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# Association between Body Measurements Trait and Live Body Weight of some Sudanese Sheep Ecotypes

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## Abstract

Two hundred and twenty-five head of three sheep ecotypes were randomly selected [80 Ashgar (male=21, female=59), 72 Dubasi (male=22, female=50) and 73 Watish (male=23, female=50)] and according to sex [rams (n=66) and ewes (n=159)] to find out the correlation between live body weight and body measurements using different mathematical models (linear, quadratic, cubic, compound, power and S). The live body weight and body measurements were significantly ($P<0.05$) affected by sheep ecotypes and sex except shank circumference (SC) and thigh circumference (TC) for sheep ecotype and chest depth (CD), rump width (RW), head width (HW) and thigh circumference for sheep sex. The live body weight was significantly ($P<0.01$) correlated with the majority of body measurements, the highest correlation coefficient in the studied sheep ecotype was between the live body weight and heart girth (0.826), followed by live body weight with wither height (0.756) and body length (0.749) respectively. $R^2$ values of the studied ecotypes showed that heart girth was the highest association ($P<0.01$) with live body weight, followed by wither height and body length. The study concluded that sheep ecotypes and sex significantly affect body weight, Watish had the highest body weight while Dubasi had the lowest.

**Keywords:** Sudanese sheep, correlation, heart girth, Watish



## Introduction

Sudanese sheep population numbers 39.6 million heads with an annual growth rate 1.3% and the estimated off- take rate of sheep was 48.7 % (Ministry of Animal Resources, Fisheries and Ranges, MARFR, 2013). Desert sheep are one of the most distributed sheep in Sudan; it represents about 65% of the total population of sheep and consists of seven regional sub-ecotypes as Gezira (Ashgar and Dubasi), Watish, Butana, Bija, Meidob, and North riverine wooled sheep.

Body measurements can be used in defining animal performance, selection processes (Lawrence and Fowler, 2002; Cam *et al*., 2010a), estimation of live weight (Elsheikh *et al*., 2012) and carcass traits (Yaprak *et al*., 2008). Estimation of genetic association between body weight and body measurements was studied by Mohammad *et al*., (2012). Several researchers showed the relationship between body measurements and performance traits in sheep (Atta and El Khidir, 2004; Janssens *et al*., 2004; Afolayan *et al*., 2006; Cam *et al*., 2010a), goats (Cam *et al*., 2010b and Atta *et al*., 2011), cows (El Khidir, 1980; Heinrichs *et al*., 1992) and camels (Boue, 1949; Elbashir *et al*., 2011; Eltahir *et al*., 2011; Ishag *et al*., 2011; Osman *et al*., 2015). In addition, most of animal veterinary prescriptions depend basically on live weight of the animal which is difficult to be measured in the field thus it is necessary to find out a quick and simple method that for estimating live body weight.

Numerous models were used to predict body weight (Enevoldsen and Kristensen, 1997). Correlation coefficients between live body weight and different body measurements are ranged from 0.506 and 0.968 (Thiruvenkadan, 2005).

The aim of the current work was to study the association between live weight and body measurements of Ashgar, Dubasi and Watish sheep ecotypes.

## Materials and Methods

The study was carried out during the period from March and May 2015 at the homeland of the studied sheep ecotypes, including Khartoum and River Nile State (Ashgar), Gezira state for (Dubasi) and Sinar state (Watish), Two hundred and twenty-five adult sheep (average age 3.8 years) head of three sheep ecotypes were randomly selected from the study area [80 Ashgar (male=21, female=59), 72 Dubasi (male=22, female=50) and 73 Watish (male=23, female=50)] and according to sex [males (n=66) and females (n=159)].

