA). Univariate animal model was fitted for estimation of heritabilities for the traits. The genetic and phenotypic correlations were estimated in bivariate analyses. For estimation of genetic and phenotypic correlations between body measurements and milk yield, measurements recorded at first stage of lactation were utilized and stage of lactation was excluded from the model. Following was the model whose different combinations were used for various traits

$$Y_{ijklm} = \mu + H_i + P_j + L_k + b_1(a_{ijklm}) + b_2(a_{ijklm})^2 + A_l + e_{ijklm}$$

Where

Y_{ijklm} = a measurement trait of an animal

μ = overall mean

H_i = effect of i^{th} herd (1-3)

P_j = effect of j^{th} parity (1-2)

L_k = effect of L^{th} stage of lactation

A_l = random animal effect with mean zero and variance σ^2A

a_{ijklm} = age at classification with b_1 and b_2 being the linear and quadratic regression coefficients of traits on age at measurement
e_{ijklm} = random error
The analysis was performed using ASREML version 2.0 computer software (Gilmour et al., 2007).

RESULTS

The herd and parity were significant source of variation for, HG, PG, CD, BD, TWA, FWA, SWA and S6R (P<0.001). The herd affected SLR (P<0.01and parity affected SLR (P<0.001). Stage of lactation was a significant source of variation for HG, PG, BD and SWA, (P<0.001). The linear and quadratic effects of age of cows affected PG, BD and SLR (P<0.01).and FWA and SWA (P<0.001).

Descriptive statistics for body capacity traits

The descriptive statistics for body measurements are presented in Table 1. The coefficient of variation ranged from 5.2% for chest depth to 13.5% for heart girth. The least square means and standard deviations for heart girth, paunch girth, chest depth, body depth, sprung at sixth rib, sprung at last rib and top wedge area, front wedge area and side wedge area were 158.7±21.39, 244.5±29.74, 65.3±3.40, 68.1±3.93, 39.8±3.71, 56.7±5.35 cm and 1429.5±153.57, 814.5±99.97 and 2232.4±279.2 cm^2, respectively. The sprung of ribs increase from 6^{th} rib position to last rib position. It gave a wedge shape appearance to cows.

Heritability estimates for body capacity traits

The heritability estimates and standard errors along with phenotypic and genetic variances for body measurements are presented in Table 2. The heritability estimates fall in medium to high range. The highest heritability estimate was for HG 0.84±0.02 followed by TWA 0.82±0.02 and FWA 0.76±0.02. The heritability estimates more than or equal to 0.70 were for PG, SWA and S6R. The heritability estimates for CD, BD and SLR were 0.66±0.03, 0.69±0.03 and 0.63±0.03, respectively.

Genetic and phenotypic correlations between body capacity traits and milk yield

The genetic and phenotypic correlations between body measurements and milk yield traits are presented in Table 3. Only the paunch girth (PG) has a notable phenotypic correlation of magnitude 0.18±0.06 with measurement day yield. The highest genetic correlation of magnitude 0.29±0.00 was of heart girth (HG) with measurement day yield. The HG, PG, CD, BD, S6R and FWA had a genetic correlation of magnitude greater than or equal to 0.20 with measurement day milk yield. The HG and PG, had a genetic correlation of magnitude more than or equal to 0.20 with 305-day milk yield. All other genetic correlations were in low range and negligible.

DISCUSSION

Means for chest depth (65.3 cm) in present study were lower than reported for Holsteins (Vinson et al., 1982). The mean heart girth 202.5±9.91 cm for Canadian Holstein (Ali et al., 1984) was higher than means for Sahiwal in present study. Hearth girth in present study was lower than reported for Holsteins 189.3 cm (Bayram et al., 2006), 194.8 cm (Sieber et al., 1988) and 179.8 cm (Bonczek et al., 1992). The paunch girth for Sahiwal in present study was higher than 230.3 cm reported for Holsteins (Sieber et al., 1988). The mean chest depth 65.9 cm (Bayram et al., 2006) was comparable and 71.3 cm (Bonczek et al., 1992), 74.4 cm (Sieber et al., 1988) and 87.1 cm (Lucas et al., 1984) for Holsteins were higher than current study. Most of the reported literature on body measurements pertains to temperate cattle. The body measurements vary and could not be compared across breeds because of breed differences. However, this new information regarding body measurements will be helpful for future planning and devising a selection program for Sahiwal cattle.

Genetic parameters

The heritabilities for most of the traits were higher than those reported for other breeds. Smaller data set may be a probable cause. Also, measurements were recorded by a single person over a stipulated period and cows belonged to experimental stations. That could reduce environmental component of variance. However, higher heritability estimates are indicative of possibility of bringing a rapid change in these traits in desired

Table 1: The means, minimum, maximum and coefficient of variation (CV %) for body capacity traits

Trait	N	Minimum	Maximum	Mean	Standard Deviation	CV (%)
Heart Girth (cm)	790	99.1	223.5	158.7	21.39	13.5
Paunch Girth (cm)	790	152.4	340.4	244.5	29.7	12.2
Chest Depth (cm)	790	52	76	65.3	3.40	5.2
Body Depth (cm)	790	56	79	68.1	3.93	5.8
Sprung at 6^{th} Rib (cm)	790	29	51	39.8	3.71	9.3
Sprung at last Rib (cm)	790	37	71	56.7	5.35	9.4
Top Wedge Area (cm^2)	790	989	1989	1429.5	153.57	10.7
Front Wedge area (cm^2)	790	546	1123	814.5	99.97	12.3
Side Wedge Area (cm^2)	790	1332	3093	2232.4	279.20	12.5

Table 2: Heritability (h^2) estimates and standard errors of body capacity traits

Traits	Phenotypic variance	Genetic variance	h^2±SE
Hearth Girth	53.99	45.4	0.84±0.02
Paunch Girth	119.6	89.73	0.75±0.02
Chest Depth	9.192	6.087	0.66±0.03
Body Depth	13.11	9.077	0.69±0.03
Sprung at 6th Rib	11.17	7.81	0.70±0.03
Sprung at last Rib	28.19	17.89	0.63±0.03
Top Wedge Area	21390	17530	0.82±0.02
Front Wedge Area	7144	5432	0.76±0.02
Side Wedge Area	59290	41520	0.70±0.03

direction. Sire model ignore females relationships resulting in lower heritability estimates as compared to animal model estimates. Current heritability estimates were calculated using animal model while Sire Model under estimates genetic variability resulting in poor estimates for genetic parameters (Misztal, 1990). So this might have contributed to high heritability estimates in current study. For most of time classifier introduces variation resulting in increased environmental variance and reduced additive variance (Vij et al., 1990; Norman et al., 1983). That results in low heritability estimates. In current study there was only one classifier. So this might have resulted in decreased environmental portion. Resultantly increased heritability estimates. The heritability estimates for heart girth in current study were higher than reported 0.61 (Touchberry, 1951) for US Holstein, 0.38±0.02 (de-Haas et al., 2007) for Holstein in Switzerland, 0.34±0.09 (Lin et al., 1987) for Holstein in Canada and 0.33 (Koenen and Groen, 1998) for Holstein in Netherland. The heritability estimate (0.41±0.07) for chest depth of first lactation Holsteins estimated by paternal sister procedure were lower than current study (Brum and Ludwick, 1969). Higher than current study heritability estimate for chest depth (0.80) for Holstein in USA were reported (Touchberry, 1951). The heritability estimates for heart girth 0.27 (Ali et al., 1984) estimated by paternal half sibs correlation was lower than found in present study. The heritability estimate 0.27 for paunch girth of Iraqi buffalo (Jaayid et al., 2011) was lower than current study estimate.

The genetic and phenotypic correlations for most of body measurements and milk yield traits in current study were in low to medium range but positive. The magnitude of the genetic correlation of heart girth, paunch girth, chest depth and body depth with measurement day yield indicates that selecting Sahiwal cows for deeper chest and body will result an increase in milk production of Sahiwal cows. These measurements could also be used as indirect selection criteria for increasing milk production in Sahiwal cows in addition to the milk records of the cows. Still it is desired that studies with larger data sets be conducted to make these estimates more reliable. The genetic correlation of 305-day milk yield with hearth girth (0.22±0.00) in present study was lower than reported for Holsteins (Lin et al., 1987). The phenotypic correlations of 305-day milk yield in present study (0.16±0.00 to 0.22±0.00) with heart girth, paunch girth, and chest depth were in agreement with (Sieber et al., 1988) for Holstein cows. The genetic correlations between the traits arise because of pleiotropic effects of gene. Pleiotropy is a type of gene action in which a gene influences more than one trait. Hence traits vary together in positive or negative direction. The knowledge of such correlations is required for devising any breeding program. If two traits are positively correlated, then selection for one trait will result a correlated response in the other trait.