### *Studied body measurements:*

Body measurements of the three sheep ecotypes (Figure 1) and sexes were determined using metric tape according to phenotypic characterization of animal genetic resources recommended by FAO (2012), the studied body measurements after animals weighing as follow: Body length (BL): which is the distance between the dorsal tip of scapula and the tip of the ischium, Wither height (WH): which is the height of the highest point of the dorsum of the animal above the scapular vertical to the ground surface at the level of the front feet, Heart girth (HG): which is the circumference of the chest just behind the foreleg, Chest depth (CD): which is the distance from the point of the couple scapular , Chest width (CW): the distance between the spin of the two scapulars, Rump width (RW): the distance between the two cocci, Head length (HL): the distance between the dorsal surface of the frontal bone to the distal end of the nasal bone, Head width (HW): the distance between the two lateral surfaces of the temporal bones, Shank circumference (SC): the circumference of the forelimb (humerous) above the elbow joint, Thigh circumference (TC): the circumference of the hind limb (femur) above the knee joint, Ear length (EL): the distance from the base of the ear on the parietal bone to the ear tip, Tail length (TL): the distance from the base of the tail (last sacral vertebrate) to the tail tip, Wool length (WL) (at rump tip): the length of the wool from the base of the hair the hair tip, Cannon circumference (CC): the circumference of the metacarpus bone.


**Figure 1:** Sudanese desert sheep ecotypes used in this study. A) Asghar; B) Dubasi; C) Watish

***Statistical analysis***

The obtained data were tested for significance using analysis of variance ANOVA followed by least significant difference (LSD) test. Also, Independent samples T. test was used and Pearson's correlation, simple regression analysis was fitted using linear, quadratic, cubic, compound, power and S mathematical models as shown below using IBM SPSS statistics for Windows program, Version 20.0. Armonk, NY: IBM Corp.

Linear $y=b_0+b_1t$

Quadratic $y= b_0+b_1t+b_2t^2$

Cubic $y= b_0+b_1t+b_2t^2+b_3t^3$

Compound $y= b_0b_1^t$

Power $y= b_0t^{b1}$

S $y= e^{b0+ b1/t}$

where: $b_0$ = a constant, $b_1$, $b_2$, $b_3$= coefficients, $t$ = independent variable

**Results**

***Effect of sheep ecotype on live body weight and body measurement:***

With exception of shank and thigh circumference there was significant differences ($P<0.01$) in live body weight and all body measurements among the studied sheep ecotypes (Table 1). Dubasi ecotype records the lowest values of most body measurements with exclusion of head width, shank circumference and ear length, while Watish ecotype showed the highest values of most body measurements not including rump length, thigh circumference, wool length and cannon circumference.

**Table 1:** Effect of sheep ecotype on body measurements

| Measurements | Sheep ecotypes | | | SEM | P. value |
|---|---|---|---|---|---|
| | Ashgar (n=80) | Dubasi (n=73) | Watish (n=72) | | |
| BW, kg | 39.03[b] | 36.77[c] | 44.98[a] | 0.61 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| BL, cm | 68.65$^b$ | 65.50$^b$ | 72.24$^a$ | 0.42 | 0.000 |
| WH, cm | 78.02$^a$ | 73.44$^b$ | 79.59$^a$ | 0.35 | 0.000 |
| HG, cm | 81.98$^b$ | 77.23$^c$ | 86.09$^a$ | 0.53 | 0.000 |
| CD, cm | 42.40$^b$ | 38.32$^c$ | 45.55$^a$ | 0.32 | 0.000 |
| CW, cm | 17.17$^b$ | 14.86$^c$ | 19.92$^a$ | 0.20 | 0.000 |
| RL, cm | 19.33$^a$ | 15.04$^c$ | 15.72$^b$ | 0.23 | 0.000 |
| RW, cm | 16.60$^a$ | 14.85$^b$ | 19.82$^a$ | 0.21 | 0.014 |
| HL, cm | 12.57$^b$ | 11.76$^c$ | 13.53$^a$ | 0.15 | 0.000 |
| HW, cm | 8.90$^c$ | 10.88$^b$ | 11.01$^a$ | 0.57 | 0.014 |
| SC, cm | 23.12 | 23.30 | 23.29 | 0.23 | 0.809 |
| TC, cm | 31.43 | 31.35 | 30.70 | 0.34 | 0.241 |
| EL, cm | 16.44$^a$ | 15.76$^b$ | 13.93$^c$ | 0.15 | 0.000 |
| TL, cm | 60.65$^b$ | 55.89$^c$ | 67.94$^a$ | 0.98 | 0.000 |
| WL, cm | 4.50$^a$ | 4.36$^b$ | 4.09$^c$ | 0.09 | 0.004 |
| CC, cm | 7.79$^a$ | 7.45$^c$ | 7.49$^b$ | 0.06 | 0.000 |

$^{a,b,c}$: different superscript letters within the same row means significant difference at $P<0.05$
SEM= Standard error of mean

**Effect of sex on live body weight and body measurement**

Sex of sheep showed significant differences in live body weight and the majority of body measurements (Table 2) however, chest depth, rump width, head width and thigh circumference were insignificant (P>0.05). The results revealed that females were higher than males in live body weight and most body measurements.

**Table 2:** Effect of sex on body measurements of sheep ecotypes

| Measurements | Sex | | Overall | P. value |
|---|---|---|---|---|
| | Male (n=66) | Female (n=159) | (n=225) | |
| BW, kg | 39.30±0.60 | 41.64±0.38 | 40.96±0.44 | 0.000 |
| BL, cm | 67.89±0.41 | 71.43±0.26 | 70.41±0.32 | 0.000 |
| WH, cm | 76.05±0.34 | 77.99±0.22 | 77.49±0.25 | 0.000 |
| HG, cm | 80.98±0.51 | 83.65±0.33 | 82.22±0.38 | 0.011 |
| CD, cm | 42.38±0.31 | 41.80±0.20 | 42.05±0.25 | 0.111 |
| CW, cm | 17.69±0.13 | 16.95±0.20 | 17.52±0.17 | 0.002 |
| RL, cm | 17.20±0.22 | 16.20±0.15 | 16.64±0.21 | 0.000 |
| RW, cm | 17.10±0.20 | 17.07±0.13 | 17.09±0.17 | 0.895 |
| HL, cm | 12.32±0.14 | 12.91±0.09 | 12.75±0.09 | 0.001 |
| HW, cm | 10.71±0.56 | 9.82±0.36 | 10.03±0.30 | 0.174 |
| SC, cm | 24.20±0.22 | 22.28±0.14 | 22.79±0.14 | 0.000 |
| TC, cm | 31.20±0.33 | 31.11±0.21 | 31.13±0.19 | 0.814 |
| EL, cm | 15.57±0.09 | 15.18±0.14 | 15.49±0.11 | 0.022 |
| TL, cm | 62.68±0.95 | 60.31±0.61 | 61.10±0.60 | 0.037 |
| WL, cm | 4.08±0.06 | 4.56±0.09 | 4.22±0.05 | 0.000 |
| CC, cm | 7.69±0.06 | 7.47±0.04 | 7.53±0.03 | 0.002 |

**Association between live body weight and body measurements of sheep ecotypes**

Table (3) showed the correlation coefficient matrix of live body weight and body measurements for the overall data of the three ecotypes of sheep, whereas Tables (4), (5) and (6) showed the correlation coefficient matrices of live body weight and body measurement for the Ashgar, Dubasi and Watish sheep ecotypes respectively. The animals' live body weight correlated significantly and positively (P<0.01) with the most of body measurements, the highest correlation coefficient was found between live body weight and heart girth, wither height, body length. it was moderately between live body weight and chest depth, chest width, the lowest correlation coefficient was found between shank circumference, thigh circumference, tail length and cannon circumference each other and with other body measurements. Moreover, Watish ecotype showed high correlation coefficient between live body weight and body length than live body weight and wither height.