Authors' contributions

This paper is part of PhD thesis of MAK who reviewed the topic, planned the study, collected data, analyzed and completed write up. MSK supervised data collection, analysis and write up. Both the authors read and agreed upon the contents of the manuscript.

Acknowledgements

The cooperation of Farm Superintendents of Livestock Experiment Stations Bahadurnagar, Jahangirabad and Khizerabad for data collection is acknowledged.

Table 3: Genetic and phenotypic correlations between body capacity traits and milk yield

Trait	Phenotypic correlations		Genetic correlations	
	Measurement day-yield	305-day yield	Measurement day-yield	305-day yield
Heart Girth	0.08±0.06	0.10±0.06	0.29±0.00	0.22±0.00
Paunch Girth	0.18±0.06	0.16±0.06	0.26±0.00	0.21±0.00
Chest Depth	0.07±0.06	0.04±0.06	0.24±0.00	0.16±0.00
Body Depth	0.08±0.06	0.03±0.06	0.23±0.00	0.16±0.00
Sprung at 6th Rib	0.02±0.06	-0.09±0.06	0.22±0.00	0.12±0.00
Sprung at last Rib	0.12±0.06	0.05±0.06	0.17±0.00	0.11±0.00
Top Wedge Area	0.06±0.06	-0.04±0.06	0.18±0.00	0.11±0.00
Front Wedge area	0.04±0.06	0.12±0.06	0.22±0.00	0.13±0.00
Side Wedge Area	0.08±0.06	-0.00±0.06	0.09±0.00	0.08±0.00

REFERENCES

Al-Amin M, A Nahar, AKFH Bhuiyan and MO Faruque, 2007. On-farm characterization and present status of North Bengal Grey (NBG) cattle in Bangladesh. Animal Genetic Resources Information, 40: 55-64.

Ali TE, EB Burnside and LR Schaeffer, 1984. Relationship between external body measurements and calving difficulties in Canadian Holstein-Friesian cattle. Journal of Dairy Science, 67: 3034-3044.

Bayram B, O Guler, M Yanar and O Akbulut, 2006. Relationship among body weight, body measurements and estimated feed efficiency characteristics in Holstein cows. Journal of Tekirdag Agriculture Faculty, 3: 64-67.

Bonczek RR, DO Richardson, ED Moore, RH Miller, JR Owen, HH Dowlen and BR Bell, 1992. Correlated response in growth and body measurements accompanying selection for milk yield in Jerseys. Journal of Dairy Science, 75: 307-316.

Brotherstone S, 1994. Genetic and phenotypic correlations between linear type traits and production traits in Holstein-Friesian dairy cattle. Animal Production, 59: 183-187.

Brum EW and TM Ludwick, 1969. Heritabilities of certain immature and mature body measurements and their correlations with first lactation production of Holstein cows. Journal of Dairy Science, 52: 352-359.

Cruickshank J, KA Weigel, MR Dentine and BW Kirkpatrick, 2002. Indirect prediction of herd life in Guernsey dairy cattle. Journal of Dairy Science, 85: 1307-1313.

DeGroot BJ, JF Keown, LD Van Vleck and EL Marotz, 2002. Genetic parameters and responses of linear type, yield traits and somatic cell scores to divergent selection for predicted transmitting ability for type in Holsteins. Journal of Dairy Science, 85: 1578-1585.

de Haas Y, LLG Janss and HN Kadarmideen, 2007. Genetic and phenotypic parameters for conformation and yield traits in three Swiss dairy cattle breeds. Journal of Animal Breeding and Genetics, 124: 12-19.

Gilmour AR, BJ Gogel, BR. Cullis, SJ Welham and R Thompson, 2007. ASReml User Guide (Version 2.0), VSN International Ltd, Hemel Hempstead, HP11ES, UK.