**Table 3:** The correlation matrix between different body measurements of studied sheep ecotypes (n=225)

| | BW | BL | WH | HG | CD | CW | RL | RW | HL | HW | SC | TC | TL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BW** | 1 | | | | | | | | | | | | |
| **BL** | 0.749$^{**}$ | 1 | | | | | | | | | | | |
| **WH** | 0.756** | 0.597$^{**}$ | 1 | | | | | | | | | | |
| **HG** | 0.826$^{**}$ | 0.687$^{**}$ | 0.714$^{**}$ | 1 | | | | | | | | | |
| **CD** | 0.599$^{**}$ | 0.475$^{**}$ | 0.638$^{**}$ | 0.732$^{**}$ | 1 | | | | | | | | |
| **CW** | 0.595$^{**}$ | 0.607$^{**}$ | 0.646$^{**}$ | 0.700$^{**}$ | 0.686$^{**}$ | 1 | | | | | | | |
| **RL** | 0.100 | 0.040 | 0.297$^{**}$ | 0.313$^{**}$ | 0.320$^{**}$ | 0.273$^{**}$ | 1 | | | | | | |
| **RW** | 0.478$^{**}$ | 0.433$^{**}$ | 0.513$^{**}$ | 0.606$^{**}$ | 0.669$^{**}$ | 0.671$^{**}$ | 0.229$^{**}$ | 1 | | | | | |
| **HW** | 0.302$^{**}$ | 0.466$^{**}$ | 0.391$^{**}$ | 0.456$^{**}$ | 0.440$^{**}$ | 0.532$^{**}$ | 0.253$^{**}$ | 0.402$^{**}$ | 1 | | | | |
| **HL** | -0.070 | -0.090 | -0.070 | -0.050 | -0.020 | -0.030 | - 176$^{**}$ | 0.010 | -0.060 | 1 | | | |
| **SC** | 0.225$^{**}$ | 0.130 | 0.030 | 0.138$^{*}$ | 0.100 | 0.020 | -0.100 | 0.150$^{*}$ | -0.040 | 0.070 | 1 | | |
| **TC** | 0.245$^{**}$ | 0.274$^{**}$ | 0.142$^{*}$ | 0.172$^{**}$ | 0.060 | 0.060 | 0.080 | -0.030 | 0.010 | -0.040 | 0.394$^{**}$ | 1 | |
| **TL** | 0.378$^{**}$ | 0.361$^{**}$ | 0.415$^{**}$ | 0.407$^{**}$ | 0.419$^{**}$ | 0.540$^{**}$ | 0.120 | 0.434$^{**}$ | 0.247$^{**}$ | 0.030 | 0.120 | -0.010 | 1 |
| **CC** | 0.080 | 0.060 | 0.149$^{*}$ | 0.080 | 0.130 | 0.070 | 0.100 | 0.090 | -0.080 | 0.030 | 0.239$^{**}$ | 0.130 | 0.161$^{*}$ |

$^{**}$: correlation is significant at $P<0.01$, $^{*}$: correlation is significant at $P<0.05$

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**Table 4:** The correlation matrix between body measurements of Ashgar ecotype (n=80)

| | BW | BL | WH | HG | CD | CW | RL | RW | HL | HW | SC | TC | TL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BW** | 1 | | | | | | | | | | | | |
| **BL** | $0.623^{**}$ | 1 | | | | | | | | | | | |
| **WH** | $0.738^{**}$ | $0.603^{**}$ | 1 | | | | | | | | | | |
| **HG** | $0.772^{**}$ | $0.662^{**}$ | $0.549^{**}$ | 1 | | | | | | | | | |
| **CD** | $0.705^{**}$ | $0.606^{**}$ | $0.557^{**}$ | $0.836^{**}$ | 1 | | | | | | | | |
| **CW** | $0.516^{**}$ | $0.673^{**}$ | $0.472^{**}$ | $0.608^{**}$ | $0.531^{**}$ | 1 | | | | | | | |
| **RL** | $0.389^{**}$ | $0.621^{**}$ | $0.441^{**}$ | $0.514^{**}$ | $0.409^{**}$ | $0.520^{**}$ | 1 | | | | | | |
| **RW** | $0.536^{**}$ | $0.504^{**}$ | $0.372^{**}$ | $0.645^{**}$ | $0.523^{**}$ | $0.456^{**}$ | $0.500^{**}$ | 1 | | | | | |
| **HL** | 0.135 | $0.473^{**}$ | 0.212 | $0.375^{**}$ | $0.343^{**}$ | $0.366^{**}$ | $0.652^{**}$ | 0.129 | 1 | | | | |
| **HW** | $0.339^{**}$ | 0.143 | $0.313^{**}$ | $0.269^{*}$ | $0.324^{**}$ | 0.023 | 0.031 | $0.445^{**}$ | $-0.260^{*}$ | 1 | | | |
| **SC** | 0.190 | 0.034 | 0.084 | 0.130 | $0.275^{*}$ | -0.119 | -0.017 | $0.236^{*}$ | -0.146 | $0.571^{**}$ | 1 | | |
| **TC** | 0.165 | $0.267^{*}$ | 0.213 | 0.117 | $0.225^{*}$ | 0.006 | $0.238^{*}$ | 0.130 | 0.135 | 0.193 | $0.528^{**}$ | 1 | |
| **TL** | $0.330^{**}$ | $0.338^{**}$ | $0.356^{**}$ | $0.270^{*}$ | $0.223^{*}$ | $0.371^{**}$ | 0.160 | 0.193 | -0.039 | $0.340^{**}$ | 0.068 | -0.019 | 1 |
| **CC** | 0.102 | 0.115 | 0.139 | 0.061 | 0.187 | 0.036 | 0.004 | $0.232^{*}$ | -0.123 | $0.469^{**}$ | $0.525^{**}$ | 0.154 | $0.237^{*}$ |

$^{**}$: correlation is significant at $P<0.01$, $^{*}$: correlation is significant at $P<0.05$

**Table 5:** The correlation matrix between body measurements of Dubasi ecotype (n=72)

| | BW | BL | WH | HG | CD | CW | RL | RW | HL | HW | SC | TC | TL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BW** | 1 | | | | | | | | | | | | |
| **BL** | 0.864$^{**}$ | 1 | | | | | | | | | | | |
| **WH** | 0.868$^{**}$ | 0.698$^{**}$ | 1 | | | | | | | | | | |
| **HG** | 0.918$^{**}$ | 0.826$^{**}$ | 0.784$^{**}$ | 1 | | | | | | | | | |
| **CD** | 0.402$^{**}$ | 0.306$^{**}$ | 0.338$^{**}$ | 0.367$^{**}$ | 1 | | | | | | | | |
| **CW** | 0.769$^{**}$ | 0.757$^{**}$ | 0.695$^{**}$ | 0.691$^{**}$ | 0.294$^{*}$ | 1 | | | | | | | |
| **RL** | -0.481$^{**}$ | -0.578$^{**}$ | -0.387$^{**}$ | -0.352$^{**}$ | -0.069 | -.402$^{**}$ | 1 | | | | | | |
| **RW** | 0.316$^{**}$ | 0.263$^{*}$ | 0.253$^{*}$ | 0.318$^{**}$ | 0.234$^{*}$ | 0.294$^{*}$ | 0.169 | 1 | | | | | |
| **HL** | 0.391$^{**}$ | 0.462$^{**}$ | 0.273$^{*}$ | 0.397$^{**}$ | 0.071 | 0.535$^{**}$ | -0.155 | 0.274$^{*}$ | 1 | | | | |
| **HW** | -0.230 | -0.210 | -0.129 | -0.159 | -0.133 | -0.121 | -0.068 | -0.217 | -0.115 | 1 | | | |
| **SC** | 0.233$^{*}$ | 0.166 | 0.189 | 0.242$^{*}$ | 0.037 | 0.251$^{*}$ | 0.177 | 0.262$^{*}$ | 0.131 | -0.099 | 1 | | |
| **TC** | 0.659$^{**}$ | 0.629$^{**}$ | 0.575$^{**}$ | 0.610$^{**}$ | 0.251$^{*}$ | 0.506$^{**}$ | -0.374$^{**}$ | 0.162 | 0.309$^{**}$ | -0.124 | 0.330$^{**}$ | 1 | |
| **TL** | 0.051 | 0.22 | 0.102 | 0.004 | -0.012 | 0.129 | -0.152 | 0.132 | 0.150 | -0.04 | 0.296$^{*}$ | 0.222 | 1 |
| **CC** | 0.100 | 0.092 | 0.147 | 0.079 | 0.195 | 0.018 | -0.106 | -0.099 | 0.067 | 0.036 | 0.041 | 0.331$^{**}$ | 0.192 |

$^{**}$: correlation is significant at $P<0.01$, $^{*}$: correlation is significant at $P<0.05$