Harris BL, AE Freeman and E Metzger, 1992. Genetic and phenotypic parameters for type and production in Guernsey dairy cows. Journal of Dairy Science, 75: 1147-1153.

Jaayid TA, MY Yousief, FH Hamed and JM Owaid, 2011. Body and udder measurements and heritability and their relationship to the production of milk in the Iraqi buffalo. International Journal of Biotechnology and Biochemistry, 7: 553-564.

Karthickeyan SMK, R Saravanan and P Thangaraju, 2006. Krishna Valley cattle in India: status, characteristics and utility. Animal Genetic Resources Information, 39: 25-37.

Koenen EPC and AF Groen, 1998. Genetic evaluation of body weight of lactating Holstein heifers using body measurements and conformation traits. Journal of Dairy Science, 81: 1709-1713.

Lin CY, AJ Lee, AJ McAllister, TR Batra, GL Roy, JA Vesely, JM Wauthy and KA Winter, 1987. Intercorrelations among milk production traits and body and udder measurements in Holstein heifers. Journal of Dairy Science, 70: 2385-2393.

Lucas JL, RE Pearson, WE Vinson and P Johnson, 1984. Experimental linear descriptive type classification. Journal of Dairy Science, 67: 1767-1775.

Meyer K, S Brotherstone, WG Hill and MR Edwards, 1987. Inheritance of linear type traits in dairy cattle and correlations with milk production. Animal Production, 44: 1-10.

Mirza RH, K Javed, M Akhtar, M Rauf SMR. Dilshad, MA. Khan and MA Tipu, 2015. Genetic and Phenotypic Correlation of Some Body Measurements with Milk Yield in Nili Ravi Buffaloes of Pakistan. Journal of Animal Health and Production, 3: 1-5.

Misztal I, 1990. Restricted maximum likelihood estimation of variance components in animal model using sparse matrix inversion and a supercomputer. Journal of Dairy Science, 73: 163-172.

Misztal I, TJ Lawlor, TH Short and PM Vanraden, 1992. Multiple trait estimation of variance components of yield traits and type traits using an animal model. Journal of Dairy Science, 75: 544-551.

Mitra A, BK Joshi and MM Kale, 1993. Body conformation characterization of Karan Swiss and Karan Fries strains of cattle. Indian Journal of Dairy Science, 46: 515-519.

Norman HD, BG Cassell and ML Dawdy, 1983. Genetic and environmental effects influencing Guernsey type classification scores. Journal of Dairy Science, 66: 127-139.

Patel AK and OS Tomar, 1990. Prediction of production performance based on pre-partum measurements in crossbred heifers. Indian Journal of Dairy Science, 43: 35-39.

Sarkar A, KC Dhara, N Ray, A Goswami and SK Ghosh, 2007. Physical characteristics, productive and reproductive performances of comparatively high yielding Deshi cattle of West Bengal, India. Livestock Research For Rural Development, 19: 1-11.

Sieber M, AE Freeman and DH Kelly, 1988. Relationship between body measurements, body weight, and productivity in Holstein dairy cows. Journal of Dairy Science, 71: 3437-3445.

Touchberry RW and JL Lush, 1950. The accuracy of linear body measurements of dairy cattle. Journal of Dairy Science, 33: 72-80.

Touchberry RW, 1951. Genetic correlations between five body measurements, weight, type and production in the same individual among Holstein cows. Journal of Dairy Science, 34:241-225.

Vij PK, DS Balain, M George and AK Vinayak, 1990. Linear type traits and their influence on milk production in Tharparkar cattle. Indian Journal of Animal Science, 60: 845-852.

Vinson WE, RE Pearson and LP Johnson, 1982. Relationships between linear descriptive type traits and body measurements. Journal of Dairy Science, 65: 995-1003.

Visscher PM and ME Goddard, 1995. Genetic parameters for milk yield, survival, workability and type traits for Australian dairy cattle. Journal of Dairy Science, 78: 205-220.

Vollema AR and ABF Groen, 1997. Genetic correlations between longevity and conformation traits in an upgrading dairy cattle population. Journal of Dairy Science, 80: 3006-3014.