**Table 6:** The correlation matrix between body measurements of Watish ecotype (n=73)

| | BW | BL | WH | HG | CD | CW | RL | RW | HL | HW | SC | TC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BW** | 1 | | | | | | | | | | | |
| **BL** | 0.780$^{**}$ | 1 | | | | | | | | | | |
| **WH** | 0.775$^{**}$ | 0.504$^{**}$ | 1 | | | | | | | | | |
| **HG** | 0.865$^{**}$ | 0.671$^{**}$ | 0.606$^{**}$ | 1 | | | | | | | | |
| **CD** | 0.695$^{**}$ | 0.653$^{**}$ | 0.469$^{**}$ | 0.623$^{**}$ | 1 | | | | | | | |
| **CW** | 0.576$^{**}$ | 0.565$^{**}$ | 0.320$^{**}$ | 0.549$^{**}$ | 0.445$^{**}$ | 1 | | | | | | |
| **RL** | 0.486$^{**}$ | 0.476$^{**}$ | 0.232$^{*}$ | 0.504$^{**}$ | 0.333$^{**}$ | 0.382$^{**}$ | 1 | | | | | |
| **RW** | 0.420$^{**}$ | 0.460$^{**}$ | 0.212 | 0.422$^{**}$ | 0.370$^{**}$ | 0.376$^{**}$ | 0.817$^{**}$ | 1 | | | | |
| **HL** | 0.149 | 0.217 | 0.073 | 0.104 | 0.141 | 0.16 | -0.13 | -0.118 | 1 | | | |
| **HW** | 0.070 | 0.089 | 0.068 | 0.058 | 0.075 | -0.012 | 0.043 | 0.069 | 0.348$^{**}$ | 1 | | |
| **SC** | 0.444$^{**}$ | 0.440$^{**}$ | 0.239$^{*}$ | 0.432$^{**}$ | 0.291$^{*}$ | 0.488$^{**}$ | 0.373$^{**}$ | 0.392$^{**}$ | 0.304$^{**}$ | 0 | 1 | |
| **TC** | 0.357$^{**}$ | 0.268$^{*}$ | 0.22 | 0.422$^{**}$ | 0.301$^{**}$ | 0.534$^{**}$ | 0.336$^{**}$ | 0.294$^{*}$ | -0.128 | -0.152 | 0.137 | 1 |
| **TL** | 0.483$^{**}$ | 0.441$^{**}$ | 0.237$^{*}$ | 0.429$^{**}$ | 0.215 | 0.461$^{**}$ | 0.211 | 0.092 | 0.21 | -0.143 | 0.376$^{**}$ | 0.251$^{*}$ |
| **CC** | 0.1 | 0.092 | 0.147 | 0.079 | 0.195 | 0.018 | -0.106 | -0.099 | 0.067 | 0.036 | 0.041 | 0.331$^{**}$ |

$^{**}$: correlation is significant at $P<0.01$, $^{*}$: correlation is significant at $P<0.05$

| | | |
|---|---|---|
| 0.192 | 1 | TL |

**Regression formulas of the sheep ecotypes**

The regression equations of the three sheep ecotypes were calculated to forecast the body weight from the body measurements (Table 7). $R^2$ values of the regressions in the three sheep ecotypes showed that heart girth was highly associated with live body weight while, body length had the least association with live body weight. Also the results showed lowest correlation coefficients between live body weight and head length, tail length, head width in Ashgar and shank circumference in Dubasi ecotype and thigh circumference in Watish.

**Table 7:** The simple regression equations of body weight and live body measurements for the studied sheep ecotypes

| Ashgar | Dubasi | Watish |
|---|---|---|
| $BW^5= 0.04\times BL^{1.61}$, $R^2= 0.431^{**}$ | $BW^3= -288.19+7.05BL$, $R^2= 0.647^{**}$ | $BW^2= 213.46-6.16BL+0.05BL^2$, $R^2= 0.617^{**}$ |
| $BW^4= 1.82\times 1.04^{WH}$, $R^2= 0.582^{**}$ | $BW^3= -322.43+6.70WH$, $R^2= 0.616^{**}$ | $BW^4= 1.73\times 1.04^{WH}$, $R^2= 0.622^{**}$ |
| $BW^6= e^{5.60-158.28/HG}$, $R^2= 0.637^{**}$ | $BW^3= 7.36+0.60HG+0.013HG$, $R^2= 0.836^{**}$ | $BW^3= -376.08+8.48HG-0.04HG^2$, $R^2= 0.888^{**}$ |
| $BW_6= e^{5.53-78.24/CD}$, $R^2= 0.521^{**}$ | $BW^3= -469.64+24.82CD-0.30CD^2$, $R^2= 0.244^{**}$ | $BW^3= -70.48+3.86CD-0.03CD^2$, $R^2= 0.487^{**}$ |
| $BW^4= 22.59\times 1.03^{RL}$, $R^2= 0.183^{**}$ | $BW^3= -79.95+10.28CW-0.10CW^3$, $R^2= 0.639^{**}$ | $BW^2= 85.90-6.02CW+0.20CW^2$, $R^2= 0.357^{**}$ |
| $BW^3= 15.33+1.16RW+0.02RW^2$, $R^2= 0.288^{**}$ | $BW^3= 122.56-7.62RL+0.01RL^3$, $R^2= 0.307^{**}$ | $BW^2= 21.96+1.13RL+0.02RL^2$, $R^2= 0.237^{**}$ |
| $BW^2= 147.97-18.02HL+0.74HL^2$, $R^2= 0.090^{**}$ | $BW^6= e^{4.34-10.24/RW}$, $R^2= 0.138^{**}$ | $BW^2= -76.15+10.60RW-0.23RW^2$, $R^2= 0.186^{**}$ |
| $BW^1= 20.22+2.35HW$, $R^2= 0.115^{**}$ | $BW^6= e^{4.38-8.61/HL}$, $R^2= 0.187^{**}$ | $BW^2= 359.76-48.43HL+1.84HL^2$, $R^2= 0.102^{*}$ |
| $BW^3= 49.08-1.75TL+0.04TL^2$, $R^2= 0.373^{**}$ | $BW^2= 4.29+4.13HW-0.05HW^2$, $R^2= 0.327^{**}$ | $BW^2= 195.25-14.30SC+0.33SC^2$, $R^2= 0.264^{**}$ |
| - | $BW^3= -597.33+53.04SC-1.10SC^2$, $R^2= 0.149^{**}$ | $BW^1= 20.40+0.75TC$, $R^2= 0.128^{**}$ |

| | | |
|---|---|---|
| - | $BW^3$= -459.51-22.61TC-0.01$TC^3$, $R^2$= 0.574** | $BW^3$= 120.67-2.09TL, $R^2$= 0.365** |
| - | $BW^3$= -103.16+3.72TL, $R^2$= 0.191** | - |

Superscript numbers represent mathematical models as
1=Linear , 2=Quadratic, 3=Cubic, 4=Compound, 5=Power and 6=S
**: significant at P<0.01, *: significant at P<0.05

## Discussion

Many factors can affect the body weight of animals such as breed, sex, age, nutrition, management system and season. In the present study the variations in live body weight and body measurements are affected by ecotypes and these variations might be attributed to genetic variation and or differences in the ecological zones (Riva *et al*., 2004), moreover the results were in line with those of Elsheikh *et al*. (2012).

In most animal species normally males are heavier in weight than females due to differences in skeletal dimensions, hormonal system (Cloete *et al*., 2012), efficiency in feed utilization (Seideman., *et al* 1982) etc.., However, in this study, females ranked higher records in live body weight and most of body measurements. This could be due to the highest off-take and continuous demands of males in different ages for both slaughter and export while females are kept for longer time for breeding purposes.

The highest association coefficient was recorded with live body weight and heart girth, wither height, these measurements are directly associated with size and weight of the animal (Sarti *et al*., 2003; Riva *et al*., 2004; Afolayan *et al*., 2006; Salako 2006; Shaker and Hammam, 2008; Cankaya *et al*., 2009). The association coefficient was moderate between live body weight and chest depth, chest width, similar results were reported by Topal and Macit (2004); Atta and Khidir (2004); Afolayan *et al.*, (2006) and Elsheikh *et al*., (2012), but shank circumference, thigh circumference, tail length and cannon circumference with other body measurements showed lower correlation coefficients, this finding was similar to those of Janssens and Vandepitte (2004); Cam *et al*., (2010a). Furthermore, only Watish ecotype recorded higher correlation coefficient between body length and live body weight (0.780) than wither height and live body weight (0.775) this result were agreed with those reported by Elsheikh *et al*., (2012).

According to regression mathematical models the association of live body weight and heart girth showed the highest $R^2$ value this is agreed with Lawrence and Fowler (2002); Atta and El Khidir, (2004); Cam *et al*., (2010a); Elsheikh *et al*., (2012) and Ali *et al*., (2014).

## Conclusion

Heart girth might be the best measure for prediction of live body weight in Ashgar, Dubasi and Watish sheep ecotypes.

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